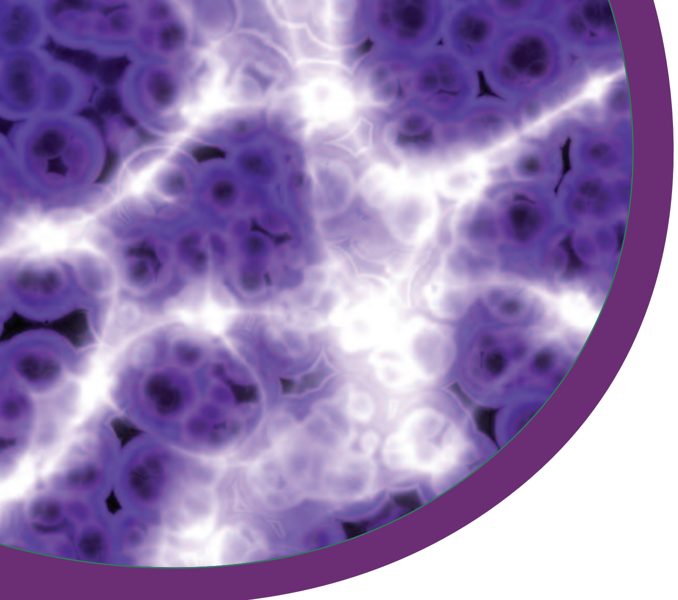

HDPE - a Hydrocarbon Resistant Membrane?

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Most brownfield development and environmental protection specifications require hydrocarbon resistant membranes; however, the majority of products claiming to be 'hydrocarbon resistant' may not be...

Many 'hydrocarbon resistant' membrane products are merely HDPE and Richard Menage, Technical Director of ITP Ltd, the York based manufacturer of barrier fabrics for chemical protective garments and chemical resistant membranes, believes that the use of this material may not be adequate because, whilst HDPE passes the current tests for chemical resistance, permeability tests show that it is readily permeable to hydrocarbons and other environmental contaminants. ITP has therefore developed a new type of membrane, 'Puraflex', which overcomes the risks associated with HDPE, polypropylene and other homogenous monopolymer membranes.

Polyethylene was synthesised by ICI in Northwich in the 1930s but the process was transferred to the United States during World War II as a security measure so that it could be utilised in the cables of radar sets. Large-scale commercial development took place in the United States after the war and since then polythene has become a part of our everyday life with many uses across a wide range of industries.

Its high-density variant, HDPE, is impermeable to water and passes 'chemical resistance' tests because it maintains its physical strength and tensile capabilities when exposed to many chemicals. As a result, for the last 30 years, HDPE has been widely employed in both landfill and construction applications.

Geosynthetic membranes are used for environmental protection applications as containment or separation layers to prevent contaminants spreading to a receptor. For example, to prevent pollution from spreading into watercourses and aquifers and to act as a barrier so that harmful chemicals cannot pass to a receptor. They are also used as gas barriers under buildings to prevent the ingress of harmful vapours and gases.

However new technologies and new permeation test methods have highlighted the limitations of HDPE and other polymer membranes in some installations; particularly those for which soil analysis confirms the presence of hydrocarbon contaminants.

The problem with HDPE

To be an effective barrier, it is necessary for that barrier to not just maintain its physical integrity when exposed to chemicals, but to also perform as a barrier. Whilst chemical resistance tests provide a measure of resilience, the measure of barrier performance is the permeation rate. This is where HDPE fails as a hydrocarbon resistant barrier because polyethylene and other common homogeneous geosynthetic membrane materials are readily permeable to hydrocarbons, because they are hydrocarbons themselves.

To illustrate this, permeation tests in Fig 1 show that a common hydrocarbon contaminant, ethyl benzene, permeates through 500μm HDPE at 136 ml per square metre per day. Putting this in context, for every square metre of membrane, 16,000ml of ethyl benzene permeates through a thicker 1.5mm HDPE membrane every year.

