ARKEMA

KYNAR®
KYNAR FLEX®

POLYVINYLIDENE FLUORIDE
Superior Permeation Barriers

The overall success of a containment material is dependent on a combination of important properties:

- The material must maintain its physical properties over time, e.g., resist stiffening or cracking.
- The material must resist swelling and weight gain.
- The material must not dissolve or soften.
- The material must not abrade away or particulate from chemical flow.
- The material must not allow permeation through the containment barrier.

Permeation through Kynar® PVDF polymers
Permeation is influenced by the phase of the matter being contained. Gas phases tend to be more permeable than liquid phases. For Kynar® PVDF as a containment barrier, permeation of gases or liquids is influenced by:

→ Thickness of the polymer barrier layer:
Permeation is generally given in rates per thousandth of an inch (mils) or millimeters (mm) of barrier thickness. Regardless of the permeation resistance of the polymer, thicker barriers tend to provide lower permeation rates.

→ Surface effects of the polymer: Materials with a fluorinated surface, like Kynar® PVDF, increase the contact angle of many fluids and thus have lower permeation rates through the polymer.

→ Crystallinity of the polymer:
The crystallinity of a polymer can have a measurable effect on permeation values. Note that crystallinity varies for Kynar® and Kynar Flex® polymers.

→ Concentration: Chemicals in solution can sometimes be pulled through the barrier by the solvent. A smaller solvent molecule will sometimes swell the polymer and allow a larger molecule to pass through. High concentrations of small molecules have greater permeation rates than low concentrations of large molecules.

→ Temperature: Permeation rates increase with temperature. For any barrier, the permeation rate at the highest anticipated temperature should determine the design of the barrier system.

→ Pressure: Higher pressures within the containment vessel will increase permeation rates through the polymer barrier.

→ Polarity: Along with molecular size, molecular polarity plays a key role in permeation through polymer barriers. Kynar® PVDF is somewhat polar (~ 1.0–1.7) and will thus be quite resistant to benzene, Cl_2, Br_2, O_2, N_2, H_2, especially when compared with non-polar fluoropolymers (PTFE, PFA, FEP) and non-polar polyolefins (PE, PB, PP). The high crystallinity gives Kynar® PVDF reasonably good resistance to even very polar chemicals like methanol and sulfuric acid.

Published data
Two definitive data tables have been published showing the permeation resistance of various polymers to specific gases and liquids.

Gas permeability of fluoropolymers*
Data based on 100 µm film thickness at 23°C. Method: ASTM D1434 for gases. Water vapor according to DIN 53122.

	PTFE	PFA	FEP	ETFE	CTFE	ECTFE	PVDF	PVF
Water Vapor $g/m^2.d.bar$	5	8	1	2	1	2	2	7
Air $cm^3/m^2.d.bar$	2000	1150	600	175	x	40	7	50
Oxygen $cm^3/m^2.d.bar$	1500	x	2900	350	60	100	20	12
Nitrogen $cm^3/m^2.d.bar$	500	x	1200	120	10	40	30	1
Helium $cm^3/m^2.d.bar$	3500	17000	18000	3700	x	3500	600	300
Carbon Dioxide $cm^3/m^2.d.bar$	15000	7000	4700	1300	150	400	100	60

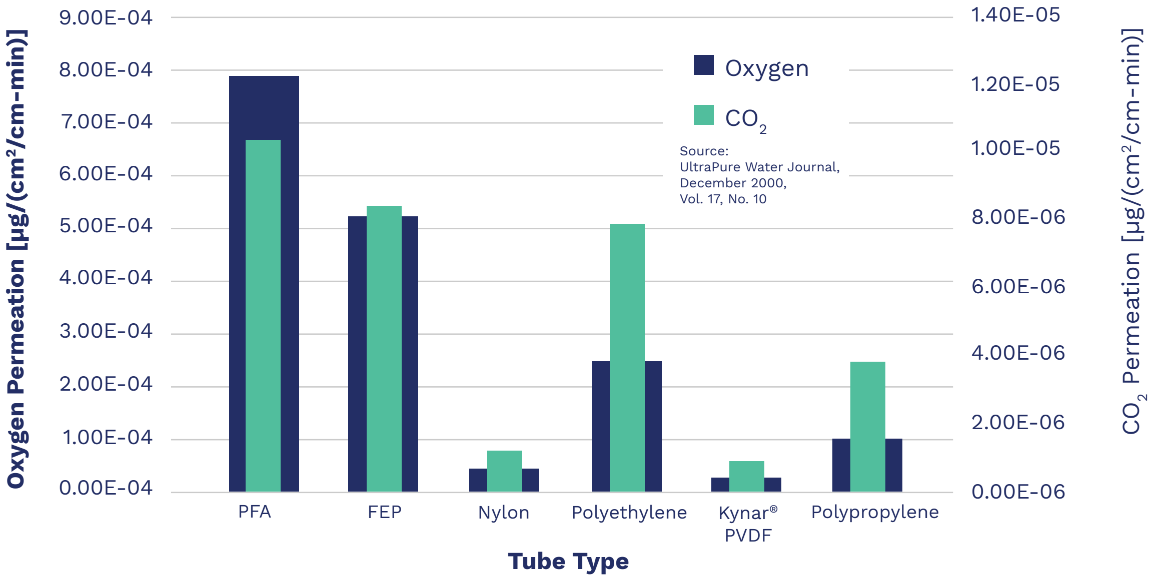
* Data published in 1980 Kunststoffe paper entitled Fluorocarbon Films–Present Situation and Future Outlook. x = Not tested

Various liquid permeation rates in corrosive chemicals
(Source Southwest Research Institute) (test 30mil tubes static 28 days/672 hours).

