Schaffhausen, October 23rd, 2019

Rev. 01

Technical Handbook
SYGEF ECTFE

1 System and product solution

This technical handbook applies to the Georg Fischer SYGEF ECTFE product range manufactured by Georg Fischer Fluoropolymer Products GmbH.

1.1 SYGEF ECTFE

The ECTFE system made of ethylene-chlorotrifluoroethylene shows excellent physical properties and mechanical characteristics. The high-performance fluoropolymer material allows applications in a very broad temperature range of -76°C to +140°C (-105°F to 284°F), on a welded system approach for the use of aggressive chemicals approved between 0°C up to 80°C (32°F to 176°F). Thanks to its extremely good chemical resistance, excellent abrasion resistance and high impact strength, ECTFE meets all requirements of demanding industrial environments. The SYGEF ECTFE system in combination with the most advanced IR-jointing technology is dedicated for demanding applications in segments like Chemical Process Industry, Water Treatment and Microelectronics.

Pipes

Fittings

Jointing technology

Essential system properties:

- Extreme corrosion resistant and reliable to highly concentrated chemicals
- Inert towards stress cracking media
- Outstanding permeation resistance
- High temperature and UV-resistance

Most important market segments:

- Chemical process industry
- Water treatment
- Microelectronics

1.2 Technical Data

Nominal pressure	10 bar (150PSI)
Temperature range on chemicals	0°C to +80°C (32°F-176°F)
Temperature range material	-76°C to 130°C (105° F - 266° F) [140°C/284°F][1]
Jointing technology	Infrared (IR) fusion
	Mechanical joints
Standards and guidelines	ISO, EN, DIN, DVS

1) Short term exposure

1.3 Product overview

SDR21/ PN10

Products	d20 DN15	d25 DN20	d32 DN25	d40 DN32	d50 DN40	d63 DN50	d75 DN65	d90 DN80	d110 DN100
Pipes									
Fittings									
Unions									
Flange rings									
Gaskets									
Valves[2]									
Automation									
Pipe supports[3]									
IR fusion machines									

2) on request (PVC/PVDF BV546 Pro with ECTFE valve ends, Type SDV SSt/PFA, BuV 065, etc.)

3) Stress Less Pipe support system recommended

2 Material

As raw material for pipes only HALAR 901S ECTFE from Solvay may be used, HALAR 350LC ECTFE for fittings.

2.1 ECTFE material properties

Property	Value[3]	Unit	Test standard
Density	1.68	g/cm³	EN ISO 1183-1/ ASTM D792
Yield stress at 23°C (73°F)	≥ 30	N/mm²	EN ISO 527-1
Tensile e-modulus at 23°C (73°F)	≥ 1600	N/mm²	ISO 527-1
Charpy notched impact strength at 23 °C (73°F)	no break	kJ/m²	EN ISO 179/1eA
Charpy notched impact strength at 0°C (32°F)	≥ 6	kJ/m²	EN ISO 179/1eA
Heat distortion temperature HDT (1.82 MPa)	≥ 65	°C	ASTM D648
Crystallite melting point	≥ 240	°C	ISO 11357-3, DSC/ ASTM D3418
Thermal conductivity at 40°C (104°F)	0.20	W/mK	ASTM C177
Water absorption at 23°C/24 h	≤ 0.07	%	EN ISO 62
Color	opaque	-	-
Limiting oxygen index (LOI)	≥ 50	%	ASTM D 2863

[3)] Typical characteristics measured at the material should not be used for calculations.

UV and weather resistance

ECTFE is very weather-resistant. Even longer exposure to direct sunlight, wind and rain causes very little change in properties or appearance of the material. Contact the responsible GF Piping Systems representative for more detailed information.

Chemical resistance

ECTFE shows an outstanding resistance against a broad range of media. For detailed information, observe the list of chemical resistance from GF Piping Systems or contact the responsible GF Piping Systems representative.

Abrasion resistance

For the use of ECTFE in abrasive applications please contact your GF Piping Systems representative.

