

# Gas membranes and “compliance” with BS8485

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This information sheet looks at whether a gas membrane can comply with BS8485. It is the responsibility of the designer to select a suitable gas membrane for a particular site taking into account the project specific factors. The designer should be appropriately qualified and must also justify the choice of membrane in a design report. A membrane cannot “achieve compliance with BS8485” since BS8485 is not a material specification. The sheet discusses the information that designers require to allow an appropriate choice of membrane. It also discusses the influence of plunger size on puncture and impact tests and the effect of cement on corrosion in aluminium foil membranes.

## Introduction

Some gas membrane suppliers claim that their membranes “comply” with BS8485 (BSI 2015b and 2019). This information sheet looks at whether these claims stack up when considered against the gas membrane selection guidance provided in BS8485.

First of all we must consider what BS8485 is intended to be. It is not a material specification and indeed it states this in the foreword: *“As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.”*

*Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.”*

British Standard Specifications are highly prescriptive standards setting out detailed absolute requirements. They are commonly used for product safety purposes or for other applications where a high degree of certainty and assurance is required by the user community. There is no British Standard Specification for gas resistant membranes and BS8485 does not purport to be one.

British Standard Methods are also highly prescriptive, setting out an agreed way of measuring, testing or specifying what is reliably repeatable in different circumstances and places, wherever it needs to be applied.

British Standard Codes of Practice, such as BS8485, recommend sound good practice is undertaken by competent and conscientious practitioners. They are drafted to incorporate a degree of flexibility in application, whilst offering reliable indicative benchmarks. They are commonly used in the construction and civil engineering industries.

Finally, British Standard Guides are published to give less prescriptive advice which reflects the current thinking and practice amongst experts in a particular subject.

### Claims of “compliance” with BS8485

It is the responsibility of the designer to specify an appropriate gas membrane for a site, taking account of site specific factors. The guidance in BS8485 indicates that the designer must assess any membrane by all the criteria stated in the standard for the specific circumstances of each site. It is not appropriate to claim compliance just because it meets a few selected criteria for membrane properties.

A full assessment following the guidance in BS8485 requires the supplier to provide the designer with all the necessary information on the properties of the membrane deemed to be important on a site-specific basis (e.g. puncture and impact resistance values using an appropriate test method that represents site conditions/causes of damage).

### Competent person

The first thing to consider is whether the person claiming compliance is appropriately qualified and experienced in ground gas risk assessment and mitigation design. The Foreword to BS8485 states *“It has been assumed in the preparation of this British Standard that the execution of*

*its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced”*.

In the USA it is a common requirement for any gas protection design to be signed off by Licensed Professional Engineer. In Australia, many design and membrane installations are overseen by a regulator-appointed Auditor. In the UK an equivalent level of professional would be a Chartered Engineer, Chartered Geologist, Specialist in Land Conditions (SiLC), SoBRA accredited risk assessor or similar with suitable experience and knowledge of risk assessment and factors that affect gas flow from the ground. Chartered professionals will have to comply with a code of professional conduct and have been scrutinised by their peers to assess their competence.

The specification of a gas membrane should be the responsibility of the gas protection designer (who meets one of the above criteria). It should not be left to suppliers or installers, unless they are suitably qualified and are specifically appointed under a contract to be the designer of the system and are covered by professional indemnity insurance.

In short there is no ‘one size fits all’ for BS8485. It is guidance that is intended to make designers think about assessing that not only is a product suitable for the intended application, but also can it be installed to form a continuous barrier to gas that is designed to last for the lifetime of the structure.

### Guidance on gas membranes

Guidance on specifying the properties of a gas membrane is provided in Clause 7.2.4 and Table 7 of BS8485 (BSI 2019). Gas resistant membranes should be:

- Sufficiently impervious, both in the sheet material and in the sealing of sheets and sealing around sheet penetrations, to prevent any significant passage of methane and/or carbon dioxide through the membrane;

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- Capable after installation of providing a complete barrier to the entry of the relevant gas.
- Sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions;
- Sufficiently strong to withstand in service stresses (e.g. due to ground settlement if placed below a floor slab);
- Sufficiently strong to withstand the installation process and following construction activities until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, and dropping tools);
- Chemically resistant to degradation by other contaminants that might be present; and
- Verified in accordance with CIRIA C735.

It is worthwhile at this point considering durability and resistance to damage a little further at this point and comparing membranes used in the gas protection with those used for similar purposes. In roof waterproofing single ply membranes are typically 1.5mm to 3mm thick (even when not exposed to UV light under green and blue roof construction). In basement waterproofing membranes are typically 0.8mm thick or more. Damp proof courses used in walls (DPC) are typically 0.5mm or 0.6mm thick because they need to resist damage.

