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TEST REPORT
ON GAS PERMEABILITY MEASUREMENTS
MSZ EN ISO/IEC 17025:2005

Page no.: 1/12
Ref. no.: 01-0901

Procurer:

Contact person: , E-Mail:

Samples received:

Testing period:

Test: CH₄ and CO₂ permeability measurements

Instrument: WaSul-PERM HL4Cf, RL4Cf, RL2Ci and HL4Mf (courtesy of Hilase Ltd.)

Test method: photoacoustic detection of CH₄ and CO₂ permeation equivalent to ISO Standards 2782:2006

Measurements made by: Zoltán Filus

Contact person: Dr. Zoltán Bozóki (mobile: +36-20-411-20-44, email: zoltan.bozoki@hilase.hu)

Effective permeation area: 38.5 cm²

Carrier gas: nitrogen

SETTINGS

Purging	Both source and receiving chamber are purged by using dry nitrogen flow prior to start of the test (after placing the sample into the permeation cell).		
	T	same as testing temperature	
	gas flow rate	100 sccm (for both source and receiving chambers)	
Testing	source chamber	initially filled with pure CH ₄ or CO ₂	
		gas flow rate during measurement	50 sccm
		CH ₄ or CO ₂ concentration	100%
	receiving chamber	purged with pure N ₂ (being enriched by permeated CH ₄ molecules)*	
		pressure	atmospheric pressure
		gas flow rate during measurement	10-100 sccm (depending on the rate of permeation)
		CH ₄ or CO ₂ concentration	0% initially and no larger than 3000 ppm during the entire test

* In case of using sensitive diffusion cells, permeating molecules enrich initially pure nitrogen in closed receiving chambers.

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HUNGARYe-mail: info@hilase.hu
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Fax: +36-62-544-658Page no.: 2/12
Ref. no.: 01-0901**Methane permeation tests: thin samples, high temperature**

Identifier by the procurer				
Surfaces ¹	indistinguishable			
Number of samples tested	1	1	1	1
HILASE identifiers	081108-01	081108-02	081108-03	081108-04
Thickness ² (mm)	Min.	1.23	1.16	0.98
	Max.	1.34	1.23	1.03
	Average	1.28	1.19	1.01
Duration of purging (hours)	5.0			
Duration of testing (hours)	20.5			
Starting date of testing	11/10/08	11/10/08	11/10/08	11/10/08
Temperature at testing	100 °C			
Pressure of testing	Atmospheric pressure			
Diffusivity (<i>D</i>) in 10 ⁻¹² m ² /sec	271	153	452	230
Solubility (<i>S</i>) in 10 ⁻⁷ 1/Pa	19.0	9.71	7.90	8.66
Permeability (<i>Pe</i>) in 10 ⁻¹⁷ m ² /sec/Pa	51.3	14.9	35.7	19.9
Flux ³ (<i>J</i>) in cm ³ /m ² /day	3463	1080	3053	1607

- 1: Identification of the two sides as follows: *a/b* (where *a* is the sample side facing source chamber and *b* is sample surface facing receiving chamber).
- 2: Measured and averaged on 6 sampling points of active sample surface.
- 3: Calculated on the region of steady-state diffusion.



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Methane permeation tests: thick samples, high temperature

Identifier by the procurer					
Surfaces ¹	indistinguishable				
Number of samples tested	1	1	1	1	
HILASE identifiers	081111-01	081111-02	081111-03	081111-04	
Thickness ² (mm)	Min.	4.05	3.95	4.04	3.94
	Max.	4.10	3.99	4.15	4.00
	Average	4.06	3.97	4.10	3.97
Duration of purging (hours)	17.5				
Duration of testing (hours)	21.9				
Starting date of testing	11/11/08	11/11/08	11/11/08	11/11/08	
Temperature at testing	100 °C				
Pressure of testing	Atmospheric pressure				
Diffusivity (<i>D</i>) in 10 ⁻¹² m ² /sec	156	340	240	186	
Solubility (<i>S</i>) in 10 ⁻⁷ 1/Pa	14.3	9.69	15.4	8.77	
Permeability (<i>Pe</i>) in 10 ⁻¹⁷ m ² /sec/Pa	22.2	33.0	37.1	16.3	
Flux ³ (<i>J</i>) in cm ³ /m ² /day	472	717	782	355	