Application limits

The application limits of the material on the one hand depend on embrittlement and softening temperatures and on the other hand on the nature and the expected service life of the application. The pressure-temperature diagrams give details on application temperatures and pressures.

Combustion behavior

ECTFE displays an exceptionally good combustion behavior without the addition of fire protection additives. Material decomposition starts at 300 °C (572°F), heating above 350°C (662°F) must be strictly avoided. The oxygen index is 44-52 % (with less than 21 %, the material is considered to be flammable). Since the combustion of ECTFE produces hydrogen fluoride and hydrogen chloride, which form corrosive acids in connection with water, immediate cleaning of areas susceptible to corrosion with water containing detergent is necessary after a fire. Additional combustion products are carbon monoxide and carbon dioxide. Suitable fire-fighting agents are sand and extinguishing powder. The use of water can lead to corrosive acids.

Electrical properties

ECTFE is, like all unmodified thermoplastics, non-conductive. This means that no electrochemical corrosion takes place in ECTFE systems. On the other hand, these non-conductive characteristics have to be taken into account because an electrostatic charge can develop in the piping. Special attention must be paid to this fact in environments in which explosive gases may occur. Various methods are available to prevent the occurrence of electrostatic charges. GF Piping Systems representatives can provide support in selecting the right one.

The specific volume resistance is greater than 10^{15} Ω cm and the specific surface resistance is above 10^{14} Ω cm.

Physiological properties

ECTFE is physiologically non-toxic as long as it is used at temperatures up to a maximum of 140 °C (284°F). During processing, adequate ventilation must be ensured and developing gases must be vented.

2.2 Advantages of ECTFE

- Outstanding chemical resistance
- Long service life, even under intensely corrosive conditions
- Outstanding resistance against UV and γ-radiation
- Reliable jointing by high-quality fusion technology
- Very low thermal conductivity
- Excellent flame retardant properties

3 Design and Installation

The choice of material and the pressure rating of the pipe components are important for both operating safety and for attaining the specified minimum service life of the system.

The decisive influencing factors are the following:

- Operating pressure
- Operating temperature
- Medium transported
- Duration of stress

Separate calculations are necessary if design factors are different or the service life is modified. The suitability of the material for the flow medium can be determined from the list of chemical resistance provided separately by GF Piping Systems.