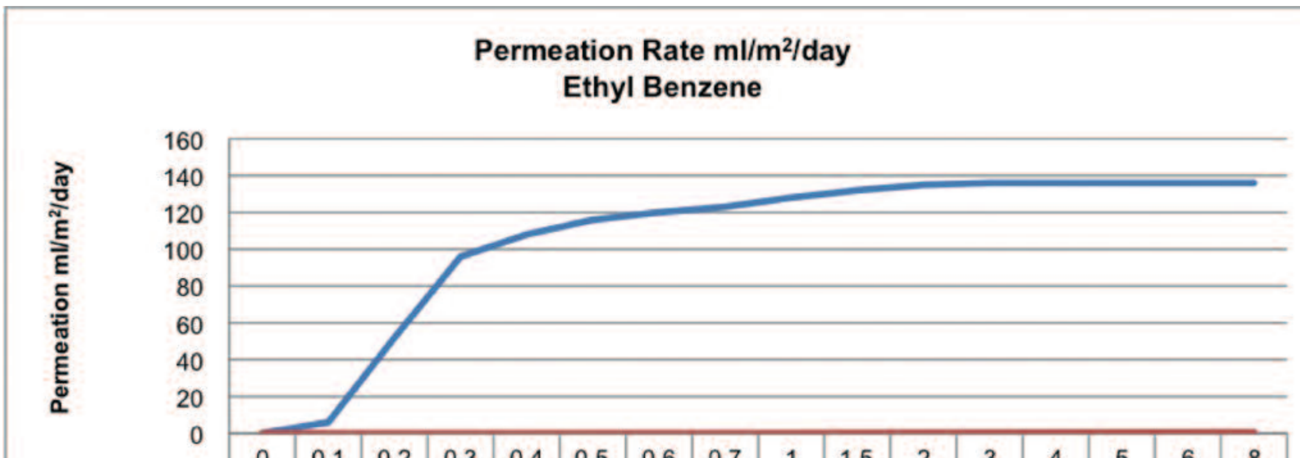
By comparison, as the graph also shows, this compares to 0.52 ml per square metre per day with Puraflex®, with only 200ml permeating through Puraflex® per year.

This highlights the shortcomings of current industry standard chemical resistant tests. Whilst HDPE may pass a chemical resistant test, it is not a good barrier since ethyl benzene readily permeates through HDPE. Therefore for environmental protection applications HDPE carries inherent risks.

Chemical Resistance Test Methods

Current industry standards for chemical resistance measure the physical changes to a membrane after exposure to a challenge chemical. The American ASTM D5322 is a widely recognised test method for chemical resistance and is incorporated within the EPA Method 9090 and ASTM D5747. The European test method procedures for EN BS 14414 & EN BS 14415 are virtually identical to ASTM D5322, the main difference being that the EN Standards define a fixed test period of 56 days, whilst the ASTM Standard allows the manufacturer to determine the duration of the test period. The test procedure involves the immersion of a sample of membrane in the challenge chemical at an elevated temperature of 50 °C for the test period after which it is inspected. Thickness, weight, tensile strength and elongation are then compared with a control sample and providing variations are within 25% of the control sample test results, the membrane is considered 'chemical resistant'.

EN BS 14414 Method C is the relevant immersion test for hydrocarbons. This single immersion test comprises a challenge solution cocktail of 35% diesel fuel, 35% paraffin and 30% lubricating oil. The value of such a test to a design engineer is limited since the test does not report on individual constituent hydrocarbons, and the cocktail is comprised of many chemical species, in different and variable ratios. In comparison with BTEX this cocktail is relatively non-challenging towards HDPE for two reasons. First, BTEX in measures of 'likeness' is more like HDPE than this cocktail so BTEX is a more aggressive solvent. Second, smaller molecules such as BTEX are much more aggressive in attacking polymers and permeating through them than the larger oil molecules of the cocktail used in the test.



	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	1	1.5	2	3	4	5	6	8
HDPE	0	6	52	96	108	116	120	123	128	132	135	136	136	136	136	136
Puraflex	0	0	0	0	0	0.02	0.04	0.06	0.11	0.21	0.29	0.35	0.4	0.45	0.5	0.52

