20th Anniversary
GFR
GEOTECHNICAL FABRICS REPORT
June/July 2002
volume 20.number 5

Choosing secondary containment liners
for small tank farms

Celebrating two decades
in the geosynthetics community

Needlepunching improvements
raise the bar on geotextile quality

20-year-old HDPE geomembrane
stands up to current testing

www.gfrmagazine.info

449181-1 ADUO
Andrew Mills
Lawfield Plastics 1978 Ltd.
11603 180th St NW
Edmonton AB T5S 2H6
Canada

Small secondary containment liners

Geomembranes can play an important role on small tank farms, which may suffer more frequent spills than large containment facilities.

Small geomembrane containments do not always get the same amount of attention as the tank farms at refineries and pipeline terminals. That's unfortunate because it is the small containments where most spills occur, and where the risks of selecting the wrong geomembrane are the highest. It is exceptionally rare to see a spill from a 65-m-diameter tank at a refinery where all the operations are handled from a modern control room with automatic safety alarms and overfill protection systems. It's far more likely that a 400-barrel fuel tank (64 m^3) that is filled every week by truck will develop a spill. The small tank, with its high traffic and manual systems, is where a secondary containment geomembrane can have the most beneficial effect. In this article, I will discuss geomembranes for small tank farms and highlight some of the design factors to consider.

Prefabricated geomembranes

On projects where the geomembrane is less than 2000 m^2, a one-piece prefabricated geomembrane is usually the most cost-effective secondary containment solution. Fabricated geomembranes are typically made from oil-resistant formulations of polyvinyl chloride (PVC), polyurethane, and specialized flexible polyolefin materials. HDPE is not used in prefabricated applications because of damage that can occur in panels that are folded and rolled.

Small geomembranes can be pre-built and shipped to the site with the other construction materials. Small prefabricated geomembranes are appropriate for secondary containments in remote sites. The liner is shipped in one piece and can often be installed by the local contractor or the owner's own forces. A typical 1,000-m^2 liner can be installed by four people in less than an hour. On small projects, an installation technician is often not practical due to the cost of mobilization. In these cases, an owner-installed prefabricated geomembrane can be a cost-effective solution.

The use of geomembranes for secondary containment is now accepted practice in many jurisdictions. Often secondary containments are built in a hurry, on poorly prepared subgrades, and in late fall to early winter. We find this especially prevalent in the resource-recovery industries. While a fuel retailer can carefully plan and prepare their tank-farm site, an oil-field drilling contractor needs to build a tank farm quickly, often on poorly prepared ground. The use of compacted clay liners is not a practical solution on many of the tank farms because the small size of the project does not permit the mobilization of the equipment required for compaction. Instead, we have many small projects that are constructed with a small crew using a skid-steer loader. This type of small crew is capable of geomembrane installation, but is not usually equipped to install a compacted clay liner.

Photo 1: This secondary containment system uses a portable steel dike system with a polyurethane geomembrane.

Barry Mykolashyn/Layfield Geosynthetics and Industrial Fabrics Ltd.

Chemical resistance

Secondary containment is an area where the chemical resistance of plastics stands out. There are many types of geomembrane materials used in secondary containment, and each material has its appropriate use. Sometimes there is no one geomembrane that will contain all of the chemicals in a tank farm. Just a few blocks from our office is a chemical distribution company whose tank farms use three different types of geomembranes. The tanks in each containment area were grouped into sets of similar chemicals and a spe-

By Andrew Mills

cific geomembrane was used for each group. Intermediate berms were used to separate the different areas of the tank farm. Although it is unusual to find so many types of chemicals in one area, this example illustrates the case in which no one geomembrane can contain all chemicals. When dealing with small containments, there are many types of prefabricated geomembranes that can be used, each with its own chemical resistance.

Geomembrane selection

There are millions of chemicals in the world and most geomembranes have only a few hundred completed chemical tests. How does the engineer decide which material is suitable for their project? First of all, the engineer needs to identify the chemicals to be contained in the tank farm. That may seem to be pretty basic, but often the chemicals are mixtures, proprietary formulae, or distillates. Distillates are mixtures of as many as 400 individual chemicals usually with only an approximate formulation. Gasoline, diesel fuel, and most other distillates can have significant variations in chemical composition depending on the initial crude oil source, the refining process, and any blending or mixing done by the refiner. In dealing with distillates, I encourage the engineer to ask the producer about the chemistry of their product. We have seen BTEX (Benzene, Toluene, Ethylbenzene, and Xylene) content in gasolines vary from under 5% to over 40% (each refinery produces fuels with typical BTEX contents that vary with changes in crude-oil feedstocks). This wide variation in fuel chemistry has a dramatic effect on geomembrane material selection even though fuels of similar grades have similar performance.