3.1 Pipeline Design

Material: ECTFE

MRS value (MPa): 18

3.2 Long-term behavior

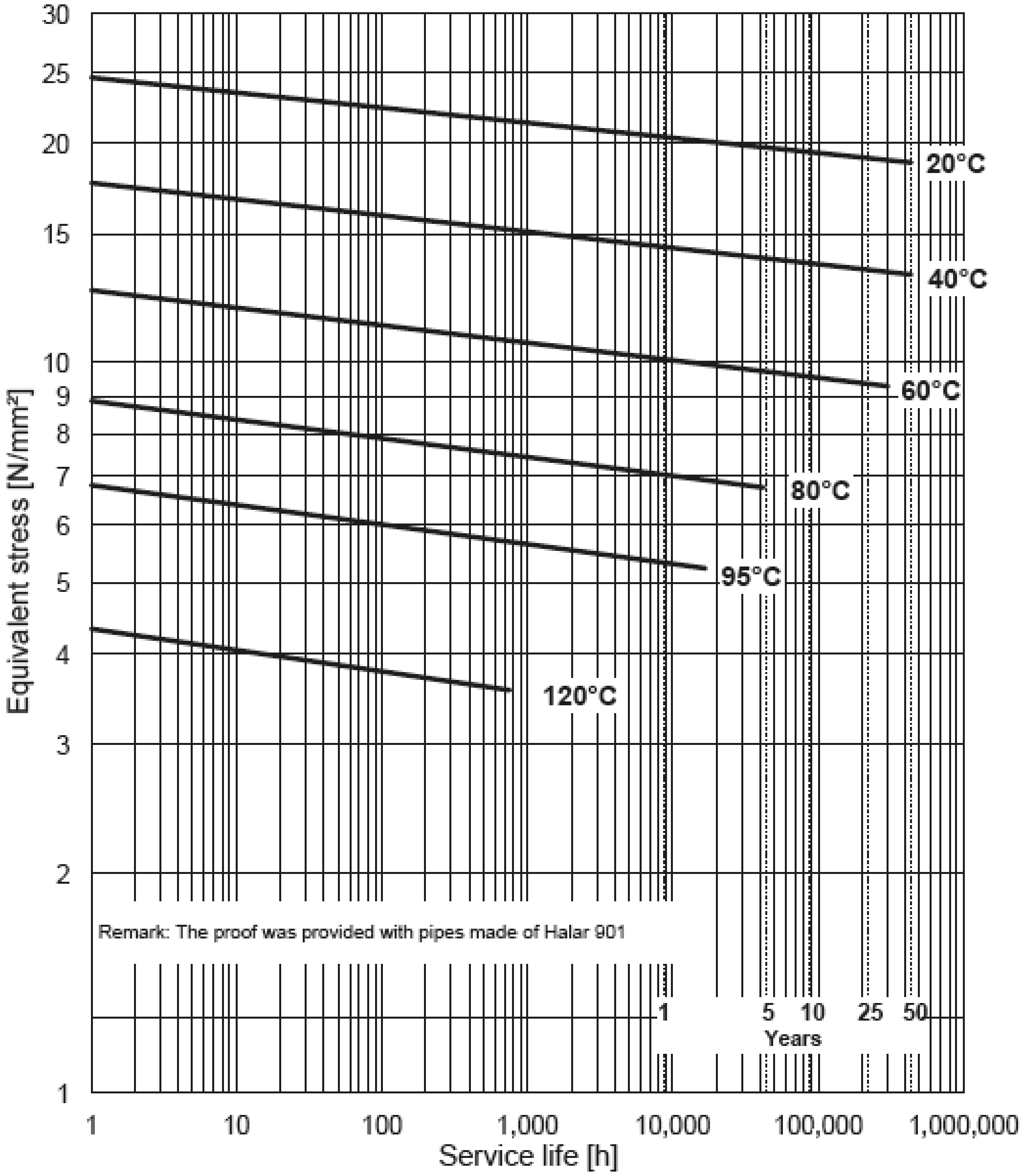
Calculation (EN ISO 9080)

The following long-term behavior shows the long-term behavior of ECTFE. For the temperature range from 0 °C to +80 °C (32°F-176°F), fracture lines are displayed. These are called LPL curves (Lower Predictable Limit); this means according to the definition that 97.5 % of all fracture points are on or above the corresponding curve.
The curves are plotted in a double logarithmic diagram (i.e. not linear). Please take this into account when reading values for stress or time.
The long-term behavior was calculated by using the extrapolation method according to EN ISO 9080. With the following equation (4-parameter model), which was derived from the diagram, stress, temperature or time can be calculated for the temperature range of 0 °C to +80 °C (32°F-176°F),.

Long-term behavior diagram

5 5E-CTFE (ethylene chlorotrifluoroethylene)

5.1 Creep curves for pipes



Straight line equation:
lg(t) = A + B/T × lg(σ) + C/T + D × lg(σ)

