Geosynthetics

Specifying allowable leakage rates

How to avoid specifying a disaster

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Introduction

Allowable Leakage Rates or Action Leakage Rates (ALRs) are specified for installed geomembranes to quantify the maximum allowable liquid leakage.

If the ALR is exceeded, corrective action must be taken to reduce the leakage rate below the set limit. To lower the leakage, the holes in the geomembrane are located and repaired. In some cases, the ALR is set so low that, if exceeded, there is no technology to locate the small leak or leaks for repair.

In other cases, surface impoundments are allowed to leak an order of magnitude more than what could be easily attained by locating and repairing leaks using currently available leak-detection technologies. Therefore, the capabilities of currently available technologies should be considered when specifying ALRs.

The logical criteria for specifying an ALR is not whether a certain low leakage rate is achievable with good construction practices, but whether there is a practical solution if the low leakage rate is not achieved. Specifying a leakage rate that is too low can be a disaster if the source of the leakage cannot be located by current technology. If the source of the leakage cannot be located then the only alternative is to reline the facility and hope that the new geomembrane does not also exceed the specified ALR.

Specifying an ALR that is too high, and easily improved with the application of a readily available technology, allows for lower construction standards and possible future environmental damage. The practical approach is to specify ALRs that are achievable in all reasonable cases when currently available leak-detection technologies are applied.

The best current technologies for locating leaks in geomembranes are geoelectric leak-location methods. They are described in ASTM Standard D6747.

Various implementations are used to locate leaks in bare geomembranes, geomembranes covered with water, and geomembranes covered with earth materials. Other methods include visual inspection, vacuum box testing, and pressure testing of seams. These methods are usually limited to pre-service testing and are not applicable after earth materials are installed on the geomembrane.

No other viable technologies are more effective than geoelectric methods in locating leaks in geomembranes. Therefore, ALRs should be established based on the technical capabilities of these leak-location methods. It is illogical and untenable to specify an ALR that may not be met in some situations and, if not met, there is no technology or practical way to meet the specified ALR. This is not a limitation of the geoelectric survey methods but a limitation of all currently available leak-detection technologies.

This article examines what is achievable—and what is unrealistic—for specifying ALRs. It considers the existing ASTM D7007 for geomembrane leak location with water or earth materials on the geomembrane and uses a mathematical equation for leakage rate vs. size of the leak. The equation is derived from Bernoulli's equation for free flow through an orifice (Giroud and Bonaparte, 1989).

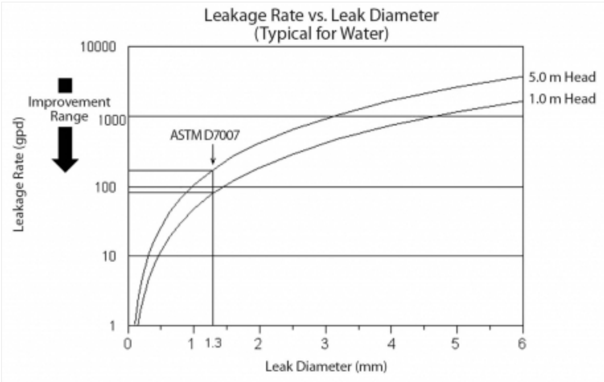
Paradoxically, the usual general technical guidance that geomembranes covered with water are allowed to leak some 10 times more than geomembranes covered with earth materials is opposite from what is attainable with technology available today.

The result is that there are landfills that may never meet their allowable leakage specification by a factor of about 10, and there are surface impoundments that are allowed to leak 10 times more than necessary. For the second case, some evaporation ponds are allowed to leak as much as they evaporate, which clearly is not a prudent environmental goal!

Water-filled impoundments

Geoelectric leak-location surveys with only water covering the geomembrane can locate leaks that would contribute to a typical ALR of 1,000 gallons per acre per day.

Figure 1 is a graph of the free flow leakage rate vs. the leak size for surveys with water on the geomembrane using the Bernoulli equation.



