Product Information
PVDF

08/98

SIMONA

Content

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General

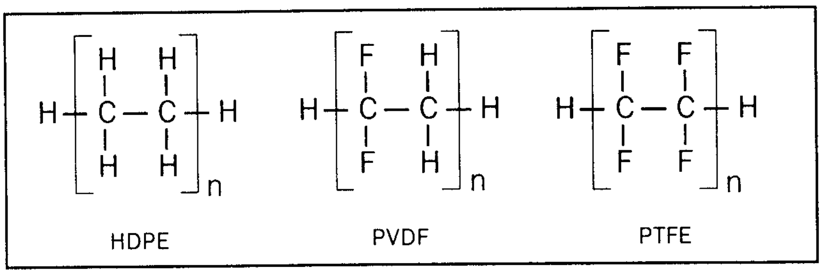
PVDF is a thermoplastic construction material and has all the typical characteristics of thermoplastics such as extrudability, weldability, thermoformability.

As a fluoroplastic, PVDF is characterized in particular by an extraordinary chemical resistance and as such may be used over a wide temperature range.

Compared to other fluoroplastics, PVDF offers many advantages in various applications; especially its easy processability, its high mechanical characteristics, its low specific gravity, thus cost saving.

Distinctive features

From a chemical point of view, PVDF lies between PE-HD and PTFE. Its relationship with PE-HD is illustrated by its easy machinability and with PTFE by its high chemical resistance at elevated temperatures.



SIMONA® plastics		PVDF	E-CTFE	PE-HWU	PP-DWU	PVC-CAW
Temperature range	°C	-30 to +140	-40 to +160	-50 to +80	0 to +100	0 to +60
Specific gravity	g/cm³	1.78	1.69	0.95	0.91	1.42
Tensile strength	MPa	56	31	22	32	58
Modulus of elasticity	MPa	1950	1700	800	1400	3000
Shore hardness D		78	72	63	72	82
Chemical resistance against halogens and other agents with oxidizing effect		excellent, even at high temperatures		—	—	conditional, at low temp. only

The PVDF monomer is a colourless gas, with a boiling point of -85.7 °C (at atmospheric pressure). Polymerization takes place under high pressure and in an aqueous medium, by 'splitting off' toxic hydrogen fluoride from the polymer, only possible at a temperature exceeding 350 °C.

SIMONA® PVDF belongs to the high crystalline thermoplastics. The crystalline structure of the polymer contains no γ-modification and little or no β-modification. The polymer consists more or less of crystalline portions of the α-modification and of amorphous portions.

Contrary to many other thermoplastics, SIMONA® PVDF contains no additives, stabilisers or coloured pigments.

Application examples

The use of PVDF is recommended whenever high temperature and/or chemical resistance is required.

- chemical industry
- food industry
- nuclear industry
- tank and apparatus construction
- electroplating industry
- paper and textile industry
- semi-conductor industry
- environmental protection

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Delivery programme

Sizes and dimensions

Colour	PVDF natural	
	sheet thickness in mm	
	standard	on request
Extruded sheets		up to 12
Size 2000 x 1000 mm	1 - 10	2 - 10
3000 x 1500 mm	3 - 4	1 - 4
on rolls		
Pressed/continuously pressed sheets		
Size 2000 x 1000 mm	10 - 80	
4000 x 2000 mm	15 - 80	
Laminated sheets		
Size 2000 x 1000 mm	2 - 6	
3000 x 1500 mm	3 - 4	2 - 5
on rolls 20000 x 1500 mm	3 - 4	2 - 5
		other lengths in 1000 and 1500
	diameter in mm	
Welding wire		
Round wire	3 - 4	PVDF-SK: The nominal thickness correspond to the residual wall thickness
Solid rods		
l = 2000 mm	10 - 180	
l = 1000 mm	100 - 300	
l = 500 mm	350 - 500	Recommended minimum wall thickness: 2.3 mm
Pipes/Fittings		
PN 10	63 - 225	
PN 16	16 - 110	
Liner pipes		
- without pretreating	75 - 400	
- with chemical pretreating for direct lamination	32 - 400	

- ▶ PVDF-S black; chlorine radical stabilized SIMONA® PVDF-CL; PVDF-EL, black
- ▶ Glass fibre lamination (GK) 1000 mm wide, 2 - 6 mm
- ▶ on request welding rods in pink colouration for simplified optical control of the weld seam

Details see delivery programm and/or catalogue „Pipes and fittings“

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Technical information

Material characteristics

	Test standard	Dimension	PVDF	PVDF-EL	PVDF-CL
Mechanical properties					
Density	ISO 1183	g/cm^3	1.78	1.78	1.78
Yield stress	DIN EN ISO 527	MPa	56	45	58
Yield strain	DIN EN ISO 527	%	8	6	6
Tensile strain at break	DIN EN ISO 527	%	22	20	15
E-modulus at tensile test	DIN EN ISO 527	MPa	1950	1800	2000
Impact strength	DIN EN ISO 179	kJ/m^2	without break	without break	without break
Notched impact strength	DIN EN ISO 179	kJ/m^2	12	6	8
Ball indentation hardness	DIN EN ISO 2039-1	N/mm^2	120	110	115
Shore hardness	ISO 868	—	78	78	79
Thermal properties					
Crystalline melting range	DIN 53736	°C	170 - 172	170 - 174	170 - 172
Vicat softening point	DIN ISO 306	°C	140	132	146
Mean linear expansion coefficient	DIN 53752	K^{-1}	$1.3 \cdot 10^{-4}$	$1.3 \cdot 10^{-4}$	$1.3 \cdot 10^{-4}$
Thermal conductivity	DIN 52612	W/mK	0.14	0.14	0.14
Fire behaviour	DIN 4102	—	non-readily ignitable	non-readily ignitable	non-readily ignitable
Electrical properties					
Dielectric strength	VDE 0303-21	kV/mm	25	—	—
Volume resistivity	DIN IEC 60093	Ohm · cm	$>10^{13}$	$\leq 10^{6}$	—
Surface resistance	DIN IEC 60167	Ohm	10^{13}	$\leq 10^{6}$	—
Tracking resistance	DIN IEC 112	V	>600	—	—
Dielectric constant	DIN 53483	—			
at 300 - 1000 Hz			6.8	—	—
at $3 \cdot 10^5$ Hz			6.6	—	—
Dissipation factor D	DIN 53483	—			
at 3000 Hz			0.017	—	—
at 1000 Hz			0.012	—	—
at $3 \cdot 10^5$ Hz			0.01	—	—
Water absorption	DIN 53495	%/24h	0.02	0.02	0.02
Physiological admissibility	acc. FDA	—	yes	no	no