Why then do we allow the use of gas membranes that are only 0.3mm thick in some cases and very prone to puncture compared to those used in other parts of building construction? Could it be that waterproofing membranes are typically guaranteed by the installers? Would this improve the quality of gas membrane designs if clients asked for guarantees?

### Gas Transmission Rate

There is often a complete focus on the gas transmission rate of gas membranes to the exclusion of all other considerations. This is the underlying basis for claims that aluminium foil membranes are better than other types of materials or membranes (which they are not).

The note to Clause 7.2.4 states that “*a methane gas transmission rate of <40.0ml/day/m/atm (average) for sheet and joints (tested in accordance with the manometric method in BS ISO 15105-1:2007) is usually considered sufficient*”. There is a similar note to Table 7. Therefore, if a designer considers it is appropriate, given the conditions in which the membrane will be used, a greater gas transmission rate may be acceptable.

The maximum Gas Transmission Rate (GTR) that is appropriate depends on the reliance that is placed on the membrane to prevent gas ingress and the gas regime itself. BS8485 suggests a maximum value of 40ml/m<sup>2</sup>/day/atm. This applies where the membrane can be used in any Characteristic Situation and it is feasible that the membrane will be the only protection against gas ingress. Therefore, a low value of GTR is necessary.

Where membranes are used together with a reinforced concrete barrier, (e.g. membranes that are used in conjunction with a raft foundation or waterproof concrete construction), there is less reliance on the membrane. Concrete has a low gas permeability and flow only occurs in significant quantities at defects or cracks in the concrete that pass through the whole depth of the concrete. The area for gas migration is very small and the allowable GTR for a membrane used in this situation may be increased.

### Specification of a gas membrane

BS8485 goes on to state “*There are many gas resistant membrane types available and membrane choice should be made according to the resistance of the material to the passage of the challenge gas and the resistance to site damage during and after installation in the designed position. The designer specifying the membrane should consider the combination of a particular membrane’s properties to assess whether it is suitable in any given situation. The specified membrane and the reasons for its selection should be described in the design stage report*”.

In order to assess a membrane against the guidance in BS8485 to determine if it is suitable for a particular

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application all of the factors listed earlier must be assessed, not just the thickness, unit weight and gas transmission rate against the values in Table 7. Tensile strength, elongation, impact, puncture and tear resistance are of particular importance when assessing the ability to withstand construction and there are no limiting values specified for these parameters. It is down to the designer to choose appropriate values for a particular application.

It is important to note that the designer of the gas protection system should specify and justify the reasons for the choice of membrane and record this in the design report. If the supplier of the membrane is to be the designer of the system, or reliance is to be placed on their advice, it is important that they are under a contract for design services. Otherwise all they are offering is advice for consideration by the designer who will ultimately be liable for the membrane specification.

Any statements about puncture resistance, durability, etc made by suppliers must be supported by evidence in the form of results that are appropriate to the type of installation. For example, the requirements for a membrane to be used below a cast in situ slab with reinforcement (Figure 1) will require a high puncture resistance from a suitable test method and is also likely to require a protection layer above it. Designers also need to be clear what the stated values are (minimum or mean average roll value). ASTM D4759-11 suggests that the designer or specifier obtain the mean, standard deviation, and/or the coefficient of variation for given physical/mechanical properties of a product directly from the manufacturer. For example, if a membrane has a mean thickness of 0.4mm the actual value will vary above and below this. If the application requires a minimum thickness of 0.4mm the membrane is not suitable.

**Membranes thickness**

Thickness is one indicator of robustness. However, care must be taken in blanket application of this parameter. For any given material the thicker the membrane, the greater the puncture and tear resistance will be.

However, if two membranes are the same thickness but are made from different materials, they may have different puncture and tear resistance. Therefore, compliance with the minimum thickness requirement in the notes to Table 7 is not a guarantee of sufficient robustness. It is a bare minimum requirement for virgin LDPE membranes that are installed above a floor slab, are well protected from damage immediately after installation and will not be subject to excessive stress/strain when in service.



**Figure 1 Membrane installation below steel reinforcement is subject to high puncture forces**

It is also important that, where reinforcing scrims (grids) are part of the membrane construction, the thickness is measured in between the scrim. This is because puncture normally occurs in the membrane by thin sharp objects (see later in this information sheet). The thickness measured over the scrim is often significantly thicker than the actual membrane material and just stating the value at the scrim is misleading for designers.

Figure 2 shows the thicknesses of membrane samples taken randomly from various sites. In two out of three cases for the scrim reinforced membranes (R-1 to R-3) the actual membrane material thickness is less than the claimed value on the data sheets, in one case by half. The coated tape membrane had the same thickness as claimed.

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The latest version of BS8485 (BSI 2019) recommends that the thickness is measured in accordance with BS EN ISO 9863-1: 2016 using a 2mm diameter tip in between the reinforcing scrim.