ASTM D7007 specifies a 1.3mm (0.05in.) test leak. The equipment and survey parameters are set up to detect leaks this size under near worst-case conditions.

This diameter and the corresponding leakage rates are indicated in Figure 1 for two levels of water above the leak. Assuming free flow, which is the case with a properly designed leak-detection system, the graph shows that the rate from such a leak is about 80 and 180 gallons per day for water depths of 1m (3.3ft) and 5m (16ft), respectively. Such a leak is practical to detect, and those leakage rates are typically a fraction of the usual ALRs for water-filled impoundments.

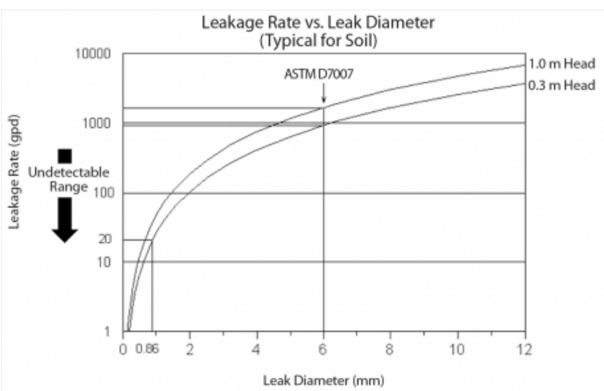
This illustration is for only one leak. For large impoundments, it is reasonable to assume there would be multiple leaks. If one would expect one leak per acre (0.4 hectare), the illustration can be extrapolated to multi-acre impoundments by using the dimensions of gallons per acre per day (gpad) instead of gallons per day (gpd). However, it is unreasonable to interpolate for smaller impoundments because that would result in a leakage rate and leak size that may not be located using leak-location methods.

This analysis suggests that typical ALRs could be made more stringent for ponds larger than about one acre. An arrow in Figure 1 shows the approximate range where ALRs could be improved.

Earth materials on the geomembrane

The analysis gets more interesting with earth materials covering the geomembrane.

Figure 2 shows a graph of the free flow leakage rate vs. leak size for surveys with earth materials on the geomembrane.



ASTM D7007 currently specifies a 6mm (0.236in.) test leak. Again, as part of the leak-location procedure, equipment and survey parameters are set up to detect leaks this size under near worst-case conditions. This diameter and the corresponding leakage rates for water heads of 0.3m (1ft) and 1.0m (3.3ft) are also shown in the figure.

Assuming free flow, which is essentially the case with granular drainage materials or geosynthetic drainage materials above and below the geomembrane, the graph shows the leakage rate from such a leak is about 950 and 1,700 gallons per day for typical hydrostatic heads of 0.3m (1ft) and 1m (3.3ft), respectively. A leak with this diameter is practical to detect, but these leakage rates are more than an order of magnitude higher than some ALRs for landfills.

This illustration shows that if an ALR is set low, detection of the small leaks in the geomembrane that cause the leakage may not be possible. This unrealistic requirement can result in disastrous consequences that may prevent the permitting of the landfill cell. Figure 2 also has an arrow indicating the approximate range where allowable leakage may not be attainable.

In some cases when a low ALR is specified, a low-permeability layer such as a geosynthetic clay liner (GCL) is placed under the geomembrane to help meet the leakage criteria. A low-permeability layer greatly decreases the leakage rate if the geomembrane makes good contact with the layer.

Therefore, larger holes can be located or tolerated. However, if the geomembrane is not in intimate contact with the low-permeability layer, such as on wrinkles or bridging, the unsolvable problem re-emerges if there are leaks in these areas.

A common geoelectric leak-location specification for landfills calls for detecting all leaks that could contribute to an ALR of 20 gallons per acre per day. Figure 2 also shows that 20 gallons per day will flow through a 0.034in.-diameter leak assuming free flow with only 1ft. (0.3m) of head.