For backed PVDF the mechanical values of the basic material are to be used.

The data specified here are guide values and may vary depending on the processing method and how the test pieces are made. These figures cannot be automatically transferred to finished components. The processor or user is responsible for checking the aptitude of our material for a specific application.

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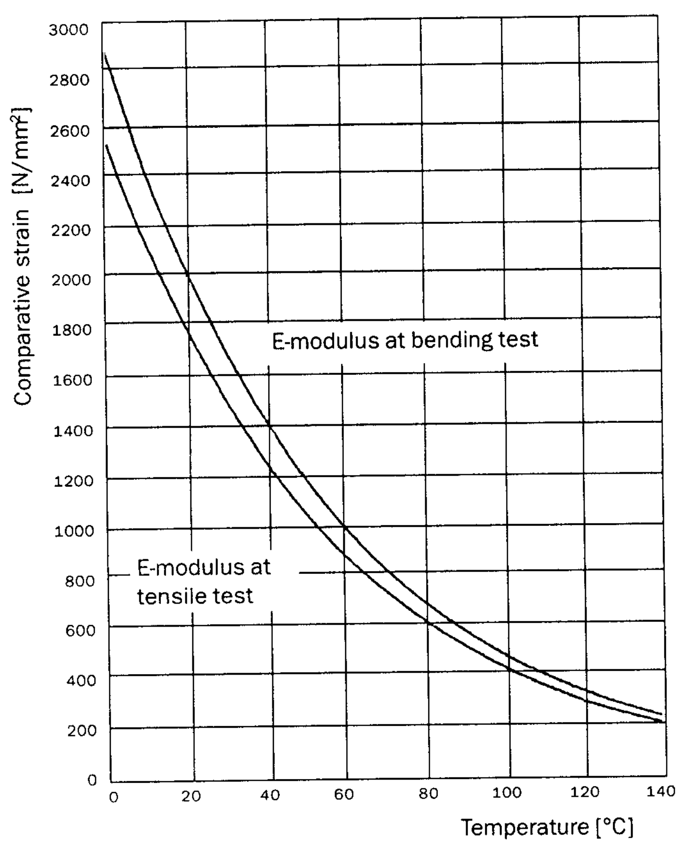
The molecular structure and the high crystallinity give SIMONA® PVDF a high rigidity. This is also valid for the upper temperature range.

- temperature of permanent use -30 °C to +120 °C
- without considerable mechanical and chemical load, for a short period up to approx. -50 °C resp. approx.s +140 °C
- crystallite melting range is about 170 °C

E-Modulus at tensile test and E-Modulus at bending test of SIMONA® PVDF



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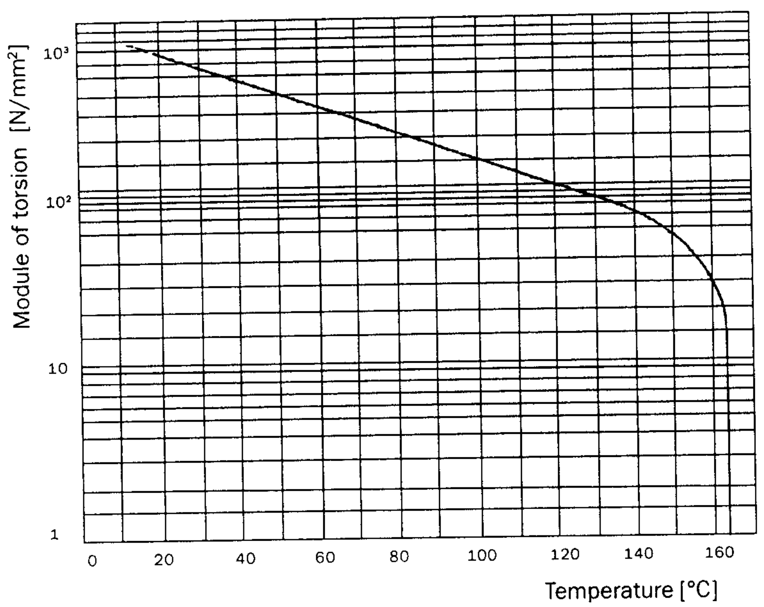
Module of torsion of SIMONA® PVDF



The test in accordance with UL 94 (Underwriters Laboratories) using an 0.8 mm test piece gave the best possible grade „V 0". No flame formation was observed, PVDF retained its form and did not flow. According to ASTM D 635-68, a 3 mm thick test piece was classified as „non-burning" (not inflammable).

After the French norm (Centre Scientifique & Technique Du Batiment, Paris) the material is classified as „M 1" - difficilement inflammable = hardly inflammable.

Combustion behaviour
SIMONA® PVDF is flame retardant and self-extinguishing after removal of the ignition source. The disintegration temperature of SIMONA® PVDF is approximately 350 °C. The amount of smoke produced is minimal at 450 °C and only slight at 600 °C.

