Verseidag-Indutex GmbH

Biogas store membranes

Methane permeability/Tensile strength

DLG Test Report 5883 F

DLG FOKUS TEST
July 10 Methane permeability/ Tensile strength

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Registering company
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DLG e.V.
Test Center
Technology and Farm Inputs

Short description

- Covering membranes for biogas fermenters, postfermenters, and fermentation residue stores for combined use as a biogas store;
- The biogas store membranes described in this report are also used for air-supported roofs;
- Fabric films coated with PVC on both sides.

Technical data (as provided by the manufacturer*)

Membrane: Classic 900 for biogas applications	
Fabric type	PES
Coating type	PVC sealed on both sides
Area weight	900 g/m²
Tensile strength (chain/weft)	4.700/4.500 N/5 cm
Tear resistance (chain/weft)	600/550 N
Adhesion	150 N/5 cm
Gas permeability	< 1.000 ml/(m² bar d)
Membrane: Classic 1100 for biogas applications	
Fabric type	PES
Coating type	PVC sealed on both sides
Area weight	1.100 g/m²
Tensile strength (chain/weft)	5.750/5.000 N/5 cm
Tear resistance (chain/weft)	950/800 N
Adhesion	170 N/5 cm
Gas permeability	< 1.000 ml/(m² bar d)

* Some of the values measured by VERSEIDAG-INDUTEX were determined according to other standards and can be compared with the values measured by the DLG only to a limited extent.

Evaluation – short version

Test criterion	Result	Evaluation
Membrane: Classic 900 for biogas applications		
Gas permeability*	188 cm³/(m² bar d)	n.o.
Tensile strength (chain/weft)	4.053/4.766 N/5 cm	+
Tear resistance (chain/weft)	492/652 N	n.o.
Elongation at fracture (chain/weft)	35.2/54.8 N	n.o.
Membrane: Classic 1100 for biogas applications		
Gas permeability*	460 cm³/(m² bar d)	n.o.
Tensile strength (chain/weft)	6.321/6.069 N/5 cm	+ +
Tear resistance (chain/weft)	886/673 N	n.o.
Elongation at fracture (chain/weft)	40,4/58,8 mm	n.o.

The test was carried out at 23°C. For this reason, it does not include any evaluation.

Evaluation range: + + / + / ○ / – / – – (○ = standard); n.o. = no objection

DLG evaluation standard for the gas permeability of fabric film for the production of biogas stores:
0 to < 400 cm³/(m² bar d) = + + / 400 to < 700 cm³/(m² bar d) = + / 700 to < 1000 cm³/(m² bar d) = ○
> 1000 cm³/(m² bar d) = – – (TI 4 standard not met)

DLG evaluation standard for the tensile strength of fabric film for the production of biogas stores:
> 5.000 N/5 cm = + + / 2.500 to < 5.000 N/5 cm = + / 1.000 to < 2.500 N/5 cm = ○ / 500 to < 1.000 N/5 cm = –
0 to < 500 N/5 cm = – – (TI 4 standard not met)

Test conditions and realization of the test

The DLG FokusTest "Methane permeability and tensile strength" was carried out based on existing standards (DIN EN ISO 1421 for tensile strength, DIN EN ISO 4674, part 1 for tear resistance, and DIN 53380, part 2 for gas permeability).

The test included the measurement of material properties (thickness and area weight), the determination of tensile strength as well as tear resistance, and the exmination of the gas permeability of methane. The tests were carried out under laboratory conditions according to the valid standards. Gas permeability was tested according to DIN 53380, part 2 at 23°C.

Tensile strength and tear resistance were tested at the DLG Test Center in Groß-Umstadt.

For the tensile strength test, five test objects each measuring 5 x 20 cm were placed in the testing device (cf. figure 2). Afterwards, each test object was stretched by a constantly growing force until it tore. The force measured at the tearing point is tensile strength. Stretching at the moment of tearing is termed elongation at fracture.

Five test objects were also used for the measurement of tear resistance. The test objects were prepared by cutting them half open with a special knife. They were also fixed in the testing device using their two legs, which were ca. 2.5 cm wide, and then stretched (figure 3). If the membrane does not continue to tear, the absorbed force grows. When the tearing process continues, it drops briefly and then grows again. The average force needed in order to make the membrane tear grow is tear force.