Another consideration of thickness is the impact it may have on the installation. The thicker the membrane the stiffer it becomes (for the same material). This can make it more difficult to install, especially around complicated foundation details. The more difficult the membrane is to install, the more likely that there will be defects in site welds or details.

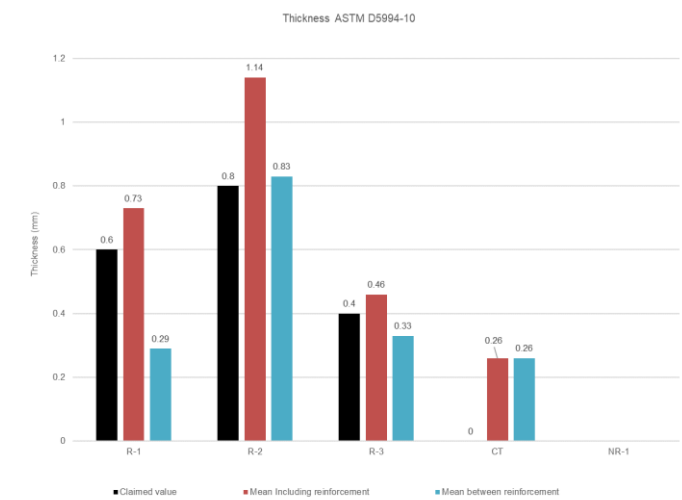
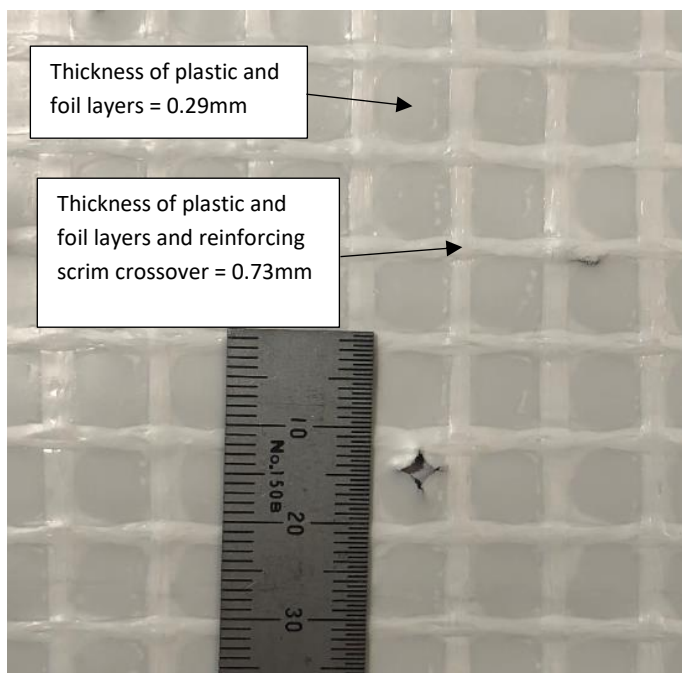


Figure 2 Comparison of measured with claimed thickness

Puncture resistance and puncturing of gas membranes on site

Small sharp objects are the most likely things to cause damage to a membrane after it has been installed and verified. A significant concern is steel reinforcement in floor slabs and screeds (Figure 3). Figure 4 shows steel fibres from fibre reinforced screed and how they have punctured the underlying membrane, which is quite robust with a reasonable puncture resistance (84N when tested to ASTM F1306 and it is 0.5mm thick). It also has a puncture resistance of >20kg when tested in accordance with BS EN 12730. However, the latter test method does not replicate the small sharp objects that have punctured the membrane on this site (the tests uses a 10mm diameter ball with the membrane supported on a hard surface).

Any membrane used below a fibre reinforced slab or screed should be protected by a geotextile protection layer (for example, a non woven geotextile of at least 300g/m<sup>2</sup> weight - performance value with a tolerance of +/- 20% tested to EN ISO 9864).

The same damage occurs with reinforcement mats and cages in concrete, mainly from the ties that hold the cages or reinforcement together. Again protection would be required in these situations.



Figure 3 Steel fibres used to reinforce floor screeds and concrete



### Puncture resistance and test methods

Designers require information about the puncture resistance of membranes to allow them to make an informed choice. Unfortunately, the membrane suppliers make an informed choice difficult because they either do not provide the test values or they use different test methods so the results are not directly comparable.