The oxygen index is 78 % according to ASTM D 2863. This index indicates the minimum oxygen level necessary for combustion. SIMONA® PVDF is practically non-inflammable in normal environments, here is a comparison of the oxygen indices of other thermoplastics:

PP	17.5 %
PE-HD	18.0 %
PMMA	18.0 %
PPs	28.0 %
PVC-U	40.0 %

In the case of values below 20.8 %, ignition and continuous combustion is possible after removing the ignition source.

According to a test carried out in accordance with DIN 4102, the material was classified as „Category B1, hardly inflammable" (due to the high oxygen index of 78 %). However, a test certificate has not been applied for.

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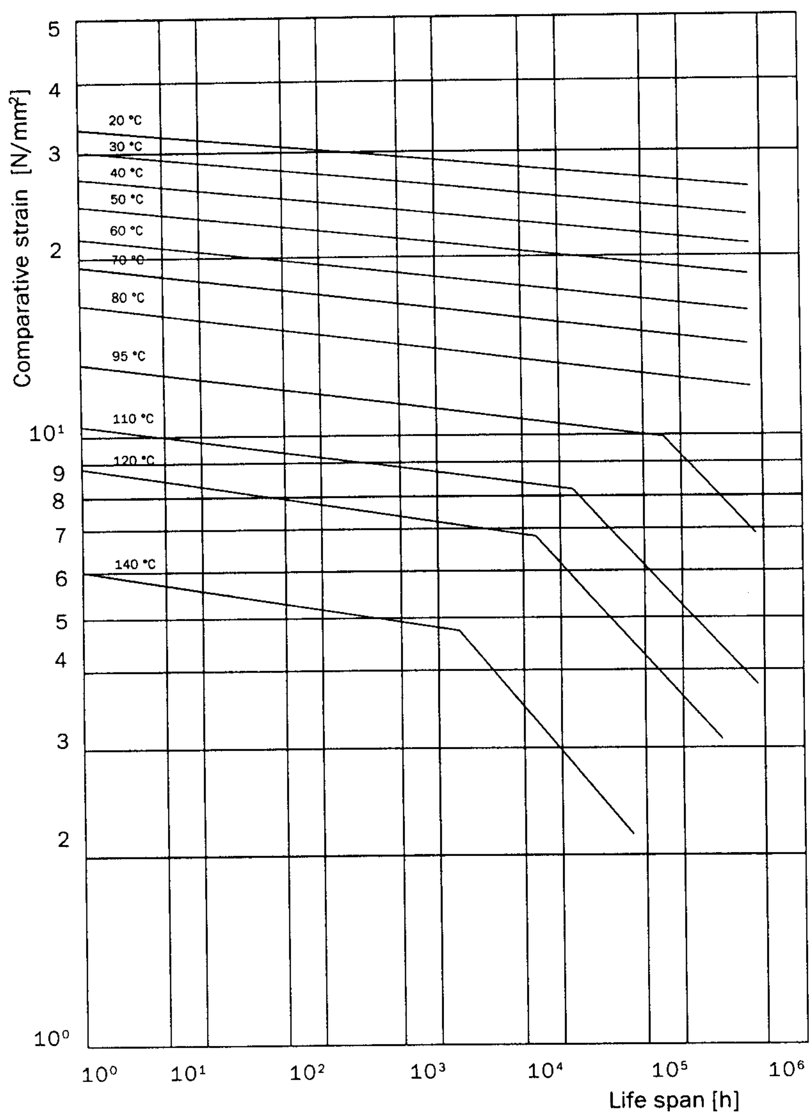
Behaviour in outdoor use / long-term behaviour

SIMONA® PVDF is characterized by an extraordinarily high ageing resistance in the atmosphere which can be attributed to its indifference to sunlight and UV rays and also its chemical resistance. Exposure tests ranging over five years produced either no change or only a slight change in the mechanical characteristics.

The material's ageing resistance in heat was tested by storage in water at 100 °C. After a test period of several thousand hours, no change in the characteristic value was found.

The creep-depending-on-time test under internal compression, normal for thermoplastics, is also used to determine the long-term behaviour of SIMONA® PVDF. The creep modulus is one of the basic factors for calculating SIMONA® PVDF construction element as it describes the material behaviour as a function of temperature and admissible stress.

Creep resistance of SIMONA® PVDF



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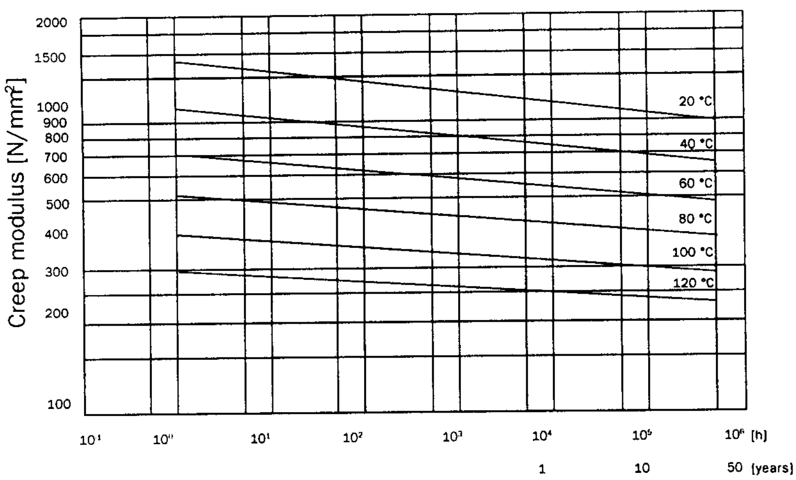
Creep modulus of SIMONA® PVDF



For PVDF pipes dimensions acc. to ISO/DIS 10931 part 2 admissible working pressures can be calculated according to the diagram „creep resistance“ (see page 8). At higher application temperatures slightly favourable admissible working overpressures can be obtained applying the values of this brochure in comparison with the values of the standard draft.