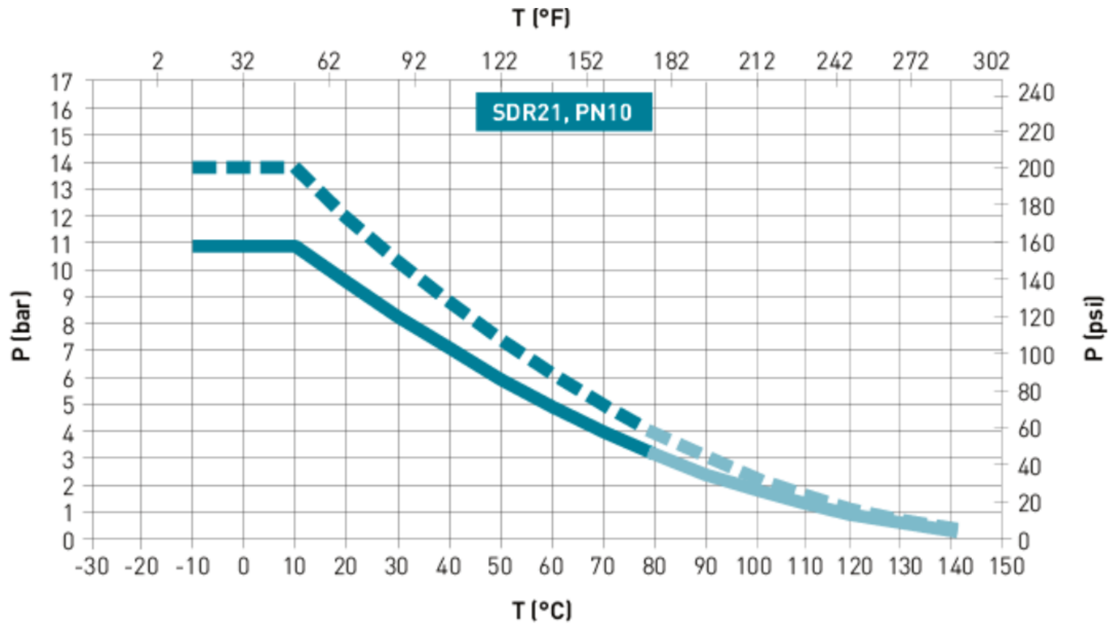
Coefficients of the minimum curves:
A = –149.9727
B = –30,448.284
C = 63,064.546
D = 56.9484

3.3 Pressure-temperature diagram

The pressure-temperature diagram that we provide for pipe and fittings made of ECTFE is derived from the long-term behavior, including the design factor, for a service life of 25 years.

The design factor of 2.0 (or 1.6) recommended by GF Piping Systems has been incorporated. It can be used for water or media resembling water, in other words, media that have no reduction factor for chemical resistance.

Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.



P Permissible pressure in bar, psi

T Temperature in °C (Celsius), °F (Fahrenheit)

---- C = 1.6
—— C = 2.0

GFPS recommends to use C=2.0 in order to include the reduction factor of 0.8 for weld joints.

The pressure/ temperature curve based on medium water, operating temperature of 20°C, valid life time of 25 years and the design factor of C = 2.0 or C = 1.6 respectively

More information regarding technical specifications can be found online in our planning fundamentals: www.gfps.com

For any additional project support like engineering, design and installation or chemical resistance please contact gss@georgfischer.com

3.4 Calculation of length changes

The change in length caused by temperature can be calculated using the following formula:

$\Delta L = L * \Delta T * \alpha$

ΔL Temperature-related length change (mm)

L Length of the pipe section (m)

ΔT Difference of temperature (K)

α Coefficient of linear expansion (mm/mK)

α = mm/mK 0.08 – 0.135 (20°C – 100°C)

3.5 Pipe bracket spacing for ECTFE piping systems

Liquids with a density of 1 g/cm³

d (mm)	Bracket spacing L for pipe PN10 / SDR21 (mm)										
	≤20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	110°C	120°C
20	750	650	600	550	500	450	400	400	350	350	300
25	850	700	650	600	550	500	450	400	400	350	350
32	950	850	750	700	650	600	550	500	450	450	400
40	1050	950	850	750	700	650	600	550	500	500	450
50	1250	1100	1000	900	800	750	700	650	600	550	500
63	1400	1200	1100	1000	900	850	750	700	650	600	550
75	1550	1350	1200	1100	1000	950	850	800	750	700	650
90	1700	1500	1350	1250	1150	1050	950	900	850	800	700
110	1850	1650	1550	1450	1300	1200	1100	1000	950	900	800