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HUNGARYe-mail: info@hilase.hu
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Fax: +36-62-544-658Page no.: 4/12
Ref. no.: 01-0901**Carbon-dioxide permeation tests: thin samples, high temperature**

Identifier by the procurer					
Surfaces ¹	indistinguishable				
Number of samples tested	1	1	1	1	
HILASE identifiers	081022-1	081022-2	081022-3	081022-4	
Thickness ² (mm)	Min.	1.01	1.23	0.98	1.13
	Max.	1.08	1.33	1.04	1.21
	Average	1.05	1.28	1.01	1.17
Duration of purging (hours)	23.2				
Duration of testing (hours)	91.5				
Starting date of testing	10/22/08	10/22/08	10/22/08	10/22/08	
Temperature at testing	100 °C				
Pressure of testing	Atmospheric pressure				
Diffusivity (<i>D</i>) in 10 ⁻¹² m ² /sec	54.0	231	106	213	
Solubility (<i>S</i>) in 10 ⁻⁷ 1/Pa	138	69.8	94.4	31.1	
Permeability (<i>Pe</i>) in 10 ⁻¹⁷ m ² /sec/Pa	74.6	161	99.6	66.0	
Flux ³ (<i>J</i>) in cm ³ /m ² /day	6135	10886	8518	4877	

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Carbon-dioxide permeation tests: thick samples, high temperature

Identifier by the procurer					
Surfaces ¹	indistinguishable				
Number of samples tested	1	1	1	1	
HILASE identifiers	081027-1	081027-2	081027-3	081027-4	
Thickness ² (mm)	Min.	3.99	4.04	3.92	3.89
	Max.	4.16	4.12	4.00	3.95
	Average	4.06	4.09	3.97	3.91
Duration of purging (hours)	14.9				
Duration of testing (hours)	52.9				
Starting date of testing	10/27/08	10/27/08	10/27/08	10/27/08	
Temperature at testing	100 °C				
Pressure of testing	Atmospheric pressure				
Diffusivity (<i>D</i>) in 10 ⁻¹² m ² /sec	251	189	62.6	235	
Solubility (<i>S</i>) in 10 ⁻⁷ 1/Pa	62.7	29.2	77.8	36.8	
Permeability (<i>Pe</i>) in 10 ⁻¹⁷ m ² /sec/Pa	157	55.1	48.7	86.7	
Flux ³ (<i>J</i>) in cm ³ /m ² /day	3344	1164	1060	1916	

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Carbon-dioxide permeation tests: thin samples, room temperature

Identifier by the procurer					
Surfaces ¹	Indistinguishable				
Number of samples tested	1	1	1	1	
HILASE identifiers	081030-1	081030-2	081030-3	081030-4	
Thickness ² (mm)	Min.	1.22	1.14	0.99	1.02
	Max.	1.32	1.22	1.06	1.10
	Average	1.27	1.18	1.02	1.06
Duration of purging (hours)	18.4				
Duration of testing (hours)	50.2				
Starting date of testing	10/30/08	10/30/08	10/30/08	10/30/08	
Temperature at testing	23 °C				
Pressure of testing	Atmospheric pressure				
Diffusivity (<i>D</i>) in 10 ⁻¹² m ² /sec	5.80	6.80	9.71	2.48	
Solubility (<i>S</i>) in 10 ⁻⁷ 1/Pa	124	36.6	81.6	175	
Permeability (<i>Pe</i>) in 10 ⁻¹⁷ m ² /sec/Pa	7.20	2.48	7.92	4.33	
Flux ³ (<i>J</i>) in cm ³ /m ² /day	490	182	671	353	

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- 3: Calculated on the region of steady-state diffusion.