For the calculation a safety factor of SF = 1,6 was used.

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Admissible working internal compression for SIMONA® PVDF-pipe acc. to DVS 2205-1, supplement 4 (6.95) in dependance of temperature and time (dimensions acc. to ISO/DIS 10931-2)

Temperature °C	Working year	SDR 33 S 16 PN 10	SDR 21 S 10 PN 16
20	1	11.1	17.7
	5	10.9	17.4
	10	10.7	17.1
	25	10.5	16.8
	50	10.6	16.9
30	1	10.2	16.4
	5	10.1	16.1
	10	9.9	15.8
	25	9.8	15.7
	50	9.8	15.6
40	1	9.2	14.7
	5	9.0	14.4
	10	8.8	14.1
	25	8.7	13.9
	50	8.6	13.8
50	1	8.2	13.2
	5	8.1	12.9
	10	7.9	12.6
	25	7.8	12.4
	50	7.4	11.9
60	1	7.0	11.2
	5	6.9	11.0
	10	6.8	10.9
	25	6.8	10.8
	50	6.6	10.6
70	1	6.4	10.2
	5	6.3	10.0
	10	6.2	9.9
	25	6.1	9.7
	50	5.9	9.4

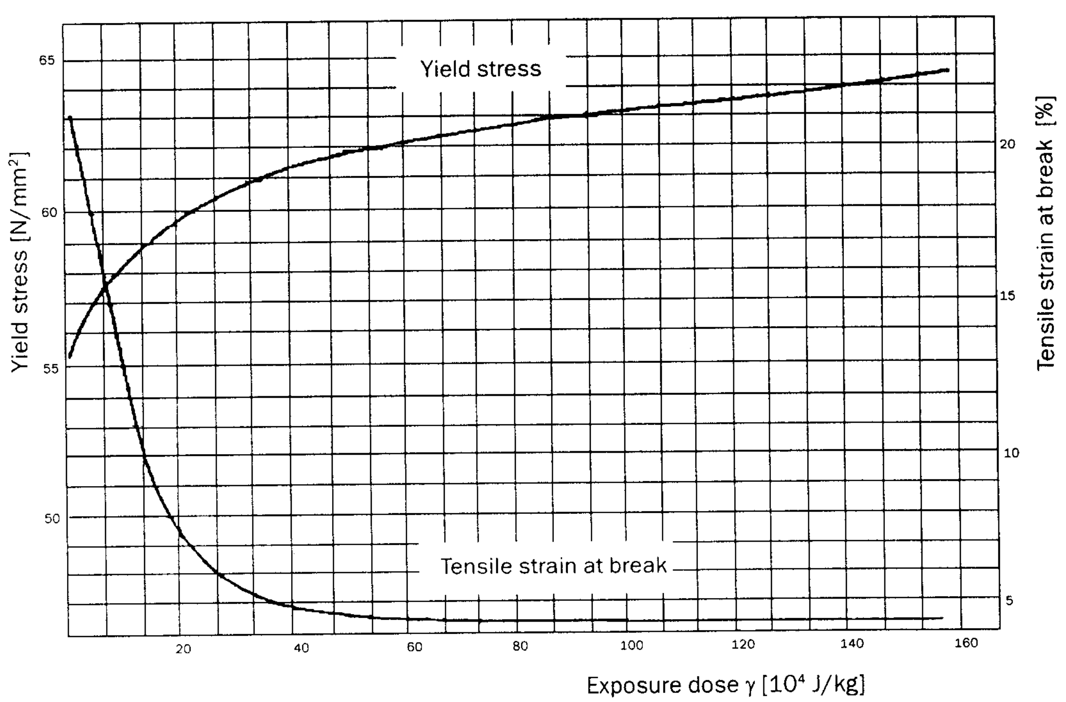
Temperature °C	Working year	SDR 33 S 16 PN 10	SDR 21 S 10 PN 16
80	1	5.5	8.8
	5	5.4	8.6
	10	5.3	8.5
	25	5.2	8.3
	50	5.1	8.1
90	1	4.7	7.5
	5	4.6	7.3
	10	4.4	7.1
	25	3.8	6.1
	50	3.3	5.3
100	1	3.9	6.3
	5	3.7	5.9
	10	3.2	5.1
	25	2.7	4.3
	50	2.3	3.6
110	1	3.3	5.3
	5	2.6	4.1
	10	2.2	3.5
	25	1.8	2.9
	50	1.6	2.5
120	1	2.5	4.0
	5	1.7	2.8
	10	1.5	2.4
	25	1.3	2.0
130	1	2.5	4.0
	5	1.2	1.9
140	1	1.3	2.0
	5	0.9	1.4

Resistance to ionizing radiation

The effects of gamma rays on this material are significantly less than in the case of many other halogen polymers (e. g. PTFE or PCTFE). This fact makes SIMONA® PVDF an ideal material for use in the nuclear power industry.

Apart from increasing the yield stress and reducing the tensile strain at break, SIMONA® PVDF can withstand a radiation dose of 20 Mrad (1 Mrad = 10^4 Gy = 10^4 J/kg). A further increase in strength is observed up to 40 Mrad. Degradation and cross-linking take place, if the radiation dose is increased to 100 Mrad, it will lead to a relative debility of the mechanical characteristics. This may start the browning of the material which increases significantly from 100 Mrad. A progressive and more rapid degradation is observed above this value.

Yield stress and tensile strain at break of SIMONA® PVDF after influence of γ-rays



This data refers to a pure radiation without any influence of media.

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Optical characteristics

SIMONA® PVDF is more or less translucent, depending on wall thickness. Its refractive index is 1.42.