d (mm)	Bracket spacing L for pipe PN10 / SDR21 (feet)										
	≤68°F	86°F	104°F	122°F	140°F	158°F	176°F	194°F	212°F	230°F	248°F
20	2.5	2.1	2	1.8	1.6	1.5	1.3	1.3	1.1	1.1	1
25	2.8	2.3	2.1	2	1.8	1.6	1.5	1.3	1.3	1.1	1.1
32	3.1	2.8	2.5	2.3	2.1	2	1.8	1.6	1.5	1.5	1.3
40	3.4	3.1	2.8	2.5	2.3	2.1	2	1.8	1.6	1.6	1.5
50	4.1	3.6	3.3	3	2.6	2.5	2.3	2.1	2	1.8	1.6
63	4.6	3.9	3.6	3.3	3	2.8	2.5	2.3	2.1	2	1.8
75	5.1	4.4	3.9	3.6	3.3	3.1	2.8	2.6	2.5	2.3	2.1
90	5.6	4.9	4.4	4.1	3.8	3.4	3.1	3	2.8	2.6	2.3
110	6.1	5.4	5.1	4.8	4.3	3.9	3.6	3.3	3.1	3	2.6

Pipe bracket spacing for lines running vertically can be increased by 30 % with respect to the values in the table, i.e. table values multiplied by 1.3.

Liquids with a density other than 1 g/cm³

If the liquid to be transported has a density not equal 1 g/cm³, then the bracket spacing in the table above should be multiplied by the factor given in the following table to obtain different support spacings.

Density of medium (g/cm³)	Type of medium	Factors for bracket spacing
1.00	Water	1.00
1.25	Other media	0.96
1.50		0.92
1.75		0.88
2.00		0.84
≤ 0.01	Gaseous media	1.48 for SDR33 and PN10
		1.36 for SDR21 and PN16

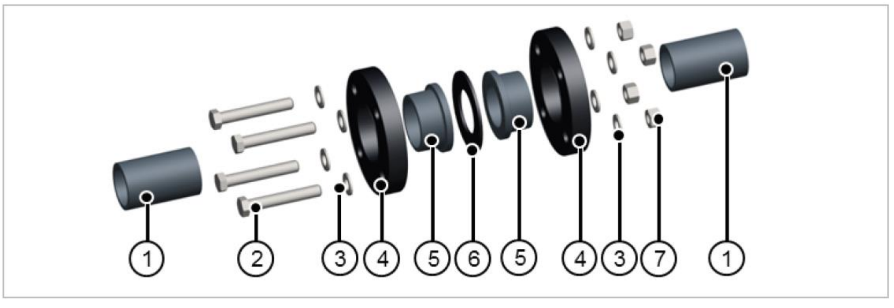
3.6 Vacuum applications

Maximum application temperatures under vacuum (1 bar or 15PSI differential partial vacuum) or under 0.4 bar (6PSI) differential partial vacuum for PVDF PN10 system

Material	PN (bar)	SDR	Max.Temperature
PVDF for Δp = 0.4 bar (6PSI)	10 (150 PSI)	33	20°C (68°F)
PVDF for Δp = 1.0 bar (15PSI)	16 (232 PSI)	21	40 (104°F)
ECTFE for Δp = 1.0 bar (15PSI)	10 (150 PSI)	21	40 (104°F)

3.7 Flange connections

Flanges with sufficient thermal and mechanical stability must be used. The different flange types by GF Piping Systems fulfill these requirements. The gasket dimensions must match the outer and inner diameter of the flange adapter or valve end. Differences between the inner diameters of gasket and flange that are greater than 10 mm may result in malfunctioning flange connections.



1. Pipe
2. Bolt
3. Washer
4. Flange
5. Valve end/flange adapter
6. Flange seal
7. Nut

Orientation of bolts beyond the two main axes

- For horizontal piping systems, the orientation shown of the bolts beyond the main axes (see the following figure) is preferred since possible leaks at the flange connection do not cause the medium to run directly onto the bolts.

Flange with main axes (centered, crosswise)

- Flange adapter, valve end or fixed flange, gasket, as well as backing flange, must be aligned centered on the pipe axis.
- Before pre-tightening the bolts, the jointing faces must be flush with each other and must fit tightly against the gasket. Pulling badly aligned flanges together within the flange connection must to be strictly avoided because of the resulting tensile stress.

