TRUE GAS BARRIER GEOMEMBRANES

PLASTIKA KRITIS S.A.

GROUP PROFILE

- **Established in 1970**
- **9 plants in 7 countries (Greece, China, France, Romania, Turkey, Russia)**
- **Group production (2015) : 127,000 MT**
- **Turnover (2015) : 257 million Euros**
- **950 employees**

KRITIFIL®
agricultural films

KRITISOL®
polyethylene pipes

KRITISAN®
Recycled plastics

KRITIFLEX®
geomembranes

KRITILEN®
masterbatches

Green Energy
wind and solar

PLASTIKA KRITIS S.A.

MANUFACTURING LOCATIONS FOR AGRICULTURAL FILMS AND GEOMEMBRANE LINERS

GREECE

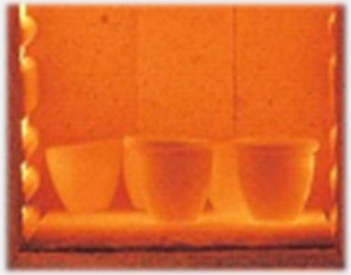
FRANCE

CHINA

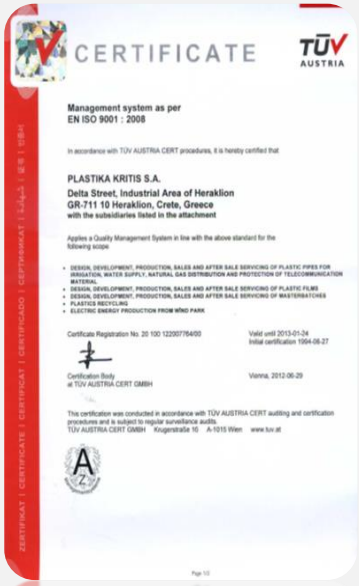
PLASTIKA KRITIS S.A.

RESEARCH & DEVELOPMENT

Extensive laboratory facilities



ISO 9001, OHSAS 18001, CE, ASQUAL certification


CERTIFICATE

TÜV AUSTRIA

Management system as per
EN ISO 9001 : 2008

In accordance with TÜV AUSTRIA CERT procedures, it is hereby certified that

PLASTIKA KRITIS S.A.
Delta Street, Industrial Area of Heraklion
GR-711 10 Heraklion, Crete, Greece
with the subsidiaries listed in the attachment

Applies a Quality Management System in line with the above standard for the following scope

- DESIGN, DEVELOPMENT, PRODUCTION, SALES AND AFTER SALE SERVICING OF PLASTIC PIPES FOR IRRIGATION, WATER SUPPLY, NATURAL GAS DISTRIBUTION AND PROTECTION OF TELECOMMUNICATION MATERIAL
- DESIGN, DEVELOPMENT, PRODUCTION, SALES AND AFTER SALE SERVICING OF PLASTIC FILMS
- DESIGN, DEVELOPMENT, PRODUCTION, SALES AND AFTER SALE SERVICING OF MASTERBATCHES
- PLASTICS RECYCLING
- ELECTRIC ENERGY PRODUCTION FROM WIND PARK

Certificate Registration No. 20 100 12200764/00
Valid until 2013-01-24
Initial certification 1994-08-27

Certification Body
at TÜV AUSTRIA CERT GMBH

Vienna, 2012-06-29

This certification was conducted in accordance with TÜV AUSTRIA CERT auditing and certification procedures and is subject to regular surveillance audits.
TÜV AUSTRIA CERT GMBH Krugerstraße 16 A-1015 Wien www.tuv.at


CERTIFICATE

TÜV AUSTRIA

Management system as per
OHSAS 18001 : 2007

In accordance with TÜV AUSTRIA CERT procedures, it is hereby certified that

PLASTIKA KRITIS S.A.
Delta Street, Industrial Area of Heraklion
GR-711 10 Heraklion, Crete, Greece
with the subsidiaries listed in the attachment

applies an occupational health and safety management system in line with the above standard for the following scope

- DESIGN, DEVELOPMENT, PRODUCTION, SALES AND AFTER SALE SERVICING OF PLASTIC PIPES FOR IRRIGATION, WATER SUPPLY, NATURAL GAS DISTRIBUTION AND PROTECTION OF TELECOMMUNICATION MATERIAL
- DESIGN, DEVELOPMENT, PRODUCTION, SALES AND AFTER SALE SERVICING OF PLASTIC FILMS
- DESIGN, DEVELOPMENT, PRODUCTION, SALES AND AFTER SALE SERVICING OF MASTERBATCHES
- PLASTICS RECYCLING
- ELECTRIC ENERGY PRODUCTION FROM WIND PARK