Physiological admissibility

PVDF is harmless and non-toxic. Indeed it is permitted in the USA by the Food and Drug Administration (code of federal regulations title 21, chapter 1, part 177.2510) for contact with food stuffs. SIMONA® PVDF satisfies the requirements of the French „Direction Générale de la Concurrence de la consommation et de la Répression des Fraudes" (O.J. no. 1227/90 and supplements) and can come into contact with all kinds of foodstuff. It is tasteless and odourless up to an application temperature of 140 °C. SIMONA® PVDF is not harmful in contact with food stuffs as the material does not provide a breeding ground for microorganisms and is not attacked by such.

Chemical resistance

SIMONA® PVDF is resistant to the majority of inorganic chemicals, e. g. acids and salts - even in high concentrations and at high temperatures. The resistance of SIMONA® PVDF to aliphatic and aromatic hydrocarbons, organic acids, alcohols and aromatic compounds is excellent.

PVDF is attacked by some ketones, hot alkalis (depending on concentration), fuming sulphuric acid, amines and pyridine. It is dissolved by dimethyl formamide and dimethyl acetamide.

The very comprehensive SIMONA catalogue „Chemical Resistance" contains detailed answers to many questions. In case of doubt, a test carried out under practical conditions will provide the most reliable result concerning the suitability of the material, particularly in fringe areas of the possible applications.

We will be pleased to conduct immersion trials for you (with about three litres of the medium to be tested, incl. safety data sheet). If you wish us to conduct such trials please contact our Technical Application Department in this respect.

Liquid permeability

Only a slight permeability was determined with respect to aliphatic and aromatic hydrocarbons, perchloroethylene and trichloroethylene.

From the measuring point of view, the course of permeation is very hard to register in quantity, especially because proportional behaviour towards temperature and affinity (interaction between foreign and plastic molecules) do not exist. The guide values given in literature refer to the foil sector (e. g. s = 0.05 mm). A linearity to large wall thicknesses principally does not exist. Therefore, main measurements for particular wall thicknesses in defined medium concentrations are carried out. However, the results of these examinations cannot be transferred to other medium concentrations and operating conditions.

Gas permeability

SIMONA® PVDF is practically impermeable throughout the whole range of semi-finished product thicknesses in respect to gases with small molecules such as nitrogen, oxygen and carbon dioxide.

The permeability of PVDF is influenced by the crystalline degree and the modification of the crystalline parts.

Permeation especially needs to be taken into account for composite constructions with thermoset resins. For example, steam may lead to de-lamination at higher temperatures and at the same time the influence of a chemical agent. This may ensue in particular, if the thermoset resin has a lower permeability than the thermoplastic.

An increased steam permeation can be observed, especially with steel tank linings where temperatures above 90 °C and the use of aqueous media applies.

If you have any problems with applications, please contact our Technical Application Department.

The following table indicates guide values of choosen media, measured at PVDF foils. A transfer to larger wall thicknesses is not admissible without restrictions.

Gas permeability of SIMONA® PVDF foil

Medium		Test method	Wall thickness [mm]	Temperature [°C]	Guide value $\left[\frac{cm^3}{m^2 \cdot d \cdot bar}\right]$
Carbon dioxide	CO_2	Lissy-test rig DIN 53380 ISO 2556	0.21 0.034 0.034 0.1	30 30 23 23	30 890 610 105
Oxygen	O_2	Lissy-test rig DIN 53380 ISo 2556	0.25 0.034 0.034 0.1	30 30 23 23	10 140 86 25
Nitrogen	N_2	Lissy-test rig DIN 53380 ISO 2556	0.25 0.034 0.2	30	8 90 28
Water vapour		NFH 00044	0.020 0.028 0.040	38	34 22 16
Hydrogen sulphide Sulphur dioxide	H_2S SO_2	DIN 53380 ISO 2556	0.025 0.05 0.1	23	62 28 15
Ammonia	NH_3	DIN 53380 ISO 2556	0.025 0.05 0.1	23	300 140 65
Hydrogen	H_2	DIN 53380 ISO 2556	0.05 0.1	23	410 230
Chlorine	Cl_2	DIN 53380 ISO 2556	0.05 0.1	23	35 14
Tetrafluorodichloroethane	$C_2Cl_2F_4$	Lissy-test rig	0.25	30	3
Trichlorofluoromethane/ Dichlorodifluoromethane CCl_3F/CCl_2F_2 50/50		Lissy-test rig	0.s25	30	2

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Processing

Under the conditions indicated in this catalogue, the processing of SIMONA® PVDF is completely without hazard. Extensive measurements in the welding area have provided conclusive evidence showing that no measureable concentrations of toxic substances occur. However, in the event of processing errors, should the material temperature exceed the critical limit of 350 °C this could lead to the production of hydrofluoric acid and/or related fluorine compounds.

In order to exclude this possibility, would you please ensure that the following rules are adhered to:

1. SIMONA® PVDF must not be exposed to a naked flame.
2. Do not smoke in areas in which there is the likelihood of an accumulation of PVDF dust.
3. When welding, ensure that the recommended air and tool temperatures are observed. This will prevent the critical temperature of 350 °C from being exceeded.