Selecting and handling bolts

- The length of the bolts should be selected in such a way that the bolt thread does not protrude more than 2 to 3 turns of the thread at the nut. Washers must be used at the bolt head as well as the nut.
  - To ensure that the connecting bolts can be easily tightened and removed after a lengthy period of use, the thread should be lubricated, e.g. with molybdenum sulphide
  - Tightening the bolts by using a torque wrench
- The bolts must be tightened diagonally and evenly: First, tighten the bolts by hand so that the gasket is evenly contacting the jointing faces. Then tighten all bolts diagonally to 50 % of the required torque, followed by 100 % of the required torque. The recommended bolt tightening torques are listed in the table “Bolt tightening torque guidelines for ISO flange connections”. However, deviations may occur in practice, e.g. through the use of stiff bolts or pipe axes that are not aligned. The Shore hardness of the gasket can also influence the necessary tightening torque.
- We recommend checking the tightening torques 24 hours after assembly according to the specified values and, if necessary, retighten them. Always tighten diagonally here, as well.
- After the pressure test, the tightening torques must be checked in any case and, if necessary, retightened.

i For more information on flange connections, see DVS 2210-1 Supplement 3.

Tightening the bolts using a torque wrench

However, deviations may occur in practice, e.g. through the use of stiff bolts or pipe axes that are not aligned. The Shore hardness of the gasket can also influence the necessary tightening torque.

In the area of flexible sections and expansion loops, no bolt connections or flange connections should be used since the bending stress may cause leaks.

Bolt tightening torque guidelines for metric (ISO) flange connections with PP-V, PP- steel and PVC flanges

The indicated torques are recommended by GF Piping Systems. These torques already ensure a sufficient tightness of the flange connection. They deviate from the data in the DVS 2210-1 Supplement 3, which are to be understood as upper limits. The individual components of the flange connection (valve ends, flange adapters, flanges) by GF Piping Systems are dimensioned for these upper limits.

Pipe outer diameter d (mm)	Nominal diameter DN (mm)	No. of bolts	For PROGEF PP, SYGEF PVDF, ecoFIT PE, ABS, PVC-U/C metric systems, with PP-Steel, PP-V and PVC-U flanges (Nm)						
			Flat gasket, lubed	Flat gasket, unlubed	Profile gasket, lubed	Profile gasket, unlubed	O-ring, lubed	O-ring, unlubed	SYGEF HP gasket unlubed
d16	DN10	4	10	13	10	13	10	13	-
d20	DN15	4	10	13	10	13	10	13	-
d25	DN20	4	10	13	10	13	10	13	14
d32	DN 25	4	15	20	10	13	10	13	16
d40	DN 32	4	20	26	15	20	15	20	20
d50	DN 40	4	25	33	15	20	15	20	26
d63	DN 50	4	35	46	20	26	20	26	34
d75	DN 65	4	50	65	25	33	25	33	38
d90	DN 80	8	30	39	15	20	15	20	45
d110, 125	DN 100	8	35	46	20	26	20	26	30
d140	DN 125	8	45	59	25	33	25	33	-
d160, 180	DN 150	8	60	78	35	46	30	39	49
d200, 225	DN 200	8	70	91	45	59	35	46	65
d250, 280	DN 250	12	65	85	35	46	30	39	65
d315	DN 300	12	90	117	50	65	40	52	76
d355	DN 350	16	90	117	50	65	-	-	223
d400	DN 400	16	100	130	60	78	-	-	176
d450, 500	DN 500	20	190	247	70	91	-	-	264
d560, 630	DN 600	20	220	286	90	117	-	-	-

Bolt tightening torque guidelines for ASME flange connections with PP-V, PP-steel and PVC flanges