Gas permeability was tested at the Institute of Process Engineering and Packing (IVV) in Freising. For this purpose, two circular test objects having a diameter of 110 mm were placed in the gastight measuring cell in order to measure gas permeability according to DIN 53380, part 2. In order to guarantee that the test gas did not leave the test object through the fabric in the membrane, the test objects were masked with aluminium foil. Then, pure methane gas was admitted at 23°C, 0 % relative humidity and an absolute pressure of ca. 5 bar. Even though a maximum overpressure of only ca. 10 mbar must be expected in biogas plants, the results can be reproduced in practice because the relation between methane transition and overpressure is linear. This means that under the conditions of fivefold overpressure methane permeability is approximately five times as high.

Figure 2:
Tensile strength test at the DLG Test Center

Figure 3:
Test of tear resistance at the DLG Test Center

Test results

With regard to gas permeability and tensile strength, both tested biogas store membranes conform to the requirements of "TI 4 – safety regulations for agricultural biogas plants" of the German Federation of Agricultural Employers' Liability Insurance Associations (status: 10/2008).

Figure 4 shows the course of the tear resistance test of all five test objects of the membrane type Classic 1100. According to the results of this test, a force of less than 600 N can be applied to this membrance after it has begun to tear without the film continuing to tear. After the fabric structure has been destroyed by the tensile force (at ca. 620 N and an elongation of ca. 50 mm), additional force absorption by the film is minimized. This means that the force needed to make the tear in the two film legs grow decreases.

Figure 5 shows using an example that the elongation at fracture of the membrane type Classic 1100 is ca. 59 mm in weft direction at an applied tearing force of more than 6,000 N. In chain direction, this membrane type also shows over-average results. As compared with the rules of the "Safety regulations for agricultural biogas plants", where only 500 N/5 cm are required, these membrances withstand the 12-fold tearing force

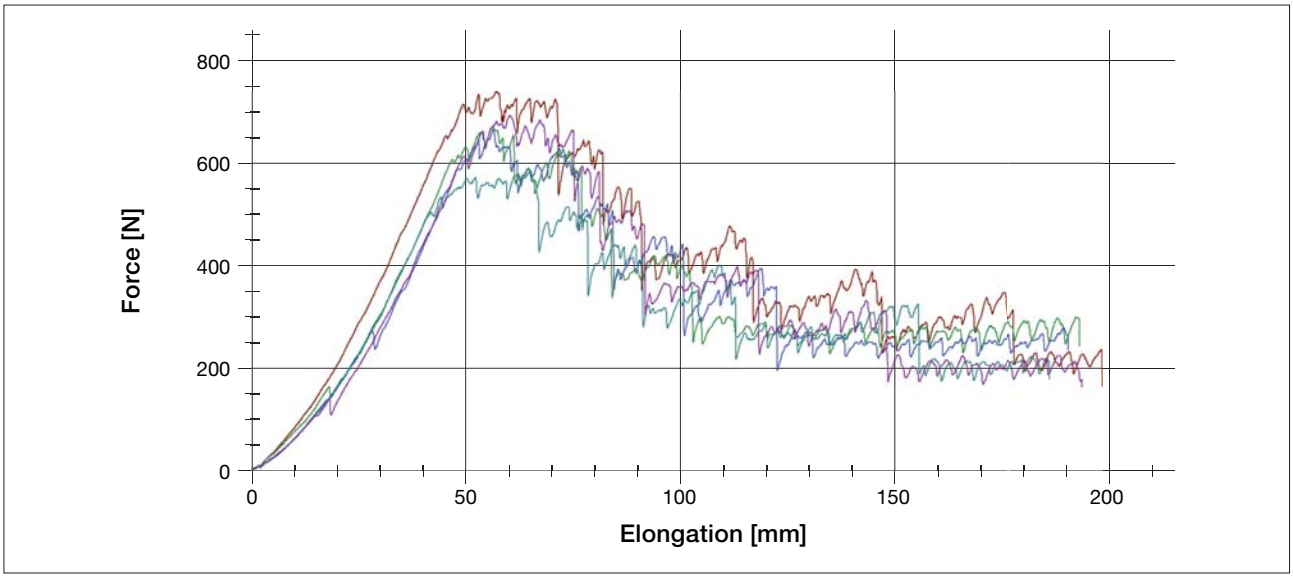

Figure 4:
Course of the tear resistance test of Classic 1100 in weft direction.
Each colour stands for one of the five test objects.