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www.hilase.hu**Phone:** +36-62-544-518
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Ref. no.: 01-0901**Carbon-dioxide permeation tests: thin samples, room temperature (sensitive diffusion cell)**

Identifier by the procurer					
Surfaces ¹	indistinguishable				
Number of samples tested	1	1	1	1	
HILASE identifiers	081104-A	081104-B	081107-A	081107-B	
Thickness ² (mm)	Min.	0.99	1.20	1.06	1.24
	Max.	1.07	1.22	1.10	1.34
	Average	1.03	1.21	1.08	1.29
Duration of purging (hours)	13.9		26.1		
Duration of testing (hours)	48.0		35.2		
Starting date of testing	11/04/08		11/08/08		
Temperature at testing	23 °C				
Pressure of testing	Atmospheric pressure				
Diffusivity (<i>D</i>) in 10 ⁻¹² m ² /sec	11.6	3.22	3.36	7.23	
Solubility (<i>S</i>) in 10 ⁻⁷ 1/Pa	156	192	120	140	
Permeability (<i>Pe</i>) in 10 ⁻¹⁷ m ² /sec/Pa	18.1	6.16	4.04	10.1	
Flux ³ (<i>J</i>) in cm ³ /m ² /day	1516	440	323	679	

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- 2: Measured and averaged on 6 sampling points of active sample surface.
- 3: Calculated on the region of steady-state diffusion.

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Ref. no.: 01-0901**Carbon-dioxide permeation tests: thick samples, room temperature (sensitive diffusion cell)**

Identifier by the procurer					
Surfaces ¹	indistinguishable				
Number of samples tested	1	1	1	1	
HILASE identifiers	081111-A	081111-B	081128-A	081128-B	
Thickness ² (mm)	Min.	4.06	3.90	4.03	3.94
	Max.	4.16	3.94	4.07	4.00
	Average	4.11	3.92	4.05	3.98
Duration of purging (hours)	18.7		22.6		
Duration of testing (hours)	16.2 days		18.8 days		
Starting date of testing	11/11/08		11/28/08		
Temperature at testing	23 °C				
Pressure of testing	Atmospheric pressure				
Diffusivity (<i>D</i>) in 10 ⁻¹² m ² /sec	2.61	4.95	1.87	1.17	
Solubility (<i>S</i>) in 10 ⁻⁷ 1/Pa	162	70.9	406	547	
Permeability (<i>Pe</i>) in 10 ⁻¹⁷ m ² /sec/Pa	4.22	3.51	7.59	6.42	
Flux ³ (<i>J</i>) in cm ³ /m ² /day	88.8	77.4	162	137	

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- 2: Measured and averaged on 6 sampling points of active sample surface.
- 3: Calculated on the region of steady-state diffusion.

