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Project Summary

Development of Chemical Compatibility Criteria for Assessing Flexible Membrane Liners

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A laboratory testing of flexible membrane liner (FML) materials was conducted to develop chemical resistance data using immersion tests. Six FML materials (polyvinylchloride, chlorinated polyethylene, chlorosulfonated polyethylene, high density polyethylene, epichlorohydrin and ethylene propylene diene terpolymer) were tested. Twenty chemical solutions providing a range of chemical challengers; acid and base, polar and non-polar, organic and inorganic, and increasing chemical concentration, were used. Duration of immersions were 1, 7, 14, 28, and 56 days, and four month increments for up to two years. All immersion tests were conducted at two temperatures, 23° and 50°C. Liners were evaluated for changes in appearance, weight, dimensions, and tensile properties.

Procedures and criteria for evaluating immersion test results were developed using data from this study and comparing them with comparable data from other studies, published reports and criteria, and liner manufacturer recommendations. The criteria for chemical resistance include the need for a liner response to have stabilized, retention of minimum physical properties, and maximum percent change of physical properties.

A mathematical curve fitting method is proposed for evaluating immersion data as a function of time. The method assumes the liner approaches a limit of physical property change (stability) asymptotically. The method can be used to predict the ultimate end point of physical property change and sampling time intervals for continued immersion testing.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Scope

Flexible membrane liners (FMLs) are used increasingly as lining materials for hazardous waste containment, in landfills and surface impoundments. A double-liner system, including at least one synthetic liner, is required in all new installations. The FML used in a waste containment application must show long-term chemical resistance to the waste stream.

Waste streams are mixtures of chemical substances, with some chemical components present in small or trace quantities. The presence of some trace components may be unknown at the time a liner is being selected. Published chemical resistance tables generally list only pure components, or mixtures of one component in water. A small amount of a substance deleterious to the liner could be present in a mixture whose major component has no effect. Looking only at the effect of the major component in tables, the liner would appear to be resistant. The presence of the incompatible chemical could mean the difference between success and failure of the installation. As an example of the effect of a small amount of an incompatible chemical, Figure 1 compares the change in weight of the PVC liner used in this study in two solutions of very different concentrations. Percent weight change is shown as a function of immersion time. While a saturated brine solution (approximately 35% by weight) causes very minor changes in FML weight, a 0.5% solution of 1,2-dichloroethane (DCE) results in much greater weight gain. A waste containing both components might be classified as a brine waste, and chemical resistance predicted. For these reasons, the EPA requires that FML selection be based on evaluation of changes in physical properties resulting from immersion in the actual waste to be contained.

More guidance information is needed by FML users, who must select the most appropriate lining material and demonstrate its resistance to the waste. Theoretical methods of predicting chemical resistance such as Hansen solubility parameters and cohesive energy density numbers are not yet well developed for FMLs, and expert systems for data interpretation are not currently refined and available. Acceptable changes in a physical property such as tensile strength at a given temperature and immersion time may be different for different FML materials. This project was initiated by the EPA to help develop chemical resistance selection guidance information for FML users.

In this project, immersion testing of six FMLs was conducted at two temperatures (23°C and 50°C) with a broad range of chemical exposures. FML property changes were measured for exposure periods from one day to two years. Results were studied to determine the basic FML responses to combinations of chemical challenge, concentration, temperature, and time. The focus in data interpretation was on the types of degradation encountered, stabilization of the material response, the extent of property change, and indicators of non-resistance. The method of interpretation can then be generalized to provide guidance to FML users testing FMLs with specific waste streams.

Conclusions

- The stabilization of a material's response to a chemical challenge, when considered in conjunction with the magnitude of that response, is an important parameter in the evaluation of chemical resistance.
- Increasing the immersion temperature may be used to accelerate the FML response to determine chemical resistance. For some chemical/material combinations, however, increasing the immersion temperature to 50°C produced a different response from the FML, instead of an accelerated response. An elevated temperature may provide a test that is too aggressive for some FMLs to simulate anticipated use (e.g., elastomers).
- Not all materials are suitable for service at 50°C. Heat degradation is an important consideration in conjunction with chemical resistance.
- Water is sometimes an aggressive medium in itself, especially in conjunction with an elevated temperature. The effect of water alone on an FML must be evaluated when evaluating chemical resistance.
- Increasing the concentration of organic solvents in water solution in general increased the magnitude of the FML response (physical changes).
- Weight change is a valuable indicator of material change for all FMLs tested.
- The proposed criteria for chemical resistance of the FMLs tested in this project generally agree with ratings given in existing chemical resistance tables. The criteria may possibly be expanded to evaluate immersion data for USEPA Method 9090.
- Chemical resistance criteria for the six materials tested are shown in Table 1.