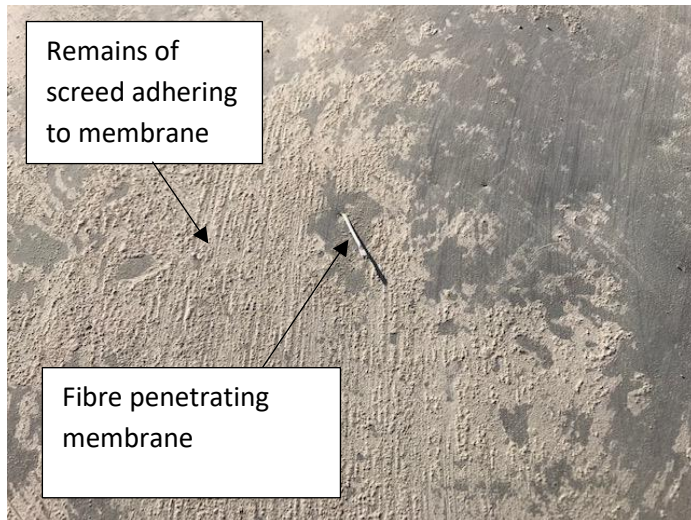


Figure 4 Membrane penetrated by fibres

There are several different puncture test methods that can be adopted and each uses a different plunger size (Figure 5):

- ASTM D4833 – plunger diameter 8mm +/- 0.1mm;
- BS EN ISO 12236 – plunger diameter 50mm +/- 0.5mm;
- ASTM F1306 – plunger diameter 3.2mm +/- 0.1mm;
- BS EN 12730 – plunger diameter 10mm +/- 0.05mm ball.

Clearly a reinforced membrane with a closely spaced scrim is going to appear to have a high puncture resistance if tested with a 50mm diameter plunger, when it may have very poor resistance to puncture by sharp or narrow objects (such as fibre reinforcement – Figure 3) in between the scrim. This has been confirmed by testing (Figure 6). The results show that reinforced membranes

appear to have increased puncture resistance with increased thickness.

The results for puncture resistance using various test methods and plunger diameters are shown on Figures 6, 7 and 8. The results for the three reinforced aluminium foil membranes are presented alongside those for a 0.5mm thick unreinforced membrane (a multi laminate polyethylene/EVOH VOC membrane) and a coated tape foil membrane.

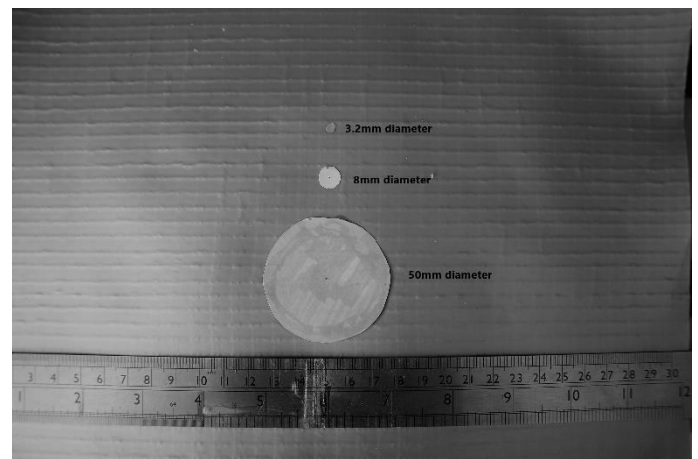


Figure 5 Plunger sizes compared to scrim spacing of a gas membrane

This test (with a 50mm diameter plunger) suggests that reinforced membrane 2 (0.83mm thick) and the coated tape membrane have higher penetration resistance than the non-reinforced membrane. The two thinner reinforced membranes have a penetration resistance that is about 22% to 24% lower than the non-reinforced membrane.

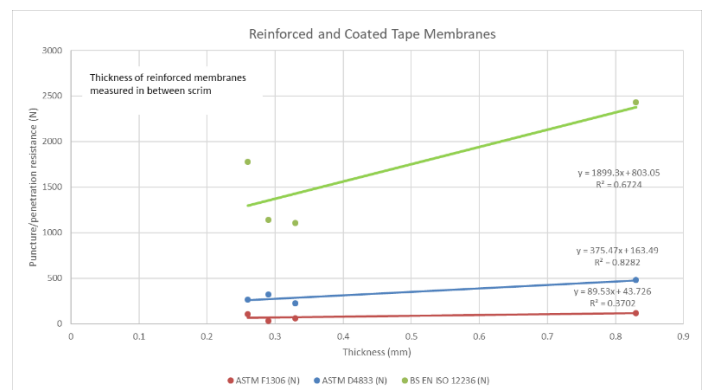


Figure 6 Puncture resistance vs thickness with various test methods

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The results from the D4833 tests (8mm dia plunger) suggest that the reinforced foil membranes and coated tape all have puncture resistance greater than the unreinforced membrane.

However, the tests following ASTM F1306 (3.2mm dia plunger) show a different picture with the two thinner reinforced membranes (1 and 3) showing much lower resistance than the unreinforced sample. This is because the plunger passes between the reinforcement scrim, a much more realistic test when considering the type of damage that occurs to these membranes on site from small diameter sharp objects.

