Damage Detection System for Testing the Integrity of Geomembranes

V. Nosko & T. Andrezal
SENSOR Spol. S R.O., Bratislava, Slovakia

ABSTRACT: The SENSOR DDS (Damage Detection System) developed by SENSOR s.r.o. detects leaks in the geomembranes of enclosed waste disposal ponds, basins, water treatment stations, industrial stockages, drainages, pipelines and various industrial installations. The "in site" DDS allows both damage detection and location. In some variations of the system, the movement of underground water and the direction of contaminant plumes may be identified. The system is based on using the flow of electric current to simulate leaking contaminants. Field data are measured as a function of position and time and processed to derive 2-D and 3-D information using software specifically developed for this purpose. Once the location of the membrane damage has been identified, it is then very easy to repair it before any contamination of the environment can take place.

Many companies try to focus their commercial activities on environmental protection. This fact is based on two reasons. The first is that legislation and ecological movements in many countries have forced companies to be more or less active in environmental protection. Through this direct way (or indirectly through subcontractors) companies spend finances to support the environment. The second reason is that many companies recognize the potential business opportunities in the environmental industry.

Unfortunately, completely clean technologies are still mostly under laboratory development and commercial worldwide application is still only a dream.

The result of the facts mentioned above is that landfills as the final termination of various types of waste will be for the next few years a necessary part of the production process of many companies. If we consider the waste landfill as a living organism, we can divide its life into five

1,design,
2,earth work, insulation and other construction activities,
3,waste deposit,
4,capping of the landfill and recultivation,
5,post recultivation period.

Periods 1,-4, are precisely determined. The time evaluation of the last period is very problematic. Supposing we want to find some time limits (if any) for the last period, we have to take into consideration lot of input data and evaluate it's mutual relations based on dialectical principles. The most difficult part of this "modeling" is the time factor for periods longer than a few years. It is obvious that the biggest influence of the human being to the landfill is during first four of mentioned periods. The influence of the human factor during the post recultivation period of the landfill is minimal (if we do not take into consideration possible activities during casual accidents).

The final target of all companies involved in building and managing landfills is to minimize possible contamination of the environment by the materials stored at the landfill. This condition is achievable only by applying high quality insulation systems between the waste and the environment. During the construction of the landfill some damage of the insulation system may appear (and in real life it does appear). That is why the observation (monitoring) of the quality of the insulation is extremely important topical. To create optimal conditions for monitoring systems, it is necessary to think about these systems in designing of the landfill. At that time is easier to choose that system or technology, which offers the best possibilities for successful control of the integrity of the insulation systems. In some cases it can also be possible to decide on a monitoring system during the building of the landfill or the depositing of the waste. In these periods it is mostly possible to evaluate the integrity of the insulation systems only once, not continually over an extended period of time.

Due to legislation or existing technical capabilities many of landfills are lined with plastic geomembranes (based on high density polyethylene - HDPE). Since the geomembrane is the part of the insulation system with the smallest coefficient of permeability, the goal of the monitoring systems in most cases is to detect any inconsistency in the homogeneity of the geomembrane. We call this type of monitoring system - Damage Detection System (DDS). To be able to repair the detected damage of the geomembrane quickly, cheaply and with sufficient quality, it is necessary to identify any damage with high precision. Therefore it is necessary to apply active monitoring systems which directly detect and accurately locate damage of the geomembrane itself, as opposed to reactively measuring leaking contaminant as the secondary result of the damage. If there is a possibility to monitor over time (e.g. several years) the integrity of the geomembrane and precisely detect damage, it is possible to repair the damage before it can cause ecological disaster from leaking contaminant. This is the only way to reach maximum protection of the landfill against pollution moving through the geomembrane.

The Damage Detection System (DDS) described in this text can completely fulfill all the conditions mentioned above.

The main advantages of the SENSOR DDS :

- the possibility to verify the integrity of a newly installed geomembrane before beginning deposit of waste (results can be used as a certification for investors, insurers, or local environmental authorities),
- long life of the system that enables continual observation of the geomembrane over time,
- the possibility to locate damages with high accuracy,
- the possibility to observe underground water movement,
- low cost and operating expenses.

The essence of the DDS is monitoring the integrity of the geomembrane by measuring the density of the physical fields around the geomembrane.

At the present time there are three main modifications of the DDS available :

A Modification PERMANENT

The monitoring element is a grid of electric sensors permanently installed under the geomembrane. The precise positions of the sensors are optimized according to construction plans for each landfill. All sensors are connected with the central unit (monitoring box) via cables which are also installed under the geomembrane.

The electric field naturally present in the area of the geomembrane is then measured. This data represents the movement of underground water under the landfill. This can be extremely important information for the hydrogeological evaluation of the influence of the landfill on its surroundings.