Further information regarding the processing of PVDF may be obtained from our product information

- ▶ Welding
- ▶ Lining and Composite Construction
- ▶ Vacuum forming, thermo-forming, bending
- ▶ Machining

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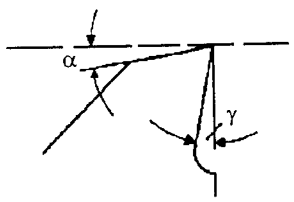
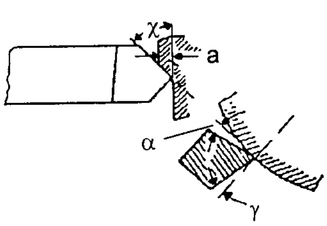
Machining

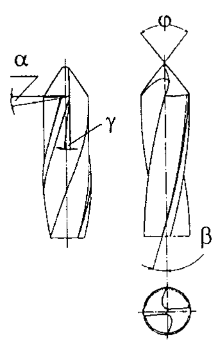


	Milling		
α	clearance angle	(°)	5 to 10
γ	rake angle	(°)	to 15
v	cutting speed	(m/min)	200 to 1000
s	feed	(mm/r)	0.1 to 0.5



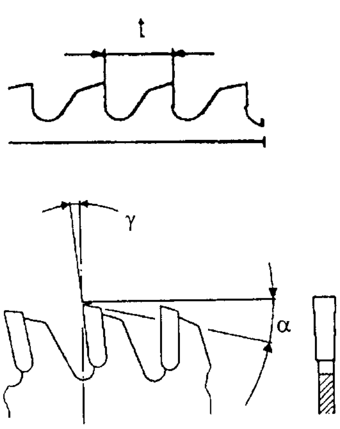
	Turning		
α	clearance angle	(°)	8 to 15
γ	rake angle	(°)	0 to 15
χ	side angle	(°)	45 to 60
v	cutting speed	(m/min)	100 to 300
s	feed	(mm/r)	0.1 to 0.3
a	depth of cut	(mm)	to 6

Radius of tip r should be approx. 0.5 mm.



	Drilling		
α	clearance angle	(°)	10 to 16
γ	rake angle	(°)	3 to 6
φ	point angle	(°)	100 to 130
v	cutting speed	(m/min)	50 to 200
s	feed	(mm/r)	0.1 to 0.5

Twist angle b of the drill should be approx. 12 to 16°. The cutting speed and feed are dependent on the drilling depth. The thermoplastic material must not clog (high v for thin walled components).



	Band saws and circular saws			
α	clearance angle	(°)	SS	30 to 40
			HM	5 to 15
γ^K	rake angle	(°)	SS	5 to 8
			HM	0 to 8
γ^B	rake angle	(°)	2 to 8	
t	pitch	(mm)	2 to 8	
v^K	cutting speed	(m/min)	to 2500	
v^B	cutting speed	(m/min)	500 to 3000	

Exponent K	= circular saw	hollow ground high speed steel blades
Exponent B	= band saw	high alloyed tool steel blades which are easily set
SS	= high speed steel	
HM	= carbide	

Welding
Plastic welding concerns the joining of thermoplastics by using heat and pressure, with or without the use of welding rod.

SIMONA® PVDF can be welded using the welding methods and corresponding machines and equipment known in connection with the processing of plastics.

For more detailed information please refer to our product information „Welding" in respect to the following tables.

Hot gas welding with welding filler

Air	Temperature measured in the nozzle	Welding speed cm/min			
		Round nozzle		High speed nozzle	
l/min	°C	Ø 3 mm	Ø 4 mm	Ø 3 mm	Ø 4 mm
60 to 70	360 to 400	10 to 15	approx. 10	40 to 50	30 to 40

Heated element butt welding (temperature at the heating element 240 ± 8 °C acc. to DVS 2207-15)

Sheet thickness	Adjustment $p \sim 0.1$ N/mm²	Heating up $p \leq 0.01$ N/mm²	Conversion	Bonding $p \sim 0.1$ N/mm² ± 0.01	
	bead height at the end of adjustment time	time = 10 x wall thickness + 40 s		time for build up the bonding pressure	cooling time under bonding press. = 1.2 x wall thickn. + 2 min
mm	mm (min. value)	s	s (max. value)	s	min (min. value)
3	0.5	70	3	3.5	5.5
4	0.5	80	3	3.0	7.0
5	0.5	90	3	4.5	8.0
6	0.5	100	4	5.0	9.0
8	1.0	120	4	5.5	11.5
10	1.0	140	4	6.5	14.0
12	1.0	160	4	7.5	16.5
15	1.3	190	4	8.5	20.0
20	1.7	240	5	10.5	26.0
25	2.0	290	5	13.0	32.0

Heated element butt welding (temperature at the heating tools 250 - 270 °C acc. to DVS 2207-15)

Pipe da mm	Heating up/ Heating up time s	Conversion/ max. adm. conversion time s	Cooling down/ Cooling down time clamped s	total min
16	4	4	6	2
20	6	4	12	2
25	8	4	12	2
32	10	6	18	4
40	12	6	18	4
50	18	6	24	4
63	20	8	24	6
75	22	8	30	6
90	25	8	40	6
110	30	10	50	8

Extrusion welding

Special endless screws which are approved for PVDF by the extruder producer must be used for extrusion welding of PVDF.

Ultra sonic and high frequency welding (remote field welding)

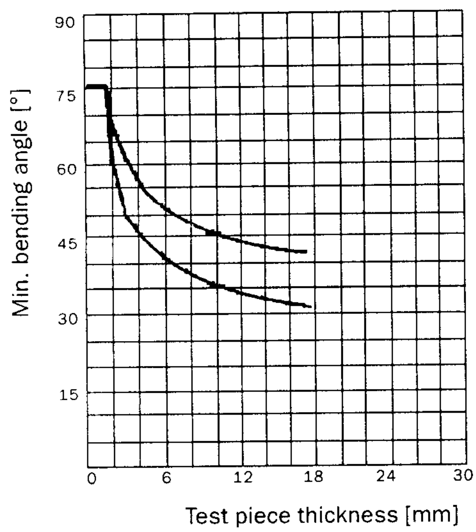
In the case of US welding, grooves must be provided as sound directors. HF welding is possible for 2 mm sheets with preheated electrodes. As the machines vary considerable, it is advisable to determine the adjustment parameters by means of preliminary tests.