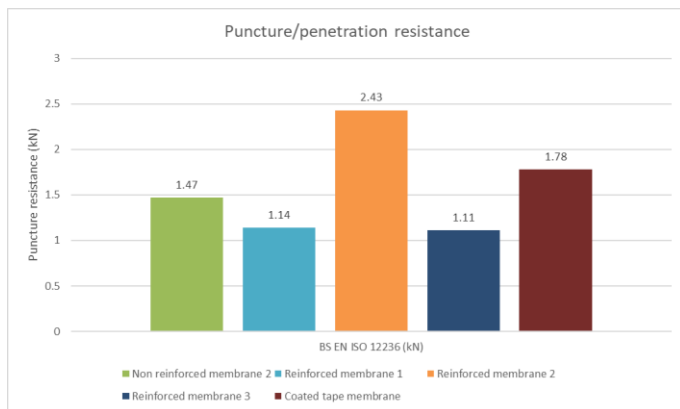


Figure 7 Results from BS EN ISO 12236.

The coated tape membrane has a resistance that is only 11% lower than the thickest reinforced membrane, which is over three times thicker (3.2x). This is consistent with evidence from site inspections which indicates that the coated tape membrane is less prone to damage than the thin scrim reinforced membranes.

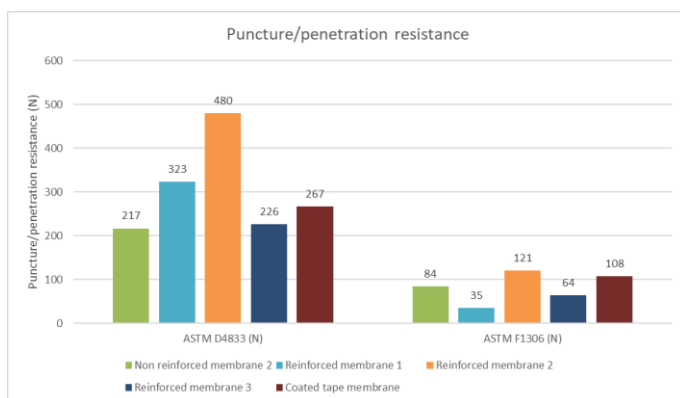


Figure 8 Results for ASTM D4833 and F1306 tests

The results of impact tests to BS EN 12692 are provided in Figure 9. The test uses a 500g weight with a 12.7mm (+/-0.1mm) diameter ball that is dropped onto the membrane. The test results from the BS EN 12691 test simply state a height in mm. If a membrane has a test value of 200mm then it can withstand the mass being dropped from a height of 200mm without puncture. A small hammer typically used on site weighs just over the 500g used in the test.

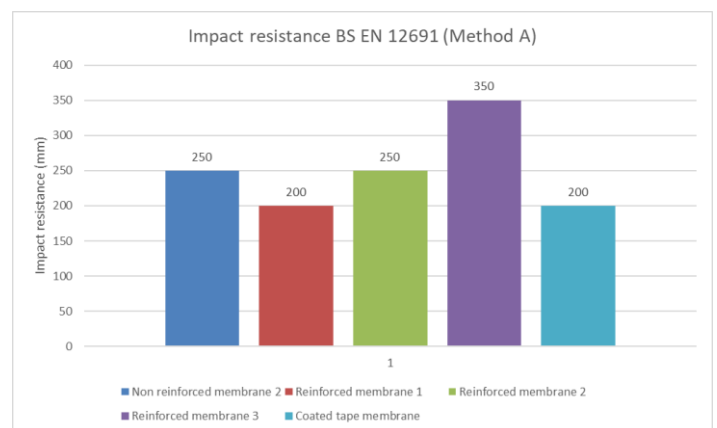


Figure 9 Results for BS EN 12691 impact test

The maximum height that any of the membranes can withstand the impact from the 500g weight at without damage is 350mm. Therefore, none of the membranes tested are particularly robust against site damage during following construction. It is quite feasible that a small hammer or similar could be dropped onto a membrane from at least 800mm height (the height of the author’s hand when at his side).

To put the puncture test results into context membranes have been tested using a simple puncture/impact test. The test comprises dropping a screwdriver (136g) and a pair of scissors (83g) onto the membrane when it is placed on a hard and a soft surface. The screwdriver and scissors were chosen to represent objects that could be dropped onto a membrane on site that are quite light.

The non reinforced membrane 2, reinforced membranes 1 to 3 along with a waterproof membrane and a 1mm HDPE membrane (both of which have a gas transmission rate greater than 40ml/day/m<sup>2</sup>/atm) have been tested using the screwdriver and scissors (Figure 10). The results are summarised in Table 1.