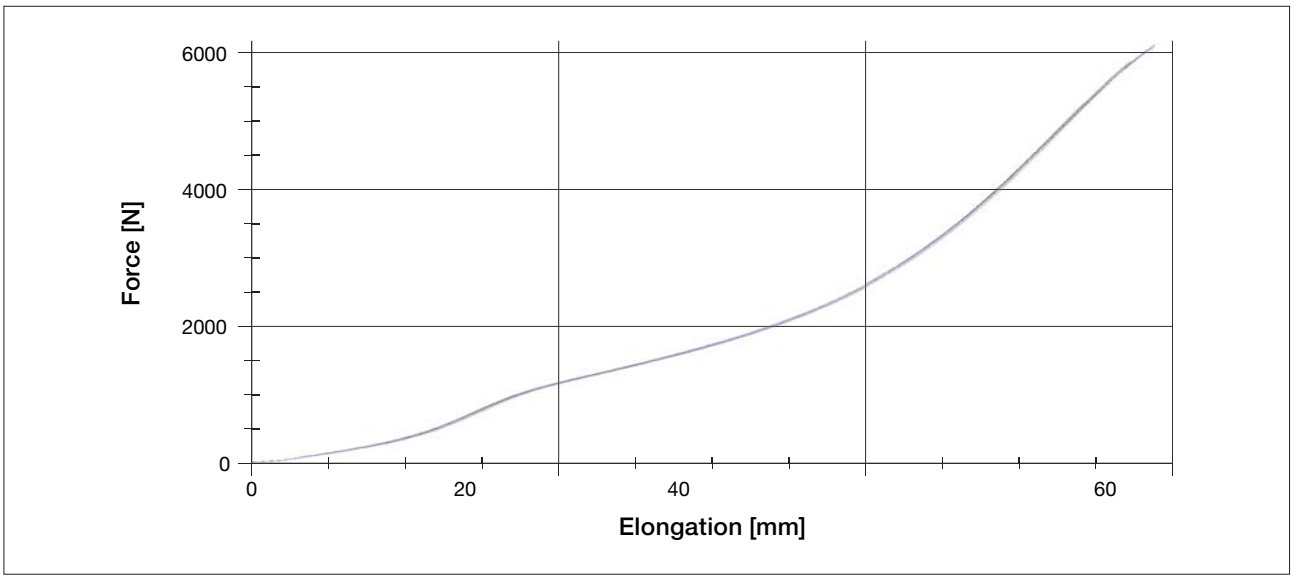

Figure 5:
Course of the tensile strength test of Classic 1100 in weft direction.
Each colour stands for one of the five test objects.

in comparison with the required values. The membrane type Classic 900 still reaches the 8 or 9-fold of the minimum value for biogas stores required by the "Safety regulations for agricultural biogas plants" in both weft and chain direction.

When gas permeability for methane was tested, the results showed that the "Safety regulations for agricultural biogas plants are met at a test temperature of 23°C.

The methane permeability of the membrane type Classic 900 is extraordinarily low at 188 $cm^3/(m^2$ bar d).

At an annual average temperature common in practice of approximately 40°C in the gas room of mesophilic biogas plants, experience shows that gas permeability is higher. In addition, the test was carried out using a test gas which contains 100 % methane. Biogas produced in biogas plants which use renewable raw materials only has a methane content of 50 to 55 % and a carbon dioxide content of 40 to 45 %. Due to this composition, gas permeability for methane must be assumed to be lower in practice.

Altogether, the tested biogas membranes proved to be well suited for use as a biogas store in biogas plants because both films clearly meet the requirements of the "Safety rules for agricultural biogas plants" with regard to tensile strength and methane permeability. While the methane permeability of Classic 900 is considerably lower, the tensile strength and tear resistance of Classic 1100 is higher.