Another troublesome type of chemical to contain is a mixture or a proprietary formula. In this instance, you need to look closely at the MSDS sheet for the approximate contents. An MSDS sheet will list all the hazardous chemicals in the mixture with a range of their content. This provides an excellent starting place for screening geomembranes.

Corrosion inhibitors are common proprietary chemicals that we see quite often in tank farms. These corrosion inhibitors usually contain a small amount of a proprietary anti-corrosion agent in a solvent. The solvent is often over 80% of the mixture. In cases where the solvent is an innocuous type of oil, the geomembrane selection can be straightforward. More often however, the solvent is toluene, which at 80% by volume makes for a more difficult liner selection requiring polyurethanes or other special materials.

Photo 2: Prefabricated liners are quickly and easily installed in small tank farms. This 30-mil flexible polyolefin geomembrane was installed in just a few minutes.

Jodi Polowich/Layfield Geosynthetics and Industrial Fabrics Ltd.

Photo 3: Oil-filled transformers, like those found at this electrical substation, often utilize small secondary containment geomembranes.

Dan Dahlen/Layfield Geosynthetics and Industrial Fabrics Ltd.

The next step in screening chemicals is to consult geomembrane manufacturers' chemical charts. Use these charts as a guide. Manufacturers' chemical charts are compiled from data taken from many sources. Some geomembrane manufacturers do their own testing; others compile data from resin suppliers, industry publications, and from plastic-design guides for other products that use similar resins. A published chemical chart is an excellent way to screen geomembranes and limit your search to two or three candidates; however, a chemical chart should not be the final deciding factor in your design. As a responsible designer, it is important that you have direct knowledge of a test performed on the chemical to be contained at the project conditions. The test could be performed by your engineering firm, by the geomembrane supplier/manufacturer, or by an independent lab.

Geomembrane materials

Because of the vast number of chemicals that need to be contained, there often seems to be an equally vast variety of geomembranes to contain them. In fact, the types of secondary containment geomembranes can be broken down into a few general chemical categories. The first category is the non-polar geomembranes. You've heard the old saw, "oil and water don't mix?" Well, non-polar is "oil." Non-polar geomembranes include all the materials made from polyethylene and polypropylene. These geomembranes "repel" water and inorganic chemicals. They have excellent resistance to acidic and basic solutions, but can absorb hydrocarbons (oils). The "water" type materials are called polar materials. These materials include polyurethane and polyester. Polar materials "repel" oil and so are resistant to hydrocarbons and many organic chemicals. Polar materials do not fare well with inorganic chemistry and are usually affected by strong acids.

Interestingly, there are many secondary containment geomembrane materials made from PVC and its derivatives. PVC has some polar characteristics and some non-polar characteristics. Depending on how you blend it with other ingredients, PVC materials may have good oil or water resistance, or a useful combination of both. There are many alloys and blends of PVC available to contain many different types of chemicals.

Photo 4: The tank at this oil well is being fitted with a PVC alloy geomembrane engineered for hydrocarbon resistance. In this case the liner was placed, and the tank set before the dike walls were built.

Rich Hollart/Layfield Geosynthetics and Industrial Fabrics Ltd.

Finally, there are specialty geomembrane materials available to contain themost difficult chemicals. Polyvinylidene flouride (PVDF) is a flouro-polymerthath as extensive chemical resistance and is now available in geomembrane form. Another interesting option is the thermosettingspray-on lining material (usually polyurethane orpolyurea). This material cross-links (unlike the majority of thermoplastic geomembrane materials), which can provide a significant improvement in chemical resistance.

Chemical exposure

In practice, geomembranes see two types of chemical exposures. The first type of exposure is a major spill in the tank farm. Although the image that comes to mind is of a catastrophic tank failure, the main cause of major spills in tank farms is overtopping during tank filling.

