Geosynthetics Asia'97, 26–29 November, Bangalore, India

CRITERION FOR SELECTING A GEOMEMBRANE: THE TECHNICAL CHALLENGE

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The Resource Conservation and Recovery Act (RCRA) was enacted in 1982 by the U.S. Congress. This Act legislated that all waste sites containing hazardous wastes had to be lined with an impermeable barrier. Leakage rates of approximately one gallon of leachate per 24 hour period were also established. This requirement placed significant emphasis on specifying seamable liners that were resistant to chemicals and the effects of sunlight.

The United States Environmental Protection Agency (USEPA) funded a committee under the guidance of the National Sanitation Foundation (NSF) to develop specification criteria for Flexible Membrane Liners. This guide was developed by a technical committee composed of end-users, specifiers, manufacturers and government officials. The first specification for FML's was published in 1983 and was designated NSF-54. NSF Standard 54 lists 18 different materials and their physical properties, the most recent version was published in 1993

The challenge today is choosing the lining product that will best meet the requirements of the project at a reasonable cost. This paper provides some guidance from our company's research and development, and that of others, to assist in making the proper choices. The following criteria will establish a needs structure prior to writing the specification:

1. Required Operating Life
2. Compatibility
3. Site Conditions
4. Reliability of Seams
5. Value
6. Installation

There are five lining products that account for 90% of all lining projects for the containment of waste.

CSPE - Chlorinated Sulfonated Polyethylene developed by DuPont.

HDPE - High Density Polyethylene - a polymerized polyethylene with excellent chemical resistance and ultra-violet resistance when compounded with carbon black.

VFPE - Very Flexible Polyethylene - a more pliable polyethylene for applications requiring greater elongation and resistance to stress cracking agents.

PVC - Polyvinyl Chloride - a compounded lining material that is very pliable, easy to install using solvent seaming and resistant to a wide range of chemicals.

PP - Polypropylene - when used for lining applications this product is copolymerized with products that improve flexibility and seamability. Polypropylene is resistant to most chemicals and has improved heat resistance.

REQUIRED OPERATING LIFE

Many RCRA projects, those funded by Superfund and/or the EPA, require a 20-year operating life with a 30-year requirement for post closure. The other end of the spectrum is a temporary lining for waste water, a slope protection project, a temporary closure while permits are being sought, a temporary pad to store contaminated soils, etc.

Many temporary lining projects are of an exposed nature, which limits the Specifier to Hypalon or High Density Polyethylene, because, in an exposed condition, PVC will deteriorate in a period of months. Heat generated by operating conditions can be destructive to linings. If operating temperatures are 70° C to 82° C, Hypalon (Chloro Sulfonated Polyethylene [CSPE]), Polypropylene (PP), or High Density Polyethylene (HDPE) would be the choice. PVC is not recommended in applications requiring service over 60° C Both HDPE and CSPE products may have a shortened life depending upon the composition of the waste stream being discharged.

For short-term use at ambient temperatures and non-hazardous products, the PVC, if covered, would provide a least-cost solution. Thinner HDPE membranes (0.75 to 1.0 MM) are also satisfactory and may be used exposed.

For long-term containment, exposed impoundments or landfills, HDPE is less expensive as it requires less maintenance, is inert to microbiological attack and resists the effects of ultraviolet light.

COMPATIBILITY

Compatibility refers to the liner's ability to withstand the effects of the specific waste stream under the planned operating conditions; the key word is specific. Presently, an EPA 9090 test is required on most hazardous wastes and industrial wastes prior to permitting. This test is run at 50° C for 120 days. The membrane is suspended in the liquid, and it may be a stirred test or static test. Test samples are removed every 30 days and tested for physical properties, weight gain and appearance. In cases where volatile compounds are present, the solution should be renewed every 30 days, as the volatiles may have dissipated. In our opinion, seams should also be included in this test, as the compound, solvent or bodied solvent, may be attacked by the waste in question.

Most suppliers of lining materials supply chemical resistance data, but this may be misleading for the following reasons:

A. The compound used to manufacture the sheet may differ from supplier to supplier; i.e. plasticizer used, fillers, percent of base resin to filler, etc.

B. In the case of polyethylene, the densities used for the tests may be different from what is used in liners. **For instance, most people refer to the polyethylene liners as "high density", but, in fact, most geomembranes used today are technically "medium density" or Type III polyethylene.** Most data on chemical resistance relates to products with density 0.95 and over.

C. Hypalon may contain from 45% to 55% CSPE by definition.

D. Polypropylene resins require the incorporation of copolymers of elastomeric materials such as rubber to provide improved flexibility. Such polymers exhibit improved dimensional stability, seamability and heat resistance.

As a final note, those liners being tested in waste streams containing hydrocarbons or chlorinated solvents should be tested for compatibility under static as well as stirred conditions since, in aqueous solutions, chlorinated solvents sink and hydrocarbons collect on the surface. Past installation references are also helpful.