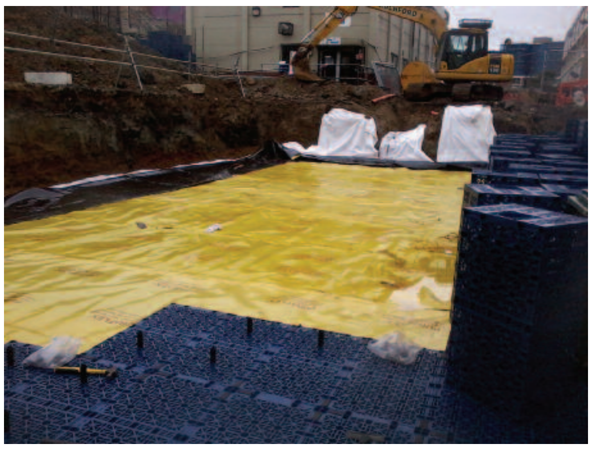
Figure 1: Ethyl Benzene Permeation

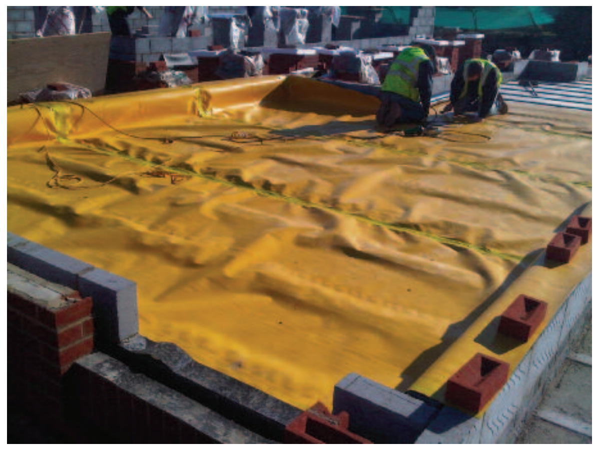
Environmental risk

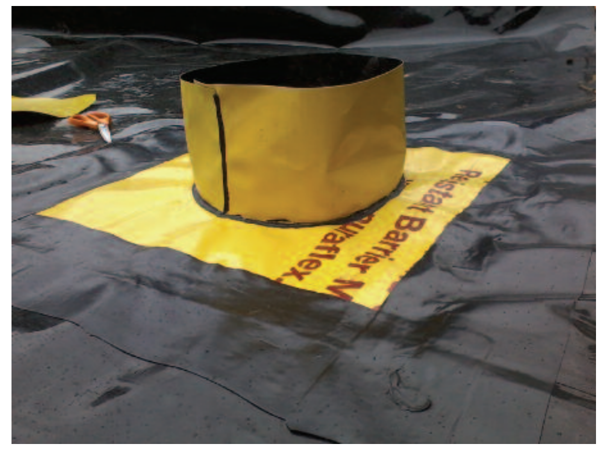
It is clear that material chemical resistance data does not provide sufficient information in the selection of appropriate barrier material. Permeation data needs to be considered to determine whether the material is fit for purpose, particularly if hydrocarbons have been identified in the soil analysis.

In the UK, land is only considered to be 'contaminated land' in a legal sense if it poses an unacceptable risk. Since the Environmental Protection Act 1990 was introduced, tens of thousands of hectares of affected land have been dealt with; the majority being addressed when brownfield land is redeveloped within the planning regulations. This risk based approach has therefore proved very successful and will be retained in the revision of contaminated land statutory guidance which commences in April 2012.

Part IIA of the Environmental Protection Act 1990 sets the minimum standard for contamination when land is redeveloped (as a minimum, sites must not qualify as







contaminated land once they have been developed). The Act also requires local authorities to find contaminated land and to ensure 'reasonable' remediation is undertaken, and to decide who will pay. The idea is that the polluter should pay, followed by the current owner and in cases where no one else can be found to pay, the authority may take action itself.

Clearly, environmental risk assessments have a vital role to perform, but the accuracy of such assessments and modelling predictions must take account of chemical permeability where a barrier is specified to provide protection from current or possible future contamination.

To assist the assessment of risk, the Environment Agency's Contaminated Land Exposure Assessment (CLEA) model provides assumptions about the movement of chemicals and contaminants in the environment and thus human exposure to soil contaminants. Soil Guideline Values (SGVs) are derived using the CLEA model by comparing estimated exposure with Health Criteria Values (HCVs) that represent a tolerable or minimal risk to health from exposure to contaminants. SGVs represent trigger values above which soil concentrations may pose a risk.