Weld seam quality

The welding parameters determined by means of bending and tensile tests inform about the quality of the weld seam. Short-term factors count for loading times of up to 1 hour. Therefore, only long-term factors should be used for calculating fabricated constructions.

	Hot gas welding	Heated element butt welding
Short term factor	0.8	0.9
Long term factor	0.4	0.6

Dependance of minimum bending angle of SIMONA® PVDF as a function of the test piece thickness



Checking of weld seams with high-voltage spark tester

The quality of the weld seams can be tested with a high-voltage generator (spark coil) - adjustable between 10 to 55 KV maximum voltage, frequences of 20 to 40 KHz. Any weak points are indicated either by formation of sparks or, depending on machine type, by an acoustic signal. A test voltage of 3 - 4 KV/mm sheet thickness is suitable for PVDF. It must not exceed 25 KV.

Thermoforming

A distinction must be made between heating on a vac-forming machine and forming under vacuum, and heating in a oven and shaping using either top or bottom dies or blowing with over pressure.

Vacuum forming

All types of machines are suitable. In the case of panels from a wall thickness of 3 mm, it is recommended that they are heated both sides in order to achieve shorter heating up times (40 to 60 s/mm wall thickness). In the case of panel thicknesses over 6 mm, machines with a high heat output requiring reduced heat output or intermittent heating are better for heat penetration.

In order to achieve plastification during clamping, the panel must be protected from draughts. The use of secondary air during the heating up process is recommended in order to avoid uneven heating (sheet deformation). The natural coloured SIMONA® PVDF becomes transparent when the shaping temperature is reached (above the crystalline melting range).

Pre-stretching the panel before shaping creates a uniform wall thickness distribution and is achieved particularly in the case of positive moulding. After vacuum forming and solidification of the surface, air (also with water added) can be used for further cooling. A high shaping temperature, slow cooling speed and low de-moulding temperature (about 40 °C) followed immediately by trimming the edges produce components with little distortion.

Shrinkage (difference between the moulding size and the tool size) is 1 to 3 %, principally in extrusion direction of the panel, depending on the shape and processing conditions.

Pressure forming

The panel, preferably clamped in a frame, is heated in a hot air oven to 175 °C. In order to achieve a short dwell time (3 to 4 min/mm) a circulating air oven with temperatures to 200 °C is recommended. The time between removing the panel from the oven and shaping should be kept to a minimum. The use of preheated air is advantageous when blowing.

In this way stretch-backed PVDF panels can be shaped to form dished tank ends and parts which are easy to shape. Shaping ratios of up to 1 : 1.4 can be achieved. Stretch-backed panels may only be heated to one side when using radiators.

The stretch-fabric can actually be shaped 3-dimensionally, but the distribution of wall thickness will not be that even as with non-backed sheets, because of the different surface temperature.

Tools

Wood, aluminium and polyester or epoxy resin can be used for tool making. High thermal conductivity of the material and cooled moulds increase the economic factor and produce more uniform shaping conditions.

Edge radii of 2 to 3 times the sheet thickness should be chosen. A taper of 5° to 10° in the case of positive moulds and the use of separators facilite demoulding. In order to evacuate the space between the panel and the tool, bores of ≤ 1 mm are necessary. Sandblasted or rough tool surfaces aid the process and provide smooth surfaces.

Bonding with solvent type adhesives

Because of its high chemical resistance, PVDF cannot be glued without special measures.

The surfaces, which have been keyed and degreased with acetone, are coated with the special SIMONA® PVDF adhesive and joined at 150 °C after allowing a reaction time of about 3 min. Bonding pressure: approximately 0.3 N/mm^2.

The adhesive contains a portion of PVDF dissolved in a solvent. The solid matter remaining in the joint after 'flashing off' has more or less the same resistance as the semi-finished product used. However, the constructional load capacity is less than in the case of a welded joint.

Bonding with thermoset resins
PVDF cannot be coated with resins without the use of adhesive agents. We recommend sheets with a stretch-backing or pipes with chemically pre-treated surface.

High bonding values with polyester or epoxy resin can be achieved as a result of the adhesive agent being firmly anchored in the sheet or tube. The first coat of resin must completely impregnate the covering when using stretch-backed sheets.

Our experience has shown that the quality of the resin has a considerable influence on the tensile strength of the laminate. The typical values specified in the table were determined in connection with Palatal A 410. The use of high temperature resistant polyester or epoxy resins is recommended in the case of temperatures exceeding 80 °C.

The chemically pre-treated PVDF-pipe only uses inorganic substances instead of an organic backing (PVDF-SK) which have a positive effect on the adhesive strength of the joint (see table „Adhesive strength“ below) due to the high requirements when using PVDF (increased temperature, very aggressive media).

The pipes which have been surface treated in accordance with a patented method (patent owner ATOCHEM, Paris), allows laminating without further preparation. The shearing strength requested by DIN 16 964 part 3 of 5 N/mm^2 is greatly exceeded. As a result of the stress-free production and thermal treatment of the SIMONA® PVDF-pipes, the bond contains no additional stresses (shrinkage at high temperatures).

Guideline: PVDF may be used up to a temperature of approximately 100 °C in composite systems. This upper temperature limit however does not apply for every system, but needs to be agreed for each individual case (temperature intervals, geometries, etc).

For the purpose of applying resin, in the case of pressure pipes, the user needs to melt in a wide meshed fabric.