To detect damage to the geomembrane changes to the active electric field are

measured. After the interpretation of this data by a special software system we have developed it is possible to evaluate the integrity of the geomembrane. The most important advantage of the SENSOR DDS is that integrity problems are not detected by measuring leakage of the contaminant. Instead, the leakage of the waste thorough the geomembrane is simulated by the leakage of the electric current. This means that the damage is detectable well before it can cause ecological problems.

To maximize effectiveness of the SENSOR DDS it is preferable to begin measurement during the construction of the landfill, immediately after the installation of the drainage and protective layers (e.g. sand, gravel, concrete, ...). These measurements can then determine the integrity of the geomembrane after the installation of the drainage/protective layers, but before any waste is brought to the site. Then any damage can be quickly and easily repaired, and the landfill declared as ready to accept the fill material.

The completion of landfill construction should mark the beginning of regular, periodic monitoring of the geomembrane integrity. Monitoring intervals can be customized according to each client's requirements and risk levels.

Our suggested monitoring schedule is as follows :

1, during the first year, twice a month with written results to the client quarterly;
2, during the second to fourth year, once every two months with written results to the client twice a year;
3, from the fifth year on, approximately twice a year with results given annually. Certainly, if any damage is detected the client would be informed immediately. If a client has any doubts about the integrity of the geomembrane, the measurement can be done at any time.

B Modification TEMPORARY

This modification is based on the same principle as the PERMANENT version. The reason why this modification has been developed is for its application for municipal waste landfills. The main difference is in the operating life of this type of the DDS. While the PERMANENT modification is designed to operate about 20 years, the TEMPORARY version is designed for 1 to 3 years. This difference is based on the parts and materials used in each modification.

Of course, any operating life between 1 and 20 years (and also longer) can be designed as sub modifications according to requirements of each client.

C Modification MOBILE

This modification is designed for testing the integrity of the geomembrane after it is already installed and covered with a drainage/protective layer. The biggest difference between this modification and the previous ones is in the network of sensors and the system of measurement. Since in most cases it is not possible to install any system under a geomembrane already installed, the measurements are done with the sensors positioned on the top of the drainage/protective layer. The sensors in this case are not designed as wide grids of measuring points. Only a small group of sensors (e.g. 2, 3, 4) are positioned on the top of the drainage/protective layer above the geomembrane. After the data is gathered, the group of sensors is moved to another position, the data is gathered again and the whole cycle is repeated until all of the surface of the landfill is evaluated. The processing of the data and interpretation is very similar to those of the previous modifications.

All of the modifications mentioned above offer the same results - the capability to accurately pinpoint possible damage in the geomembrane.

At the moment when some details of the project are delivered from the client, the preparation of the system begins. This includes computer modeling and designing the specific variations of the DDS according to the client's needs. After the installation of the system on site, the monitoring of the geomembrane begins. The monitoring itself is done by

gathering the data from the monitoring box through a measuring device into a portable computer. From the data acquisition system all data is transferred via PC link to desktop or notebook type computers for final processing and interpretation.

The final goal of the DDS is to detect and locate damage in the geomembrane, so that it can be repaired before dangerous and expensive leaking occurs. Thus it protects our clients from being labeled as polluters of the environment.

Fig. 1 illustrates the three dimensional results of the Damage Detection System on an industrial waste landfill. The size of the landfill was about 8000 m^2. The three peaks in the middle section represent the positions of the damage.

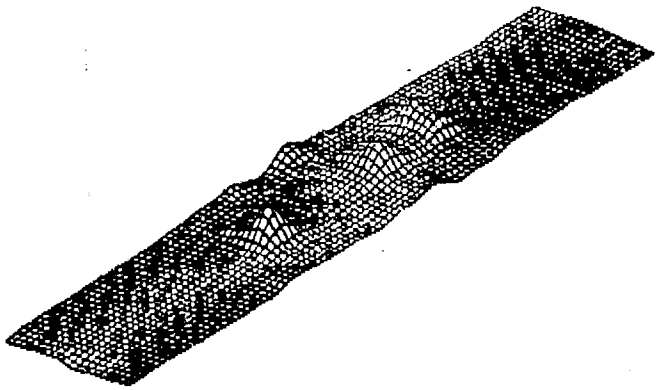

Figure 1 The Results of the Damage Detection System

D Already Completed Projects

So far the Damage Detection System has been installed in six countries: in Slovakia (104450 m^2), Czech Republic (8700 m^2), France (95090 m^2), Belgium (2500 m^2), Germany (100 m^2) and Portugal (10100 m^2).

From projects already completed the PERMANENT modification has been used on 35.6% of the total area, the TEMPORARY modification on 14.8% and the MOBILE modification on 49.6%.