New membrane technology – hydrocarbon and chemical resistant

Puraflex® is a new chemical resistant barrier membrane material specifically developed for its resistance to hydrocarbons and toxic industrial chemicals. Typically, the installed cost of Puraflex® is up to 20% more than HDPE, but this is heavily outweighed by substantially lower levels of risk.

Installed using conventional thermal welding equipment, Puraflex® is classed as a GBR-P polymeric geosynthetic barrier for covered installations and specified for contaminated land and environmental applications.

Permeation is influenced by a chemical's polarity - 'like is soluble in like' and since both are non-polar, hydrocarbons permeate readily through HDPE.

Employing patented technology, Puraflex® incorporates a multilayer structure incorporating both polar and non-polar polymers. The outer layers of the Puraflex® barrier comprise non-polar polymers with a polar core sandwiched in the middle. It is this polar core that provides the effective barrier to hydrocarbons and other non-polar chemicals.

The Puraflex® design ensures that it has exceptional barrier performance to a wider spectrum of environmental contaminants and pollutants including hydrocarbons, industrial chemicals, toxic waste, and natural and radioactive gases. Comprehensive Chemical Resistance data is available for over 200 hydrocarbons and toxic chemicals.

In Fig. 2 below it can be seen that HDPE is a homogenous non-polar membrane, which is permeable to non-polar hydrocarbons. In contrast, Puraflex®, as shown in Fig. 3, is a multilayer membrane with a polar core; the region providing the effective barrier to hydrocarbons.

The chart and table in Fig. 4 below give test results for the permeability of a number of common geosynthetic membrane materials against a 100 mg/kg soil contamination of Benzene, Fluorene, Hexane, Methyl Isopropyl Ketone and Vinyl Chloride. It can be seen from the chart that Puraflex® is an effective barrier against all these chemicals, whereas the other membranes have significantly higher permeation rates.

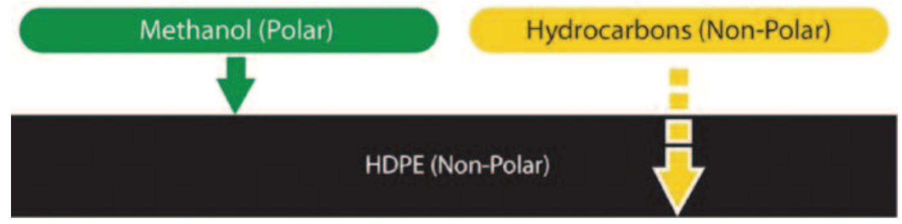


Figure 2: HDPE Menbrane

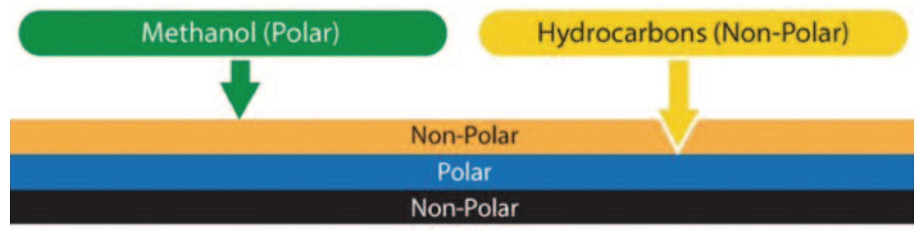


Figure 3: Puraflex® Membrane

Other applications for Puraflex®

In addition to its obvious advantages in the management of contaminated land, Puraflex® is also used for secondary containment in petrochemical and industrial plants.

With low permeability to both gases and vapours, Puraflex® is also used to protect buildings from the ingress of hydrocarbon vapours, methane, radon, carbon dioxide and carbon monoxide. Some gas barrier membranes incorporate an Aluminium foil for this purpose, but these materials are susceptible to delamination when exposed to hydrocarbons and oxidation when exposed to acidic soil moisture.

Used on many civil engineering and groundwork projects, Expanded Polystyrene (EPS) is a cost-effective fill material in structural load bearing installations. Since EPS is vulnerable to attack from hydrocarbon vapours and liquids, it is often protected by encapsulation with Puraflex®.

Puraflex® is also used for groundwater protection applications. It is normally installed as a trench liner to protect rivers and water courses and as a liner for water channels.

A self-adhesive version is available for tanking, foundations, tunnels and other structures.