Certificate Registration No. 20 116 12200765/00
Valid until 2014-01-30
Initial certification 2004-12-20

Certification Body
at TÜV AUSTRIA CERT GMBH

Vienna, 2012-06-29

This certification was conducted in accordance with TÜV AUSTRIA CERT auditing and certification procedures and is subject to regular surveillance audits.
TÜV AUSTRIA CERT GMBH Krugerstraße 16 A-1015 Wien www.tuv.at

KRITIFLEX® GEOMEMBRANES

- Made of HDPE, fPP, fPE, EVA, LLDPE, LDPE
- Thickness 0,3-2,5 mm
- Smooth or Textured
- Black or Bicolor
- Used for :
  - Landfills
  - Water applications
  - Mining
  - Construction

PLASTIKA KRITIS S.A.

WIDE 7-LAYER FILMS & LINERS

- One of just 4 wide 7-layer lines in the world
- Tailor design based on in-house engineering
- Thickness : 0,3-2,5 mm
- Width : 1-20 m
- Capacity : 30 MT/day
- An investment of 12 million Euros in Crete-Greece

PLASTIKA KRITIS S.A.

KRITIFLEX® 7-LAYER EVOH GEOMEMBRANES & LINERS

PO: Polyolefin

EVOH: $-(CH_2-CH_2)_m-(CH_2-\underset{\displaystyle OH}{\underset{|}{CH}})_n-$

- **Combining HDPE, LLDPE, VLDPE, fPP in outer layers, with a thin layer of EVOH**
- **Polyolefins (PO) ensure excellent mechanical properties and very low permeability to liquids**
- **EVOH renders the liner virtually impermeable to gases**
- **Thickness : 0.3-2 mm**

PLASTIKA KRITIS S.A.

Oxygen Transmission Rate of Films

Polymer	Oxygen Transmission 20º C, 65% RH
EVOH – 32 mol%	0.4
EVOH – 44 mol%	0.8
PVDC copolymer (extrusion grade)	2.6
Nylon	38.0
PET	54.0
HDPE	2300.0
C-PP	3000.0
PC	5000.0
LDPE	10000.0
EVA	18000.0

Unit: cc.20mic/(m2.day)

Source : Kuraray

Comparison of gas barrier properties of HDPE & EVOH

Gas	EVOH*	HDPE**
Nitrogen	0.019	190
Oxygen	0.25	2300
Carbon Dioxide	0.6	17526
Sulfur Dioxide	0.3	21844
Methane	0.4	2845

Volumetric permeation rate in cc.20mic/(m2.day)
Conditions: 23ºC– o% RH (ASTM D1434T)

KRITIFLEX® 7-LAYER EVOH GEOMEMBRANES & LINERS

Methane barrier

The problem

Methane gas can migrate significant distances under the ground surface and be forced into buildings causing accidents by ignitions or explosion

Current solution

Reinforced liners with Aluminum foil (0,4 mm)

PLASTIKA KRITIS S.A.

Kritiflex® Methane barrier

DESCRIPTION	7-layer CH_4 barrier liner	
RESIN(S)	m-LLDPE, EVOH	
NOMINAL THICKNESS (mm)	0,40	
MECHANICAL PROPERTIES	TYPICAL VALUES	TEST METHOD
TENSILE STRENGTH AT BREAK (kN/m)	13	ASTM D6693
ELONGATION AT BREAK (%)	650	ASTM D6693
TEAR RESISTANCE (N)	45	ASTM D1004
PUNCTURE RESISTANCE (N)	140	ASTM D4833
IMPACT RESISTANCE (gr)	>2100	ASTM D1709/B
CH_4 PERMEABILITY $cm^3\ m^{-2}\ day^{-1}\ atm^{-1}$	<12	ISO 15105