SITE CONDITIONS

Temperatures

High or low temperature extremes are a major consideration in liner selection. Recent guidance by the USEPA suggests proper seaming conditions from 10° C to 40° C. Much work is done at temperatures below 10° C with HDPE because extrusion welding and fusion welding may be carried on with proper preparation, even at temperatures below 0° C using portable enclosures. Liner expansion, contraction, and resistance to embrittlement at cold temperatures must be examined in the design and construction phase.

Winds

High winds can permanently stress and deform thin polyethylene liners and PVC liners. Thick HDPE liners and reinforced Hypalons are less subject to permanent deformation. Winds can also cause slack compensation to accumulate in one area rather than be uniformly distributed. The issue of wind uplift must be addressed.

Soils

In the case of some soils containing rock fragments or gravel, the concept that thicker is better may not apply. Tests done by the U.S. Bureau of Reclamation and Poly-Flex, Inc. indicate that membranes of PVC and VFPE (Very Flexible Polyethylene) are more ductile and resist puncture, due to greater deformation prior to rupture under load, to a greater extent than HDPE and Hypalon. Temperatures at the time of installation are important to puncture resistance, and PVC cannot be installed below -20° C. VFPE can be installed below freezing without cracking.

Slope angle and length places emphasis on frictional resistance to sliding, seam strength capability, and creep factors of the liner. Seaming with adhesives on steep slopes (2:5 to 1 or greater) places stress on the seam and require longer cure times.

Vegetation

Soil sterilants may or may not be compatible with the liner being considered. Rhizomes of certain plants such as "nut grass" will easily penetrate PVC, Hypalon (CSPE) and thinner polyethylene membranes.

Animals

Rodents must chew to properly maintain their teeth. Burrowing animals such as beavers, muskrats and mice will penetrate thinner membranes. Plasticizers contained in some PVC's have been shown to attract mice. Studies done in Germany in the early 1970's indicate HDPE liners of 1.5 MM or greater as being most resistant to rodent penetration and contain no additives which serve as food value.

SEAMING

A survey conducted by the USEPA of 27 lined facilities determined that 11% had leakage problems due to improper seaming.

Polyvinyl Chloride, HDPE and PP may all be seamed using hot wedge seaming. Hot wedge seaming improves peel values some 5-10 times greater than using chemical bonding agents for seaming. The principle of hot wedge seaming is placing a heated metal wedge between the overlap area of the geomembrane and heating the material to its melting point. Bonding is accomplished by compressing the heated material with metal or rubber rollers.

Extrusion welding can be utilized on HDPE, VFPE and PP. A fillet of extrudate made from the same material as the base liner is placed on the overlap of the sheets. The sheet must be ground lightly in the area of the weld to effect bonding.

Hot air seaming utilizes a hot air nozzle which is placed between the overlap of the sheets melting the surfaces, metal rollers are then utilized to compress the sheet forming a bond. While there is some disagreement about the use of hot air seaming machines it is our opinion that this method is applicable to non-critical applications and is greatly affected by changes in temperature and wind speed.

The methods reviewed result in seams which approximate 60% of the liner's tensile at yield values in peel and 90% of the tensile at yield value in sheet strength.

VALUE

The cost per square meter on an installed basis in descending order would be as follows:

CSPE: The most costly liner but it is generally sold in a reinforced version and in a prefabricated form.

Polypropylene: In a reinforced form which enhances dimensional stability, it is very expensive. In it's non-reinforced form it is generally more expensive than other linings but the extra cost can be justified in applications requiring greater heat resistance.

VFPE: This category includes very low density polyethylene with densities of .912 or less, and linear low density polyethylene with densities from .915 to .925. These specialty resins are generally more expensive than other polyethylenes due to the cost of catalyst technology and copolymers. These products exhibit greater multiaxial burst values and improved cone puncture values.

HDPE: When properly seamed, HDPE provides the strongest seams and has excellent chemical and hydrocarbon resistance. It is cost competitive with PVC but has improved physical properties. It is also available in thicker gauges up to 3.0 MM for improved abrasion resistance.

INSTALLATION

The final criterion to insure a quality installation is to review the installer's past references and past projects that may be closely related to the specific project being constructed. The financial strength of the installing company is also important as it allows the installer to complete the project even under adverse conditions. Other considerations in the selection process are:

1. The installer's QC/QA programs.
2. The experience of the specific personnel that are assigned to the project.
3. The on-site testing program and testing equipment the installer is bringing to the site.

A document published by the USEPA, titled ***Quality Assurance for Hazardous Waste Sites***, EPA 530 SW86031, provides additional information.

Regardless of whether your liner requirement is hazardous or non-hazardous, the same quality assurance and liner performance requirements should apply. The future of our environment depends upon it.

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