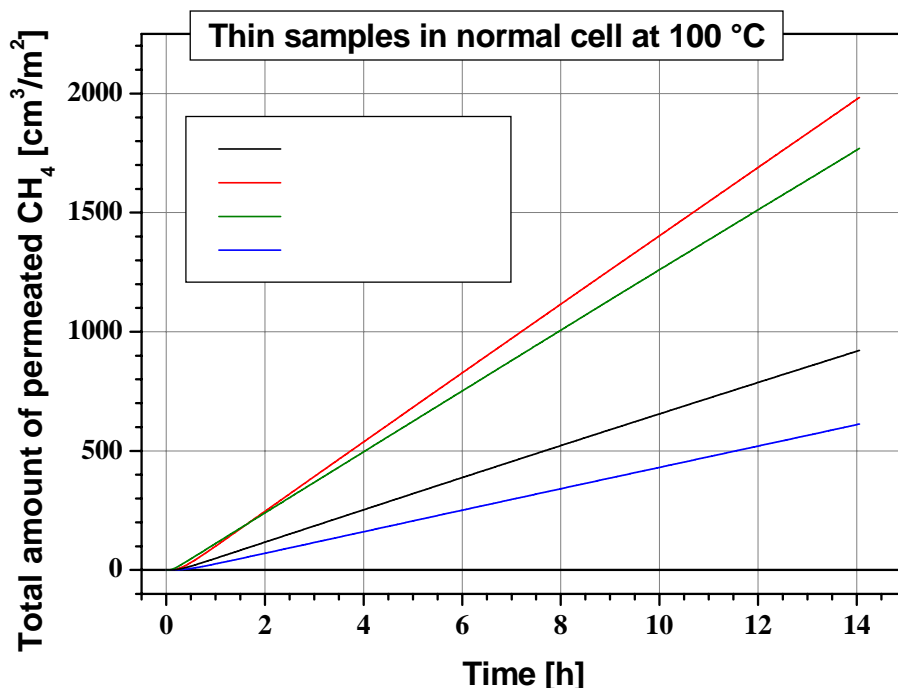
Szeged, January 23, 2009

Dr. Zoltán Bozóki CEO

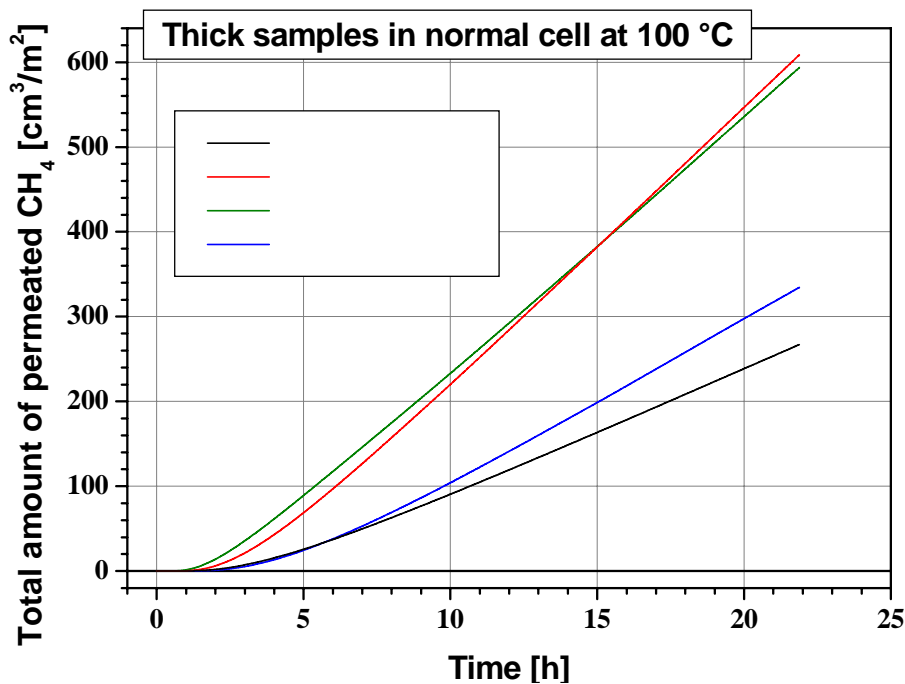
APPENDIX: Permeation curves after integrating the recorded data sets