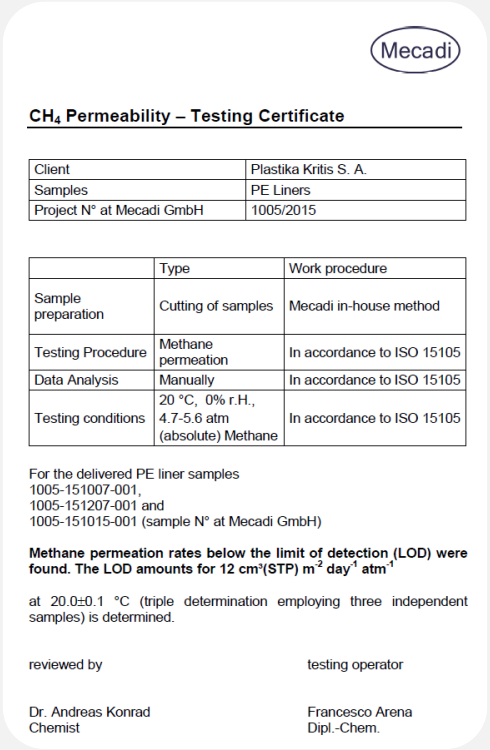
Our solution

7-layer PE+EVOH liner (0,4 mm)

Advantages relative to liner with Aluminum foil:

- Higher flexibility
- Easier installation
- Lower cost
- Equal permeability

Kritiflex® Methane barrier testing certificate



Mecadi

CH_4 Permeability – Testing Certificate

Client	Plastika Kritis S. A.
Samples	PE Liners
Project N° at Mecadi GmbH	1005/2015

	Type	Work procedure
Sample preparation	Cutting of samples	Mecadi in-house method
Testing Procedure	Methane permeation	In accordance to ISO 15105
Data Analysis	Manually	In accordance to ISO 15105
Testing conditions	20 °C, 0% r.H., 4.7-5.6 atm (absolute) Methane	In accordance to ISO 15105

For the delivered PE liner samples
1005-151007-001,
1005-151207-001 and
1005-151015-001 (sample N° at Mecadi GmbH)

Methane permeation rates below the limit of detection (LOD) were found. The LOD amounts for 12 cm^3(STP) m^{-2} day^{-1} atm^{-1}

at 20.0±0.1 °C (triple determination employing three independent samples) is determined.

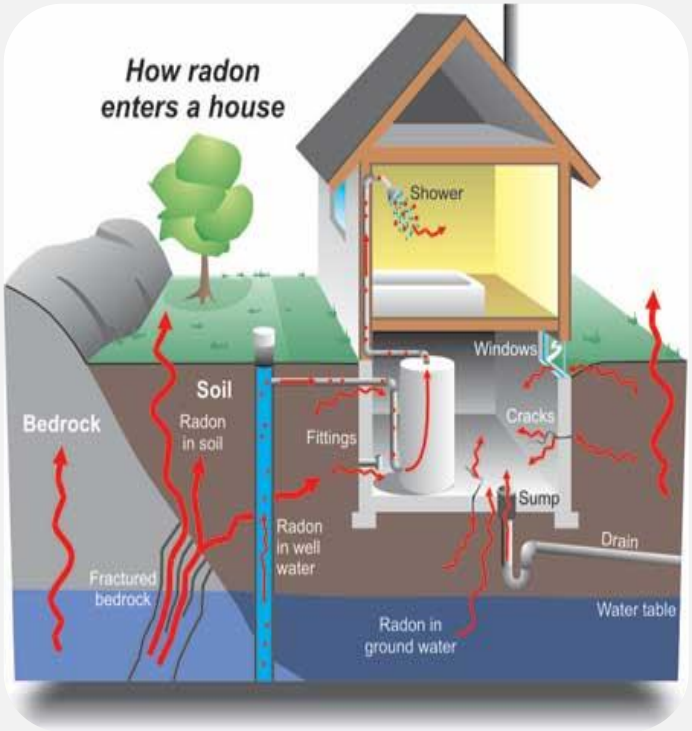
reviewed by

Dr. Andreas Konrad
Chemist

testing operator

Francesco Arena
Dipl.-Chem.

Radon barrier



The problem

Radon is a radioactive gas whose inhalation increases the risk of lung cancer. Concrete floors and basement walls slow-down the movement of radon from underground into the building, however, cracks in the floor, wall slab joints and the drainage system allow radon to enter !

Radon barrier

Current solutions

- PE or fPP liners (0.8 mm)

  - Very poor barrier !