Recommendations

- Immersion testing of a liner in the waste it is intended to contain is essential for determining chemical resistance. Low concentrations of some chemicals can cause more significant change in FML physical properties than higher concentrations of othr chemicals. Testing only with major constituents would not be satisfactory.
- The proposed method of determining stability may be useful in determining longevity of service based on chemical resistance, and also for comparing FMLs for relative suitability for waste containment.
- Minimum as-received property values listed in NSF Standard 54 for Flexible Membrane Liners can be useful as benchmarks in evaluating chemical resistance test results.
- Compatibility tables can best be used to screen FMLs to identify possibly incompatible combinations. However, compatibility tables are limited because materials are usually rated qualitatively: (good, fair, poor) and the test conditions used to determine resistance are not always detailed.
- Generalizations about the criteria and chemical immersion responses of the FMLs tested in the project

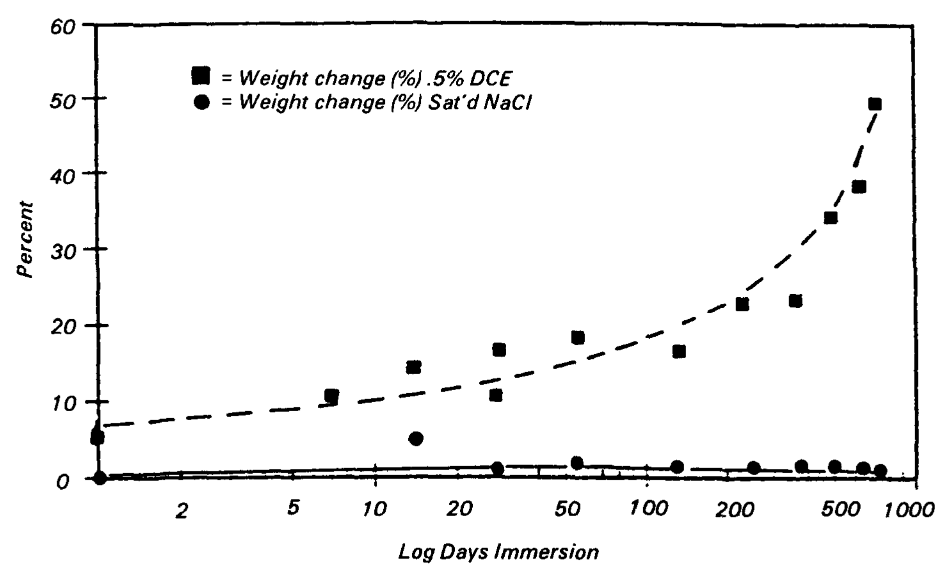

Figure 1. PVC in brine and 0.5 percent DCE.

Table 1. *Criteria for Determining FML Chemical Resistance*

Criteria	Material Type PVC (Plasticized Thermoplastic)	Material Type CPE* (Thermoplastic)	Material Type HDPE (Partially Crystalline)	Material Type EPDM ("Non-polar" Cross-linked Rubber)	Material Type EPI-CO ("Polar" Cross-Linked Rubber)	Material Type CSPE-LW (Vulcanized Rubber)
Stability	Yes	Yes	Yes	Yes	Yes	Yes
Weight gain Stability	-10% ≤ Wt. change ≤ 5%	≤ 25%	≤ 3%	≤ 30%	≤ 20%	≤ 5%
Breaking Factor	≥ 80% of initial and ≥ NSF Std. 54	≥ 75% of initial and ≥ NSF Std. 54	≥ 80% of initial and ≥ NSF Std. 54	≥ 80% of initial and ≥ NSF Std. 54	≥ 80% of initial and ≥ NSF Std. 54	≥ 80% of initial
% Elongation at Break	≥ 70% of initial and ≥ NSF Std. 54	——	≥ 80% of initial and ≥ NSF Std. 54	≥ 75% of initial and ≥ NSF Std. 54	≥ 70% of initial and ≥ NSF Std. 54	≥ 125% of initial
Yield Strength	——	——	≥ 80% of initial and ≥ NSF Std. 54	——	——	——
% Elongation at Yield	——	——	≥ 80% of initial and ≥ NSF Std. 54	——	——	——
Tear Resistance	——	≥ 70% of initial and ≥ NSF Std. 54	≥ 80% of initial and ≥ NSF Std. 54	——	——	≥ 80% of Initial
Modulus of Elasticity	——	——	≥ 70% of initial and ≥ NSF Std. 54	——	——	——
S-100 Modulus	60% < S-100 Modulus < 140%	≥ 70% of initial and ≥ NSF Std. 54	——	——	——	≥ 70% of Initial

* *All criteria for 23 C immersion tests*

must be made with caution. Similar liner materials (such as two polar elastomers) may be expected to respond similarly, but the degree of the response (amount of property change) may change with different formulation and fabrication techniques.

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***Mary Ann Curran** is the EPA Project Officer (see below).*

The complete report, entitled "Development of Chemical Compatibility Criteria for Assessing Flexible Membrane Liners," (Order No. PB 87-227 310/AS; Cost: $42.95, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Officer can be contacted at:

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