The analysis above shows that meeting that geoelectric leak-location specification may be in conflict with the ASTM standard and the available technology. Meeting this low ALR depends almost entirely on the GCL or other leak-sealing layer having intimate contact with the geomembrane and not on the detection capabilities of the geoelectric leak-location method.

When the U.S. Environmental Protection Agency (EPA) promulgated the final rule for Action Leakage Rates in 1992, it considered what was usually attainable with good construction quality assurance. It may not have considered the technologies available to remedy the problem if the leakage rate was not attained, particularly for landfills.

Technology is available to attain action leakage rate for water-filled impoundments that are an order of magnitude lower than the guidance. Considering the best available technology, the action leakage rate for solid-waste facilities should be greater than the action leakage rate for liquid-waste impoundments, which is the opposite of the guidance.

A sensible solution

In the cases of a low acceptable leakage level for geomembranes covered with earth materials, a sensible approach is to test the bare geomembrane for leaks before the earth materials are placed to detect the smallest installation leaks and then assume no more small leaks will be caused as the earth materials are placed on the geomembrane.

Another leak-location survey is needed to test for larger construction damage after the earth material is put on the geomembrane.

The misconception of zero leakage

Specifying zero leakage for a geomembrane is even more unreasonable than specifying an ALR that is too low.

Some engineers and owners are still specifying zero leakage or no leaks. Although one strives to obtain the best attainable results with a specification, it is naive to specify something that cannot be remedied if the specification is not met. That is the case when specifying zero leakage in a geomembrane of any practical size.

There have been several instances of this, particularly in water storage reservoirs with many pipe penetrations and other penetrations including roof support columns with battens and other details. In some situations, the leakage is zero or ignorable. But specifying zero leakage or specifying that a liner has no leaks almost always results in disputes and sometimes unsolvable problems.

A dilemma

The industry has been fortunate by installing geomembranes to meet low ALRs. However, that does not justify flirting with disaster by continuing to specify low ALRs.

Consider the scenario of a landfill installation by a qualified and reputable general contractor, geomembrane installer, and construction quality assurance firm. Despite their best efforts, the primary geomembrane experiences a leakage that is slightly above the specified low ALR. A geoelectric leak-location survey is conducted in the hope that any leaks detected will lower the leakage rate after they are repaired. However, no leaks are detected.

Now what to do? The only alternative is to remove the cover material and geosynthetics from the geomembrane, remove and replace the geomembrane, and hope that the problem does not recur. All of this added expense and possible lost revenue and liquidated damage because of a few gallons of leakage a day through the primary geomembrane, and probably very negligible leakage through the secondary geomembrane! This can be avoided if a proper and reasonable ALR is specified from the beginning.

Easily attainable better performance

The prospect for water-filled impoundments is more promising. In most cases, the ALRs can be made much lower.

It does not make sense to install a geomembrane as an impermeable layer and tolerate easily detectable leaks. The technology is widely available to locate leaks that would contribute an order of magnitude less than some ALRs.

If a lower ALR is exceeded, there are easy ways to solve the problem.

A workable specification

An important part of engineering and specification writing is to balance the desire for perfection with what is suitable for the purpose, at a reasonable cost and attainable with existing technology.

Table 1 shows a hierarchy of specification levels, the corresponding desired performance levels, and the possible results of the specification levels.

Specification	Performance Level	End Results
Perfection	Zero leakage	May not be attainable at any cost
Attainable in many or most situations	Very low allowable leakage rate	Cost is reasonable if allowable leakage rate is met, but cost may be prohibitive if allowable leakage rate is not met
Attainable in all reasonable situations	Allowable leakage rate based on leaks that can be detected with geoelectric leak location methods	Optimum benefit for the cost

Although perfection may be the goal, specifying perfection or the unattainable without regard to the technology, cost, and consequences is not good engineering.

It does not make sense to provide a specification that, if not met, cannot be practically solved. Specification writers and design engineers should consider what is attainable using the available technology and understand the implications for their project if the ALR cannot be met.

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Comments

There are not yet any comments.

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