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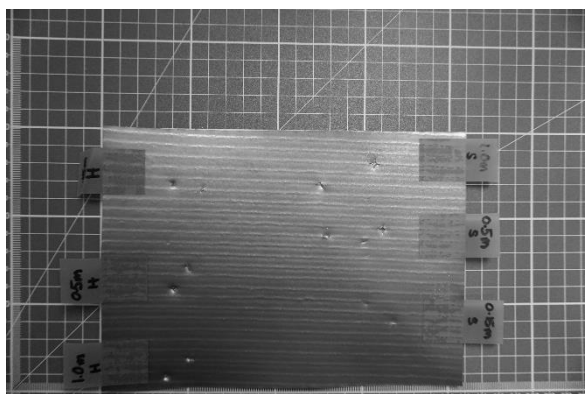
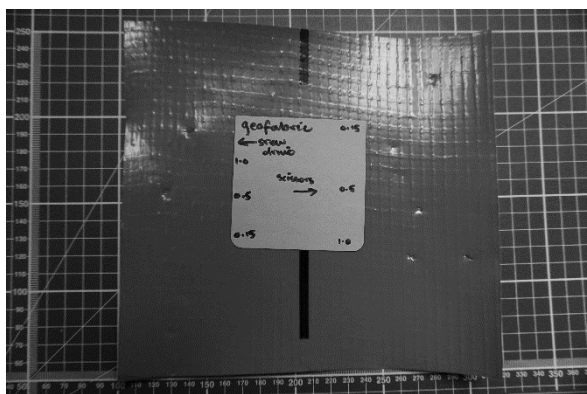


Figure 12 Results of simple puncture tests on reinforced aluminium foil membranes

to identify holes that are only found on one side of the membrane through the thin layer of LDPE (Mallett et al, 2014). These partial defects are unlikely to be found and repaired unless tested for, resulting in exposure of the thin aluminium layer.

Cement used to construct floor slabs and screeds is alkaline when placed (wet) with a pH >12.5 (Grubb et al, 2007) and in these initial conditions any exposed aluminium may be corroded.

Tests have shown that small nicks in the very thin plastic sheet that protects the foil will lead to corrosion of the membrane (Figure 13). This is caused by the alkaline conditions.

Protection of the membrane with a thick protective geotextile fleece (300g/m<sup>2</sup> non woven) to minimise contact with the wet cement appears to be one way to minimise this effect.

Thus foil membranes are not better than others, especially in applications where they are exposed to puncture damage or to contact with wet cement.

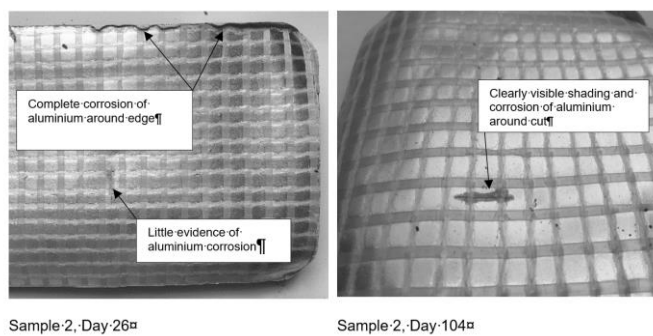


Figure 13 Corrosion of foil membrane in contact with cement

Compliance with BS8485 – complete assessment

An example assessment has been made to compare the suitability of two different types of membrane considered for use below a cast in situ reinforced concrete floor slab, where it will be exposed to construction workers installing the reinforcement and the concrete pour. It is located above the sub-base for the slab and will not be

Corrosion of aluminium foil membranes

Damage can easily be caused to the thin aluminium foil membranes, especially the extremely thin plastic layer that protects some foils (which can be as thin as 0.15mm). In addition, the membrane sheet edges can be left exposed and dielectric porosity testing has been known

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exposed to aggressive substances. Settlement of the ground below the slab may occur up to 200mm. One membrane has a gas transmission rate less than the suggested value in Table 7 and one has a higher value. The assessment is summarised in Table 2.

The example shows that in this situation a thicker more robust membrane that has a higher GTR is suitable whereas the thin one is not, even though the GTR is less than 40ml/day/m<sup>2</sup>/atm and it is not significantly less than 0.4mm thick. If settlement was not a concern the thinner membrane would be suitable, but would require protection from a geotextile or other layer with adequate puncture resistance (for example sometimes insulation boards can be used to provide protection).

In situations above a block and beam floor slab the 0.4mm thick membrane may be suitable if it is protected from damage by follow on trades after installation.