The test results are summarized in Table 1.

Table 1:
Comparison of the test results

Film type	according to	Classic 900 for biogas applications	Classic 1100 for biogas applications
Carrier fabric	DIN 60001	PES	PES
Coating type	PVC on both sides	PVC fungicide	PVC fungizid
Area weight	DIN EN ISO 2286-2	991 g/m²	1.086 g/m²
Film thickness		0,72 mm	0,82 mm
Tensile strength chain	DIN EN ISO 1421	4.053 N/5 cm	6.321 N/5 cm
Tensile strength weft	DIN EN ISO 1421	4.766 N/5 cm	6.069 N/5 cm
Elongation at fracture chain	DIN EN ISO 1421	35,2 mm	40,4 mm
Elongation at fracture weft	DIN EN ISO 1421	54,8 mm	58,8 mm
Tear resistance chain	DIN EN ISO 4674-1	492 N	886 N
Tear resistance weft	DIN EN ISO 4674-1	652 N	673 N
Gas permeability methane	DIN 53380-2	188 $cm^3/(m^2$ bar d)	460

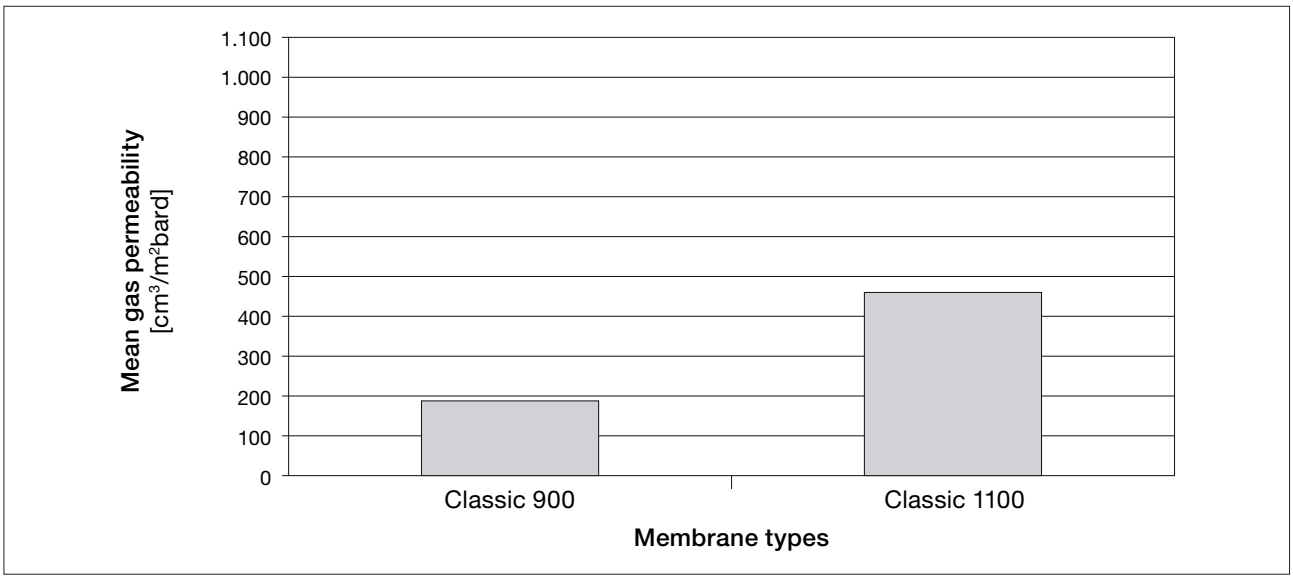

Figure 6:
Gas permeability of the two membranes

Test

Tensile strength, tear resistance, and gas permeability were tested under the above-described laboratory conditions.

Based on the present results, both membrane types are suitable for use as biogas store membranes in biogas plants according to the TI 4 "Safety regulations for agricultural biogas plants" of the Federal Association of Agricultural Biogas Plants.

The test was not carried out at 40°C because it turned only out during the test that testing at operating temperature was possible.

Other criteria were not tested.

Realization of the tests

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09-714
October 2010

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