- Reinforced liners with Aluminum foil (0.4 mm)

  - High cost
  - Difficult installation

KRITIFLEX® 7-LAYER EVOH GEOMEMBRANES & LINERS

Kritiflex® Radon barrier

DESCRIPTION	7-layer CH_4 radon barrier liner	
RESIN(S)	m-LLDPE, EVOH	
NOMINAL THICKNESS (mm)	0,40	
MECHANICAL PROPERTIES	TYPICAL VALUES	TEST METHOD
TENSILE STRENGTH AT BREAK (kN/m)	13	ASTM D6693
ELONGATION AT BREAK (%)	650	ASTM D6693
TEAR RESISTANCE (N)	45	ASTM D1004
PUNCTURE RESISTANCE (N)	140	ASTM D4833
IMPACT RESISTANCE (gr)	>2100	ASTM D1709/B
RADON TRANSMITTANCE P	$<3*10^{-9}$	SP Method no 3873

Our solutions

- **7-layer flexible PE + EVOH (0,4 mm)**
- **Composite liner with non-woven substrate**

PLASTIKA KRITIS S.A.

Radon barrier test results

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Appendix 1

Test results

Client	Plastika Kritis SA
Sample for testing	EVOH Radon Barrier
Date of testing	2015-10-23—2015-11-02
Test data	Free volume, source box, V_1: 0.027 m³ Free volume receiver box, V_2: 0.026 m³ Total free volume, V: 0.053 m³
Equipment	Atmos 33 (SP no. 202266) for measurement of Polonium-218 concentration. Most recently calibrated 2014-12-03, by Swedish Radiation Safety Authority
Radon source	Lightweight concrete emitting Radium Ra-222, with Po-218 as the first decay product.
Ambient temperature	23 ± 1 °C
Ambient RH	50 ± 5 %
Uncertainty of measurement	The increased uncertainty of measurement was estimated as ± 11 %, including a coverage factor of k = 2. Uncertainty of measurement for temperature was ± 2 °C, and that for relative humidity was ± 5 % in the test chamber.
Observation	No changes in the test material were observed during the tests.
Miscellaneous	The test results given in this report relate only to the particular samples of material that were tested.

The following results have been calculated under the conditions as shown in the table below:

Material, name	EVOH Radon Barrier
Exposed area of test material A, m²	0.250
Thickness of test material d, m	0.0003
Radon concentration at start C_0 Bq/m	41
Radon exhalation Φ, Bq/s	$3.0 \cdot 10^{-3}$
Effective radon sink λ 1 , s-1	$3.2 \cdot 10^{-6}$
Radon transmittance P, m/s	$<3.0 \cdot 10^{-9}$
Radon resistance Z, s/m	$>3.3 \cdot 10^{8}$

Theory

Emission of radon from the radon source results in an increase of radon concentration in the source box, leading to a difference in concentration between the source box and the receiver

SP Technical Research Institute of Sweden

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Appendix 1

box. This difference causes a flow of radon by diffusion through the test material. Only radon gas (Rn) passes through, and not its decay products (RnD). Radon transmittance is measured by measuring the change in radon concentration on both sides of the test material. Figures 1 and 2 show how the radon concentrations build up in the two boxes.

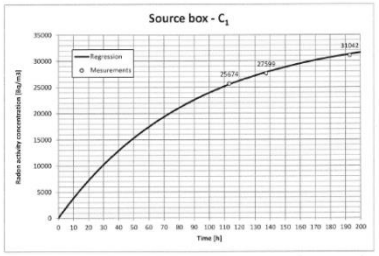


Figure 1 Radon concentration in the primary box: measured daily average values and the regression curve.

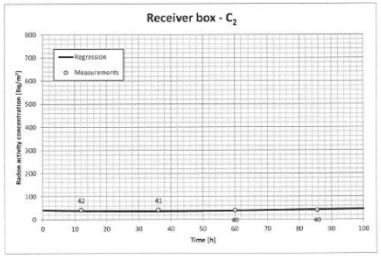


Figure 2 Radon concentration in the secondary box: measured daily average values and the regression curve.

SP Technical Research Institute of Sweden

PLASTIKA KRITIS S.A.

Remediation of brown-fields

The problem

Remediation of abandoned or under-used industrial facilities that had been producing high levels of contaminants during their operation

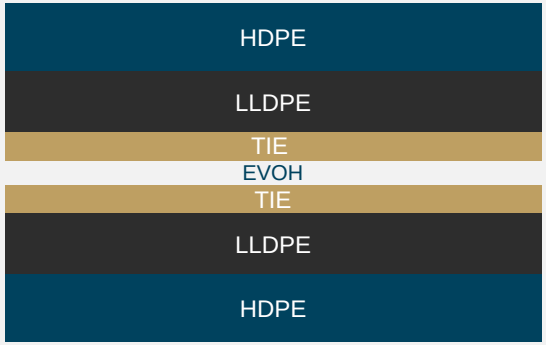
Brownfields are often polluted by aromatic hydrocarbons that produce VOC gases