Ambient Permeation Rates (g-cm/hr/m)

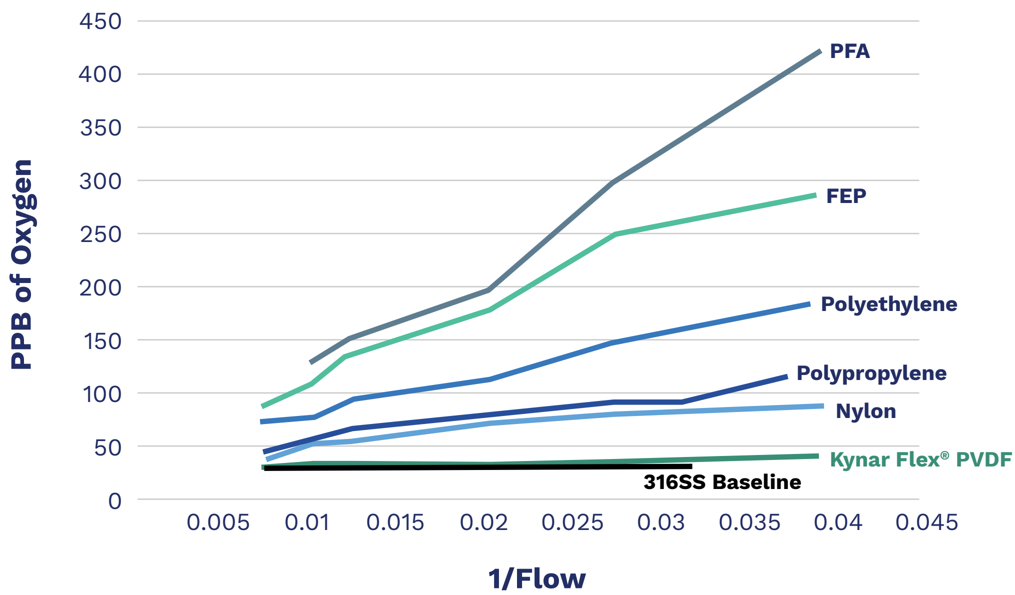
	Chloroform	Methanol	Toluene	HCL	Hydrochloride	Bromine
Kynar Flex® 2800	$<1x10^{-5}$	$<1x10^{-5}$	$<1x10^{-5}$	$<1x10^{-5}$	$<1x10^{-5}$	$<1x10^{-5}$
Kynar Flex® 2850	$<1x10^{-5}$	$<1x10^{-5}$	0.00004	$<1x10^{-5}$	$<1x10^{-5}$	$<1x10^{-5}$
Kynar® 740	$<1x10^{-5}$	$<1x10^{-5}$	$<1x10^{-5}$	$<1x10^{-5}$	$<1x10^{-5}$	0.00026
66 C Permeation Rates (g-cm/hr/m)						
Kynar Flex® 2800	0.177716	0.16340	0.05972	0.01621	0.00347	
Kynar Flex® 2850	0.09386	0.11966	0.03488	0.01226	0.00258	
Kynar® 740	0.02142	0.00063	0.00966	0.02930	0.00170	

PLASTIC PERMEATION CONSTANTS FOR THE DIFFERENT TUBE TYPES



OXYGEN PERMEATION OF THE SAMPLE VS. THE FLOW RATE FOR ALL THE TUBING TYPES

Source:
UltraPure Water Journal
December 2000
Vol. 17, No. 10



PERMEATION CONSTANTS

Plastic Type	Oxygen (O_2)*	Carbon Dioxide (CO_2)*	Water**
PFA	1.56E-8	1.42E-8	1.08E-7
FEP	1.08E-8	1.11E-8	7.08E-8
Polyethylene	5.07E-9	1.06E-9	8.92E-8
Polypropylene	1.96E-9	4.9E-9	2.45E-8
Nylon	8.25E-10	1.41E-9	2.16E-6
PVDF	1.84E-10	1.8E-10	2.24E-10

*from experimental data **estimated from literature by ratio of water-to-oxygen rates
Source: UltraPure Water Journal, December 2000, Vol. 17, No. 10

PERMEATION RATES

Micrograms/min. through plastic sheet, 1 cm thick, with an area of cm²

Plastic Type	Oxygen (O_2)*	Carbon Dioxide (CO_2)*	Water**
PFA	7.81E-4	1.05E-6	2.58E-5
FEP	5.13E-4	8.23E-7	1.69E-5
Polyethylene	2.4E-4	7.83-7	2.13E-5
Polypropylene	9.28E-5	3.64E-7	5.85E-6
Nylon	3.9E-5	1.05E-7	5.17E-4
PVDF	8.68E-6	8.39E-8	5.35E-8

*from experimental data **estimated from literature by ratio of water-to oxygen rates Note: 8.68E-6 means 8.68 *10 to the -6th power
Source: UltraPure Water Journal, December 2000, Vol. 17, No. 10

Additional data for other gases and liquids are available on request. Please consult an Arkema Inc. representative for further details.

Arkema Inc.
900 1st Ave,
King of Prussia, PA 19406,
United States
T +1 610 205 7000

Headquarters: Arkema France
420 rue d’Estienne d’Orves
92705 Colombes Cedex
France
T +33 (0)1 49 00 80 80

MARCOM EU – n° réf/202201-50/Quantité – Design : AS Images: Arkema,Getty