Flange size (inch)	Nominal diameter DN (mm)	No. of bolts	For PROGEF PP, SYGEF PVDF and ecoFIT PE systems, with PP-Steel and PP-V flanges (ft-lb)				
			Flat gasket, lubed	Flat gasket, unlubed	SYGEF HP gasket, unlubed	Profile gasket, lubed	Profile gasket, unlubed
½"	DN15	4	7	9	-	5	7
¾"	DN20	4	9	12	10	7	9
1"	DN25	4	11	14	12	9	12
1¼"	DN32	4	14	18	15	10	13
1½"	DN40	4	16	21	19	13	17
2"	DN50	4	28	36	25	19	25
2½"	DN65	4	43	56	28	21	27
3"	DN80	4	47	61	33	25	33
4"	DN100	8	30	39	22	16	21
6"	DN150	8	45	59	36	25	33
8"	DN200	8	52	68	48	33	43
10"	DN250	12	56	73	48	31	40
12"	DN300	12	64	83	56	37	48
14"	DN350	16	66	75	165	49	64
16"	DN400	16	75	80	130	45	59
18"	(DN450)	16	120	132	195	56	73
20"	DN500	20	140	154	-	60	78

⚠ **Please observe the special bolt tightening torques listed for butterfly valves. See also the section "Planning fundamentals for butterfly valves, hand-operated".**

Installation recommendation:

Either the bolt or the nut, and preferably both, should be zinc-plated to ensure minimal friction.

- zinc-on-zinc, with or without lube
- zinc-on-stainless-steel, with or without lube
- stainless-on-stainless, with lube only

Cadmium-plated fasteners are also acceptable with or without lubrication. Galvanized and carbon-steel fasteners are not recommended. Use a copper-graphite anti-seize lubricant to ensure smooth engagement and the ability to disassemble and reassemble the system easily.

Length of bolts

In practice, it is often difficult to specify the correct bolt length for flange connections. It can be derived from the following parameters:

- Thickness of the washer (2x)
- Thickness of the nut (1x)
- Thickness of the gasket (1x)
- Flange thickness (2x)
- Thickness of flange collar (valve end or flange adapter) (2x)
- Valve installation length, if applicable (1x)

According to DVS 2210-1, you should dimension the necessary bolt length for flange connections so that 2-3 turns of the thread protrude beyond the nut.

Online tool "Bolt lengths and tightening torques" located at www.gfps.com/tools

3.8 Storage

The pipe storage surface must be level and free of stones. Pipe must be layered and stacked in a way that avoids the risk of damage or permanent deformation. Larger-diameter, thin-walled pipe must be fitted with stiffening rings. Avoid single-point or narrow longitudinal supports.

The following table gives recommended maximum stacking heights for non-pallet pipe storage. Provided pipe are stacked on pallets and protected against sideways movement, the nominal stacking heights specified in the table may be increased by 50%. Pipe storage areas should be as well-protected as possible. Absorption of oil, solvents and other chemicals must be avoided at all costs during storage.

Stored pipe must not be exposed to the elements more than absolutely necessary, i.e. they should be kept in a covered warehouse. If stored outdoors (e.g. on a construction site), they should be covered with sheeting for protection against the weather (e.g. UV radiation).

One-sided warming from exposure to the sun could cause deformations.

Pipe and parts should be used in the order of manufacture/delivery, to ensure proper warehouse turnover of the plastic material.

The permissible stacking height of SYGEF ECTFE is 1 meter.

4 Pressure test commissioning

The internal pressure test is done when installation work has been completed and presupposes an operational pipeline or operational test sections. The test pressure load is intended to furnish experimental proof of operational safety. The test pressure is not based on the operating pressure, but rather on the internal pressure load capacity, based on the pipe wall thickness.

Addendum 2 of DVS 2210-1 forms the basis for the following information. This replaces the data in DVS 2210-1 entirely. The modifications became necessary because the reference value "nominal pressure (PN)" is being used less and less to determine the test pressure (1.5 x PN, or 1.3 x PN) and is being replaced by SDR. In addition, a short-term overload or even a reduction in the service life can occur if the pipe wall temperature TR = 20 °C (68°F) is exceeded by more than 5 °C (41°F) in the course of the internal pressure test based on the nominal pressure.