KRITIFLEX® 7-LAYER EVOH GEOMEMBRANES & LINERS

Remedation of brown-fields

Our solution

1-1,5 mm 7-layer EVOH liner with LLDPE for elasticity and HDPE in the outer layers for chemical resistance



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Landfill capping

The problem

- Spread of odors from the landfill
- High VOC emissions
- Low quantity of useful gases collection
- Landfill gas migration

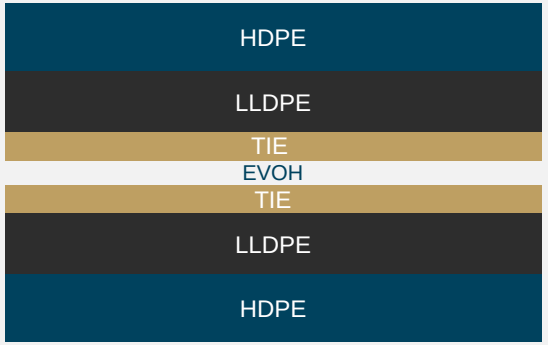
KRITIFLEX® 7-LAYER EVOH GEOMEMBRANES & LINERS

Landfill capping

DESCRIPTION	7-layer gas barrier geomembrane	
RESIN(S)	HDPE, LLDPE, EVOH	
NOMINAL THICKNESS (mm)	1,00	
PROPERTIES	TYPICAL VALUES	TEST METHOD
CARBON BLACK CONTENT (%)	2-3	ASTM D4218
CARBON BLACK DISPERSION (note)	1,2	ASTM D5596
TENSILE STRENGTH AT BREAK (kN/m)	20	ASTM D6693
ELONGATION AT BREAK (%)	480	ASTM D6693
TEAR RESISTANCE RESISTANCE (N)	125	ASTM D1004
PUNCTURE RESISTANCE (N)	400	ASTM D4833
OXIDATIVE INDUCTION TIME (min)	> 00	ASTM D3895
OXYGEN TRANSMISSION RATE (ml/m².day)	< 1	ASTM D1434

Our solution

1-1,5 mm 7-layer EVOH liner with LLDPE for elasticity and HDPE in the outer layers for chemical resistance



PLASTIKA KRITIS S.A.

Geofoams

The problem

EPS geofoams are degraded by VOCs emitted by fuels leading to deterioration of the road condition

Common liners (typically 1 mm LLDPE) cannot prevent this effect due to their high gas permeability

KRITIFLEX® 7-LAYER EVOH GEOMEMBRANES & LINERS

Geofoams

DESCRIPTION	7-layer gas barrier geomembrane	
RESIN(S)	HDPE, LLDPE, EVOH	
NOMINAL THICKNESS (mm)	1,00	
PROPERTIES	TYPICAL VALUES	TEST METHOD
CARBON BLACK CONTENT (%)	2-3	ASTM D4218
CARBON BLACK DISPERSION (note)	1,2	ASTM D5596
TENSILE STRENGTH AT BREAK (kN/m)	23	ASTM D6693
ELONGATION AT BREAK (%)	600	ASTM D6693
TEAR RESISTANCE RESISTANCE (N)	120	ASTM D1004
PUNCTURE RESISTANCE (N)	380	ASTM D4833
OXIDATIVE INDUCTION TIME (min)	> 100	ASTM D3895
OXYGEN TRANSMISSION RATE (ml/m².day)	< 1	ASTM D1434

Our solution

- 7-layer LLDPE + EVOH liner (1 mm)
- Can be produced in large widths (6-10 m) for ease of installation

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KRITIFLEX® 7-LAYER EVOH GEOMEMBRANES & LINERS

INNOVATIVE products under design

Gas Barrier GCL

Our concept

- GCL laminated with 0,2-2 mm PE+EVOH

Applications

- Landfill capping
- Mining

Benefits

- Combines hydraulic and gas barrier properties

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KRITIFLEX® 7-LAYER EVOH GEOMEMBRANES & LINERS

INNOVATIVE products under design

PE+EVOH liner with welding zone

The problem

- Existing EVOH geomembranes suffer from delamination during welding

Our concept

- A PE+EVOH 1-2 mm geomembrane with a certain width from each side free of EVOH, to prevent delamination during welding as well as moisture pick-up of the EVOH layer during storage

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