**Methane permeability coefficient vs gas transmission rate**

BS8485 provides guidance on a suitable value of gas transmission rate. Suppliers data sheets sometimes incorrectly use other terminology such as methane permeability. It is important to check that the value quoted is the gas transmission rate.

$$GTR = P/d$$

GTR = gas transmission rate (ml/m<sup>2</sup>/day/atm)

P = methane gas permeability (ml.mm/(m<sup>2</sup>.day.atm))

d = thickness (m)

The methane gas permeability is also known as the coefficient of methane gas permeability. For membranes less than 1mm thick the GTR will less than the gas permeability.

**Table 1 Summary of results for simple impact test**

Membrane	Membrane support	Scissors	Screwdriver
HDPE Smooth 1mm	Soft	No rupture at 1.0m	No rupture at 1.0m
	Hard	Very close to rupture at 1.0m	Very close to rupture at 1.0m
Waterproofing membrane	Soft	No rupture at 1.0m	No rupture at 1.0m
	Hard	Ruptured at 1.0m	Ruptured at 1.0m
Reinforced membrane 1	Soft	Ruptured at 0.15m	Ruptured at 0.15m
	Hard	Ruptured at 0.15m	Ruptured at 0.15m
Reinforced Membrane 2	Soft	Ruptured at 0.5	No rupture at 1.0m
	Hard	Ruptured at 0.5m	Ruptured at 0.5m
Reinforced membrane 3	Soft	Foil ruptured at 0.15m, membrane at 0.5m	Foil ruptured at 0.5m membrane at 1.0m
	Hard	Ruptured at 0.15m	Ruptured at 0.15m
Non reinforced membrane 2	Soft	Ruptured at 0.5m	Very close to rupture at 1.0m
	Hard	Ruptured at 0.5m	Ruptured at 0.5m

**Table 2 Example comparison of membrane suitability**

	Typical scrim reinforced aluminium foil/LDPE membrane 0.4mm thick between scrim	0.75mm thick polymeric membrane with protective/bonding layer
Sufficiently impervious to prevent passage of methane and/or carbon dioxide through the membrane	Acceptable✓ GTR Methane <40ml/day/m2/atm	Acceptable✓ GTR Methane > 40ml/day/m2/ - Greater than the suggested value in BS8485 but when assessed with the crack ratio in the floor slab (in a similar manner to the approach adopted when assessing VOC ingress to buildings), slab thickness, reinforcing design and concrete w/c ratio it is sufficiently impervious

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	Typical scrim reinforced aluminium foil/LDPE membrane 0.4mm thick between scrim	0.75mm thick polymeric membrane with protective/bonding layer
Capable after installation of providing a complete barrier to the entry of the relevant gas	Acceptable✓ Membrane can be sealed effectively if installed by specialist experienced in heat sealing thin plastic layers	Acceptable✓ Membrane can be sealed effectively using wide taped seams and bonded to concrete after construction
Sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions	Not acceptable on its own X Risk of corrosion to aluminium foil from alkaline conditions caused by cement. Adequate protection must be provided (which is actually a requirement of the BBA certificate).	Acceptable✓ The material is sufficiently resistant to puncture from small sharp tools
Sufficiently strong to withstand in service stresses	Not acceptable – X settlement could cause strain in membrane that will tear the foil and significantly increase the GTR methane	Acceptable✓ The membrane is bonded to the concrete and has sufficient strength and elongation such that settlement or movement will not affect the performance
Sufficiently strong to withstand the installation process and following construction activities until covered	Not acceptable on its own X Puncture resistance to small pointed objects is low. BBA certificate indicates it can only withstand foot traffic. Does not comply on its own. Adequate protection must be provided (which is actually a requirement of the BBA certificate).	Acceptable✓ Can withstand impact and puncture to an acceptable level. Still requires adequate supervision on site to prevent damage.
Chemically resistant to contaminants	Acceptable✓ Membrane is not exposed to ground contaminants, but see comment above re exposure to alkaline conditions from concrete	Acceptable✓ Membrane is not exposed to ground contaminants
Verified in accordance with CIRIA C735	Acceptable✓ Installation will be verified in accordance with CIRIA C735	Acceptable✓ Installation will be verified in accordance with CIRIA C735 by the waterproof design consultant

layers and insulation boards. One the of the main ways of providing protection is to use a geotextile layer. Commonly this will be a 300g/m<sup>2</sup> non woven fleece.

However, the overriding requirement for any protection layer should be an adequate puncture resistance to protect the membrane from likely damage. Geotextiles come in various thicknesses and manufacturing methods and if it has less puncture resistance than the material it is protecting there is little point using it. Static puncture and dynamic perforation tests are useful indicators of performance.

A geotextile used for protection of gas membranes should at the very least meet the requirements for the Protection function (P) in one of the harmonised Technical Specifications for geotextiles or geotextile related products (known as application standards, for example BS EN 13257: 2016 for the Characteristics required for use in solid waste disposal). BS EN 13719: 2016 gives an indication of long term protection efficiency for landfill liners but may also be useful in other applications (for example the loads used in the test are similar to loads that might be applied to some protection layers during construction , eg wheel loads from construction vehicles that may run over a protection layer).