A. CH₄ permeability tests

1. THIN SAMPLES AT HIGH TEMPERATURE

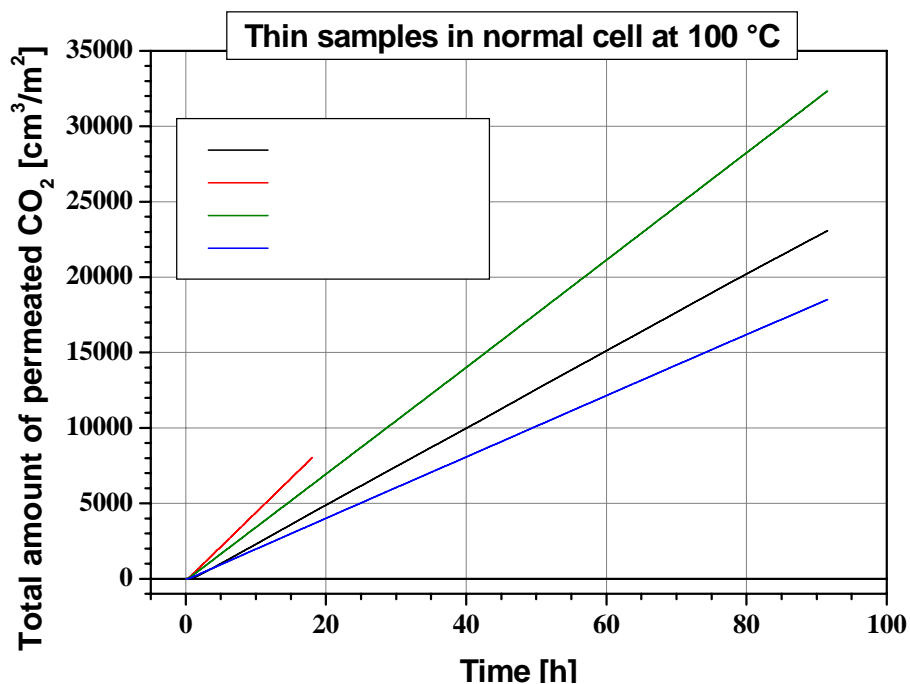


2. THICK SAMPLES AT HIGH TEMPERATURE

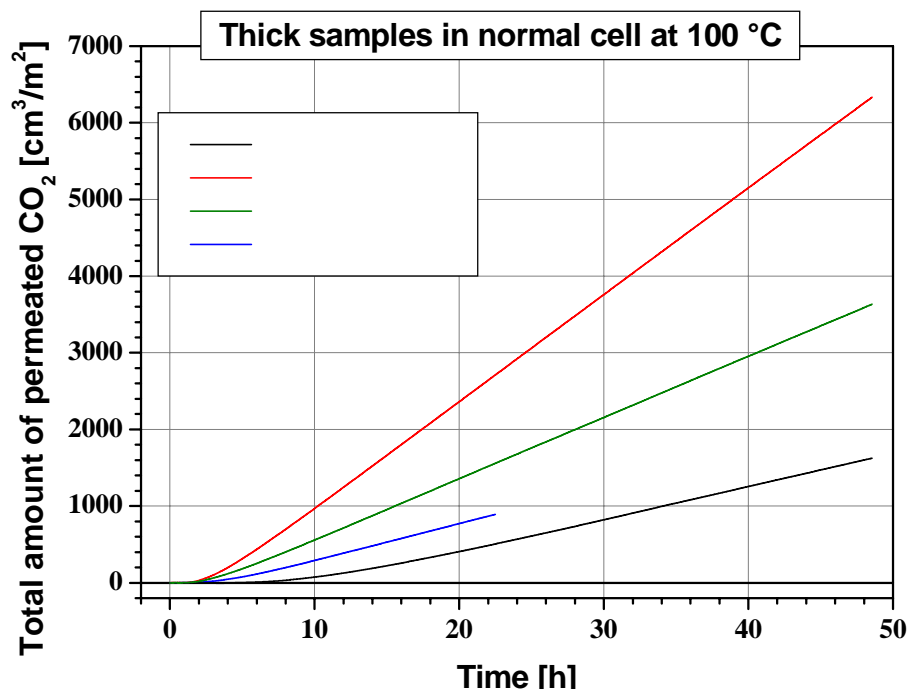


A. CO₂ permeability tests

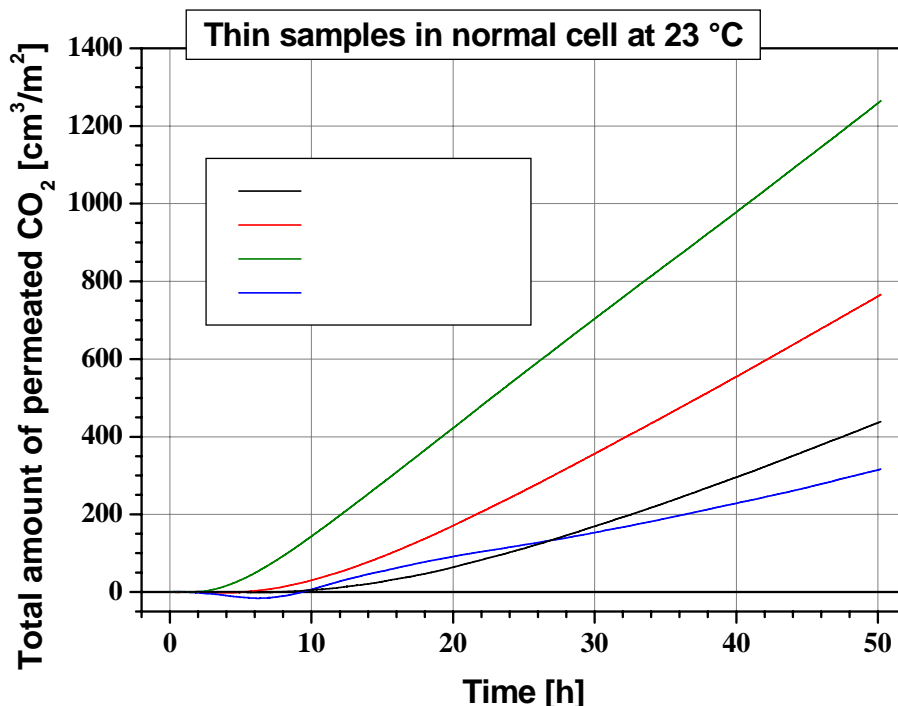