The second type of spill in a tank farm is the day-to-day spillage from tank-farm operations. In aviation fuel facilities, tanks are checked for water content every day and a small amount of spillage often results from the handling of these samples. In heavily used tank farms, there can be small spills from the making and breaking of filling-hose connections, operation of tank sampling valves, or in the loading rack. How these small spills are handled can affect your choice of geomembrane.

Most chemical testing exposes a plastic material to a chemical for seven days at room temperature. In practice, a major spill will be cleaned up very quickly and a contact time of more than seven days would be very unlikely. You can imagine how your local fire chief would react to a tank farm full of gasoline for seven days! On the other hand, a large spill of PCB-contaminated transformer oil might need to remain in the secondary containment until a suitable cleanup crew was available. In any event, a chemical test of seven days will give us an excellent indication of the performance of the material.

It is not such an easy matter to determine the long-term effect of a chemical that is spilled frequently in a tank farm. The effect of long-term minor spills may be significant over many years. A seven-day immersion test is not always a clear indicator of how a material will perform in the long term. It is unlikely that there will be long-term chemical testing on the geomembrane/chemical combination in your design, and a long-term test can often be prohibitively expensive. In this instance, it is best to design the tank-farm area in such a way as to prevent the long-term contact of the chemical and the liner. The best way to do this is to allow any spilled chemical to drain to a sump where the spill can be dealt with. Sumps can be placed near the most likely sources of spills and the liner sloped in the direction of the sump. Unfortunately, this relatively easy technique is often missed.

A common problem we find in tank farms is a lack of drainage slope at the liner elevation. The liner needs to be sloped to drain spills to the sump; however, the subgrade is built level in order to ensure that the tanks are level. The simple solution is to grade the subgrade towards the sump, place the geomembrane, and then backfill with enough fill material to make the tank base level. This variation in backfill thickness may be a little more difficult to place during construction but will result in much better drainage of spills and rainwater over the life of the tank farm.

The use of backfill in a tank farm is highly recommended. Many smaller tank farms have a lot of daily activity. Backfill protects the geomembrane and reduces the risk of mechanical damage from daily use.

Tank farm operations

Secondary containment is one area where the owner's intended use could actually change the selection of the geomembrane material. The purpose of the secondary containment is to hold the spills until the owner has the opportunity to clean them up. That's the key. But how fast can cleanup occur? Two oil companies that we are aware of have taken a different approach to cleanup. One company has a standby spill response team. The company is committed to having its team on site within 24 hours of any spill. The second company participates in an industry-sponsored spill-response plan. In this plan, equipment is placed around the country and the spill-response team is assembled from trained staff in the area near the spill. With the additional time required to assemble the team, this response technique usually has a longer lead-time.

Interestingly, the spill-response criteria of each of these companies were a factor in their evaluation of their geomembranes. The company with the standby spills team decided to use a lower-cost liner since they were going to limit exposure to spills. The company participating in the industry spills team decided to use a geomembrane with better chemical resistance and a lower fuel permeability to the fuels being contained. They paid a little more for their geomembranes during construction. Instead of asking how long the geomembrane can contain the chemical, often the more important question is, "How long will it be before the spill will be cleaned up?"

Temporary secondary containments

Sometimes the spill will be cleaned up immediately. Temporary secondary containments, if permitted by local authorities, can be very effective in certain cases. Temporary secondary containments may use a lightweight reinforced polyethylene or thinner gauges or other geomembrane materials. Often these are "course of construction" containments—containments that will only remain in place until construction is completed. We have done some interesting temporary secondary containments in the Arctic where the berms are made out of ice and the tanks are in place for only a few months. We also see temporary secondary containments used in emergency cleanup applications. The lightweight liner material is placed under the portable tank used to store the liquid during emergency operations. A secondary containment liner here can prevent an already difficult emergency from becoming much worse.

A secondary containment using a geomembrane is an appropriate solution for small above-ground tank farms in a variety of applications. These small tank farms often see much more traffic than large tank farms, and the risk of spills is higher. In designing these small tanks farms, the correct selection of a suitable geomembrane, along with some simple design details, will ensure that any spills are contained. In almost all cases, an actual chemical test of the geomembrane selected, at project conditions, is the best way to verify material performance. A discussion of how the owner will operate the tank farm will also help you determine the required properties of a geomembrane. A properly selected geomembrane will ensure that your site is protected against spills for many years to come. **GFR**

Andrew Mills, C.E.T., is research and technology manager for Layfield Geosynthetics and Industrial Fabrics Ltd.