Polyethylene terephthalate (PET), commonly called polyester, is used to manufacture some geotextiles. However, the ester group of the PET molecule can be hydrolysed in the presence of water (Geofabrics, undated). Polyester can also be susceptible to heightened degradation where there is lime treated soil, concrete or cement present.

Conclusions

Gas membranes cannot comply with BS8485: 2015 +A1 2019 because it is not a material specification. It provides guidance on what a designer should consider when completing a site specific assessment of the suitability of a gas membrane. This should take account of a number of factors besides methane permeability, thickness and weight. These other factors include puncture and tear resistance and long term durability. It is not acceptable

Protection layers

There a number of ways to protect membranes from damage. The first and foremost requirement is that the membrane is laid on a smooth substrate that supports the membrane without any sharp protrusions that could puncture it. Protection can also be provided by materials including specific protection boards, sand

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to state a membrane can meet these other requirements without providing proof in the form of test certificates for the appropriate properties.

There are many different types and compositions of materials, and the suitability of each, must be assessed on a site by site basis, as opposed to simply completing checks on weight/thickness and GTR and inferring ‘compliance’.

The choice of membrane and reasons for it should be documented in the design report. Various tests are available to measure puncture and impact resistance. The impact of plunger diameter on the tests results from scrim reinforced should be recognised. Some membranes have little resistance to small tools dropped from very low heights. Most membranes will require protection to prevent damage on site.

Aluminium foil membranes are likely to suffer corrosion of the foil if placed in contact with cement where moisture is also likely to be present. This will render them much less effective as gas membranes than other types that do not have foil and consequently, they may have a higher GTR when installed.

## References

ASTM D4226-16. Standard test methods for impact resistance of rigid poly(vinylchloride) (PVC) building products.

ASTM D4833-07 (reapproved 2013). Standard test method for index puncture resistance of geomembrane and related products.

ASTM D5994 / D5994M - 10(2015)e1. Standard Test Method for Measuring Core Thickness of Textured Geomembranes

ASTM F1306- 16. Standard test method for slow rate penetration resistance of flexible barrier films and laminates

BSI (2005) Geosynthetics. Test method for the determination of mass per unit area of geotextiles and geotextile-related products. BS EN ISO 9864

BSI (2006) Flexible sheets for waterproofing – Bitumen, plastic and rubber sheets for waterproofing – Determination of resistance to impact. BS EN 12691: 2006

BSI (2006a) BS EN ISO 12236: 2006. Geosynthetics – static puncture tests (CBR tests)

BSI (2009) BS EN 1849-2:2009. Flexible sheets for waterproofing. Determination of thickness and mass per unit area. Plastic and rubber sheets

BSI (2009) British Standard BS8102: 2009. Code of Practice for Protection of Below Ground Structures Against Water From the Ground.

BSI (2016) BS EN 13257: 2016. Geotextiles and geotextile related products. Characteristics required for use in solid waste disposals.

BSI (2011) British Standard BS10175: 2011. Investigation of Potentially Contaminated Sites. Code of Practice (+A2:2017).

BSI (2013) British Standard BS8576: 2013. Guidance on Investigations for Ground Gas – Permanent Gases and Volatile Organic Compounds (VOCs).

BSI (2015) British Standard BS5930: 2015. Code of Practice for Ground Investigations.

BSI (2015a) Flexible sheets for waterproofing – Bitumen, plastic and rubber sheets for roof waterproofing – Determination of resistance to static loading. BS EN 12730: 2015.

BSI (2016) Geosynthetic. Determination of thickness at specified pressures. Single layers. BS EN ISO 9863-1: 2016.

BSI (2016a) BS EN 13719: 2016 . Geotextiles and geotextile related products. Determination of the long term protection efficiency of geotextiles in contact with geosynthetic barriers

BSI (2019) British Standard BS8485: 2015 +A1: 2019. Code of Practice for the Design of Protective Measures for



**Gas membranes and “compliance with BS8485”**

Wilson, Lucas and Flood

Geofabrics (undated). The durability of geotextiles. <https://www.tencategeo.us/media/50b6a456-96ab-4943-9985-a137c8ad43c3/U-y8rA/TenCate%20Geosynthetics/Documents%20AMER/Industry%20Papers/The%20durability%20of%20geotextiles.pdf>

Methane and Carbon Dioxide Ground Gases for New Buildings.

Grubb J A, Limaye H S and Kakade A M (2007). Testing pH of concrete, need for a standard procedure. Concrete International, April 2007, pp78 – 83

Mallett H, Cox L, Wilson S and Corban M (2014). Good practice on the testing and verification of protection systems for buildings against hazardous ground gases. CIRIA Report C735, London.