1. THIN SAMPLES AT HIGH TEMPERATURE



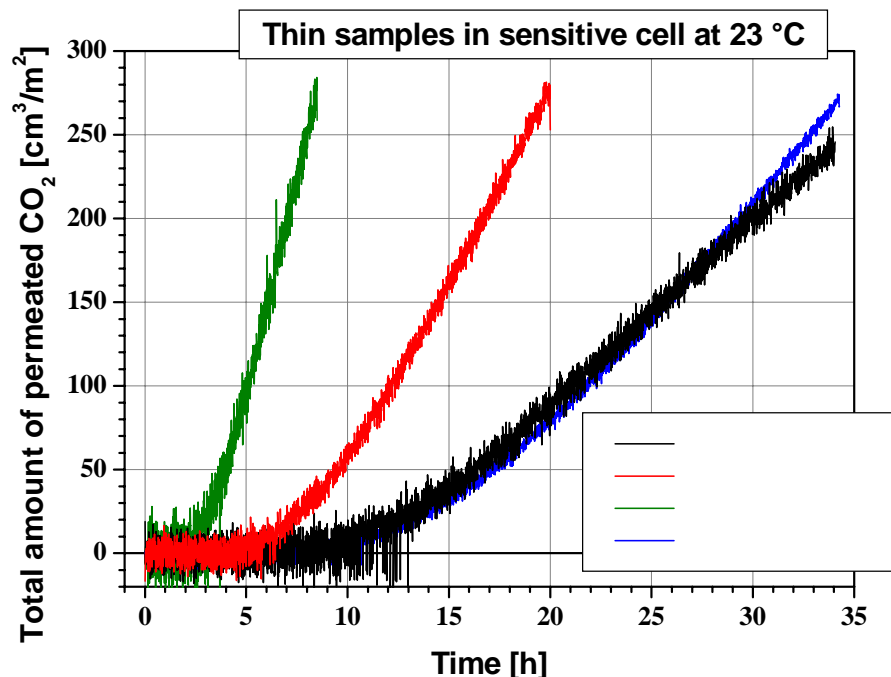
2. THICK SAMPLES AT HIGH TEMPERATURE



3. THIN SAMPLES AT ROOM TEMPERATURE



4. THIN SAMPLES AT ROOM TEMPERATURE (IN SENSITIVE CELL)



5. THICK SAMPLES AT ROOM TEMPERATURE (IN SENSITIVE CELL)