Test pressures are, therefore, determined in relation to SDR and the pipe wall temperature. The 100-h value from the long-term behavior diagram is used for the test pressure.

Test parameters

The following table provides recommended methods for performing the internal pressure test.

Object	Pre-test	Main test
Test pressure Pp (depends on the pipe wall temperature and the permissible test pressure of the built-in components, see the section "Determining the test pressure")	≤ Pp (perm)	≤ 0.85 Pp (perm)
Test duration (depends on the length of the pipeline sections)	L ≤ 100 m: 3 h 100 m < L ≤ 500 m: 6 h	L ≤ 100 m: 3 h 100 m < L ≤ 500 m: 6 h
Checks during the test (test pressure and temperature progression must be recorded)	At least 3 checks, distributed over the test duration with restoring the test pressure	At least 2 checks, distributed over the test duration without restoring the test pressure

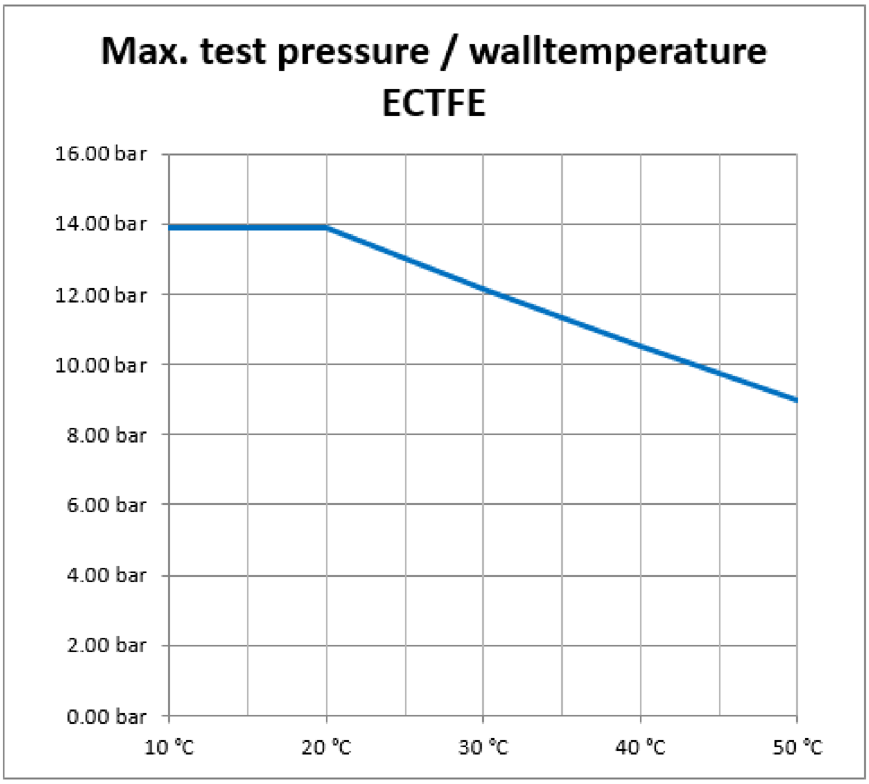
Pre-test

The pre-test serves to prepare the piping system for the actual test (main test). In the course of pre-testing, a tension-expansion equilibrium in relation to an increase in volume will develop in the piping system. A material-related drop in pressure will occur which will require repeated pumping to restore the test pressure and also frequently a re-tightening of the flange connection bolts.

Internal pressure test with water or a similar incompressible test medium. The permissible pressure drop is 0.9 bar/hour (13 PSI/hour).

Filling the pipeline

Determining the test pressure:



Long-term creep strength for pipe wall temperature (t= 100h), Sp= 1.6

S_p Minimum safety factor for pressure test (DVS2210-1Bbl.2) is 1.6

C_{min} Minimum safety factor (ISO 12162) @20°C / GF recommendation for industrial applications is 1.6 / C ≤ 60°C – Cmin = 1.6 ; T > 60°C – Cmin = 2.0

Disclaimer

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