Summary

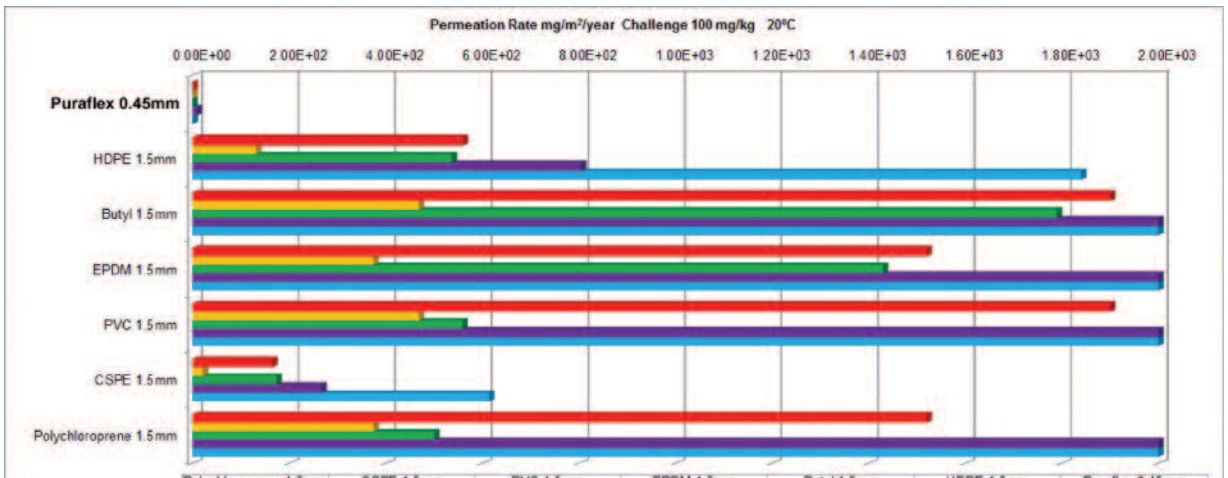
It is important to make the distinction between a membrane being resilient to hydrocarbons and a membrane being effective as a barrier to permeation. The specification: 'a hydrocarbon resistant barrier shall be installed' needs to be more specific because without measurable permeation data, the membrane may not be fit for purpose, failing to adequately contain contamination and posing an unacceptable risk with the potential to incur substantial environmental and financial costs.

Permeation software

Permeation rates for each contaminant are also affected by site-specific conditions, particularly soil temperature and soil moisture conditions. Therefore ITP has developed a software programme specifically to meet the needs of environmental consultants and design engineers. Calibrated by extensive absorption and permeation tests, Puraflex® Permeation Modeller is a powerful and effective program that calculates site-specific permeation rates for soil contaminants.

Following soil analysis, contaminant concentrations are uploaded into the program, key variables directly influencing contaminant permeation rates (soil temperature, soil moisture content, soil density etc.) are entered and the software then calculates project-specific permeation rates. Using the appropriate soil densities, the standard (free) software also calculates the permeated data in mg/kg/year for importing directly into environmental risk assessment modelling software programs such as the Environment Agency's CLEA Model.

In addition, a software upgrade ('Professional' version) is available which calculates vapour migration in g/cc and μm/m[3].



	Polychloroprene 1.5mm	CSPE 1.5mm	PVC 1.5mm	EPDM 1.5mm	Butyl 1.5mm	HDPE 1.5mm	Puraflex 0.45mm
Benzene	1.52E+03	1.65E+02	1.90E+03	1.52E+03	1.90E+03	5.60E+02	3.52E-04
Fluorene	3.75E+02	2.17E+01	4.69E+02	3.75E+02	4.69E+02	1.32E+02	3.23E-06
Hexane	5.01E+02	1.74E+02	5.59E+02	1.43E+03	1.79E+03	5.37E+02	1.56E-06
Methyl Isopropyl Ketone	2.15E+03	2.67E+02	2.68E+03	2.15E+03	2.68E+03	8.05E+02	9.43E+00
Vinyl Chloride	4.92E+03	6.14E+02	6.15E+03	4.92E+03	6.15E+03	1.84E+03	1.67E-01

Figure 4: Permeation rates for Puraflex® in comparison with other barrier materials