Test		Test method		Guide value [N/mm^2]	
sheet	pipe	sheet	pipe	sheet	pipe
Adhesive strength	Ring shearing test up to da d_a 110 mm Segment shearing test strating from d_a 125 mm	in accordance to DIN 53397 v = 5 mm/min	following DIN 16964, p. 3 v = 5 mm/min	23 °C 7.5 40 °C 6.5 60 °C 5.4 80 °C 3.5 100 °C 2.5 120 °C 2.0	23 °C 8.5 40 °C 7.0 60 °C 5.5 80 °C 4.5 100 °C 3.5

SIMONA

Advice

Our Sales and Technical Application personnel have a long experience in the use and processing of thermoplastic semi-finished products. We will be pleased to give you any further advice you may require.

SIMONA

CEE-Safety Data Sheet according to 91/155/EWG

Trade name: **SIMONA® PVDF / PVDF-pipe / PVDF-CV-pipe / PVDF-CL**

7/1998

1. Indications to the manufacturer

SIMONA AG
Teichweg 16
D-55606 Kirn

Phone (0 67 52) 14-0
Fax (0 67 52) 14-211

2. Composition / Indications to components

Chemical characteristics: Polyvinylidenefluoride
CAS-number: not necessary

3. Possible dangers

unknown

4. First-aid measures

General comment: medical aid is not necessary

5. Fire-fighting measures

In case of fire please use gas mask and breathing equipment independing of circulating air. Fire residues must be disposed of according to the local instructions.

Suitable fire-fighting appliance: water fog, foam, fire fighting powder, carbon dioxide

6. Measures in case of unintended release

not applicable

7. Handling and storage

Handling:
1. Working rooms must dispose of good ventilation, separate flue has to be installed.
2. Do not expose to open flame.
3. Do not smoke in such areas where an accumulation of PVDF dust has to be expected.
4. When welding please avoid an exceeding of the recommended air and tool temperature.

When not observing these safety instructions people can suffer from teflon fever (high fever with symptoms of influenza). Medical aid is necessary.
Storage: unlimited good storage property

8. Limitation of exposition

Personal protective equipment not necessary

Trade name: **SIMONA® PVDF / PVDF-pipe / PVDF-CV-pipe / PVDF-CL**

7/1998

9. Physical and chemical characteristics

Phenotype:
form: semi-finished product
colour: different
smell: not distinguishable

Change of state:
crystallite melting point: 170 - 172 ° C
density: 1.78 g/cm³

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10. Stability and reactivity

Thermal decomposition: from 350° C
Dangerous decomposition products:
Above 350 °C decomposition in toxic fluor containing substances. During the burning process hydrofluoric acid, carbon dioxide and water will develop, in case of incomplete burning also carbon monoxide and low molecular fluorocarbons may arise.

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11. Toxic indications

During several years of usage no effects being harmful for the health were observed.

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12. Ecological indications

No biodegradation, no solubility in water, no effects being harmful to the environment must be expected.

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13. Waste-disposal indications

Can be recycled or can be disposed of together with household rubbish (acc. to local regulations).

Waste key for the unused product: 57 126
Waste name: waste of fluoro-plastics

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14. Transport indications

No dangerous product in respect to / according to transport regulations

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15. Instructions

Marking according to GefStoffV/EG: no obligation for marking
Water danger class: class 0 (self classification)

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16. Further indications

The indications are based on our todays knowledge. They are meant to describe our products in respect to safety requirements. They do not represent any guarantee of the described product in the sense of the legal guarantee regulations.

CEE-Safety Data Sheet according to 91/155/EWG

Trade name: **SIMONA® PVDF-EL**

7/1998

1. Indications of manufacturer

SIMONA AG
Teichweg 16
D-55606 Kirn

Phone (0 67 52) 14-0
Fax (0 67 52) 14-211

2. Composition / Indications to components

Chemical characteristics: Polyvinylidenefluoride
CAS-number: not necessary

3. Possible dangers

unknown

4. First-aid measures

General comment: medical aid is not necessary

5. Fire-fighting measures

In case of fire please use gas mask and breathing equipment independing of circulating air. Fire residues must be disposed of according to the local instructions.

Suitable fire-fighting appliance: water fog, foam, fire fighting powder, carbon dioxide

6. Measures in case of unintended release

not applicable

7. Handling and storage

Handling:
1. Working rooms must dispose of good ventilation, separate flue has to be installed.
2. Do not expose to open flame.
3. Do not smoke in such areas where an accumulation of PVDF dust has to be expected.
4. When welding please avoid an exceeding of the recommended air and tool temperature.

When not observing these safety instructions people can suffer from teflon fever (high fever with symptoms of influenza). Medical aid is necessary.
Storage: unlimited good storage property

8. Limitation of exposition

Personal protective equipment not necessary

9. Physical and chemical characteristics

Phenotype:		Change of state:	
form:	semi-finished product	crystallite melting point:	170 - 172 ° C
colour:	black	density:	1.78 g/cm^3
smell:	not distinguishable	conductibility:	≤ 10^6 Ohm

10. Stability and reactivity

Thermal decomposition: from 350° C
Dangerous decomposition products:
Above 350 °C decomposition in toxic fluor containing substances. During the burning process hydrofluoric acid, carbon dioxide and water will develop, in case of incomplete burning also carbon monoxide and low molecular fluorocarbons may arise.

11. Toxic indications

During several years of usage no effects being harmful for the health were observed.

12. Ecological indications

No biodegradation, no solubility in water, no effects being harmful to the environment must be expected.

13. Waste-disposal indications

Can be recycled or can be disposed of together with household rubbish (acc. to local regulations).

Waste key for the unused product: 57 126
Waste name: waste of fluoro-plastics

14. Transport indications

No dangerous product in respect to / according to transport regulations

15. Instructions

Marking according to GefStoffV/EG: no obligation for marking
Water danger class: class 0 (self classification)

16. Further indications

The indications are based on our todays knowledge. They are meant to describe our products in respect to safety requirements. They do not represent any guarantee of the described product in the sense of the legal guarantee regulations.