Engineering Design of SYGEF-PVDF

Safety Factors

The SYGEF piping system has been designed with a safety factor of no less than 200%.

Calculating Effective Safety Factors and Permissible Operating Pressures

To calculate the safety factor and permissible operating pressure it is necessary to know the long term rupture stress of material (see Diagram).

This diagram allows the long term rupture stress K to be read depending on the desired operating life and working temperature. Since George Fischer fittings and valves are generally designed to withstand higher operating presures than pipe of the equivalent pressure rating, all calculations can be based on the outside diameter and wall thickness of the pipe.

The effective safety factor is given by the following formula:

$$C = \frac{K \cdot 20 \cdot e}{p \cdot (d - e)}$$

where:

C = safety factor (2 for PVDF)
K = long-term creep strength in psi
e = wall thickness in inch of pipe of a given pressure rating
d = outside diameter of pipe in inch
p = working pressure in psi
20 = constant

Example:
Intended operating life: 20 years
Max. operating temp.: 176°F
Max. operating pressure: 101.5 psi
Material: SYGEF-PVDF
Pressure rating: 232 psi
Pipe dimension: up to 3.543" (4" diameter) x 0.169"
K_{20} from Diagram: 275.5 psi

$$C = \frac{275.5 \cdot 20 \cdot 0.169}{101.5 \cdot (3.543 - 0.169)} = 2.7 > 2$$

Similarly, the permissible operating pressure is given by rewriting the formula above as:

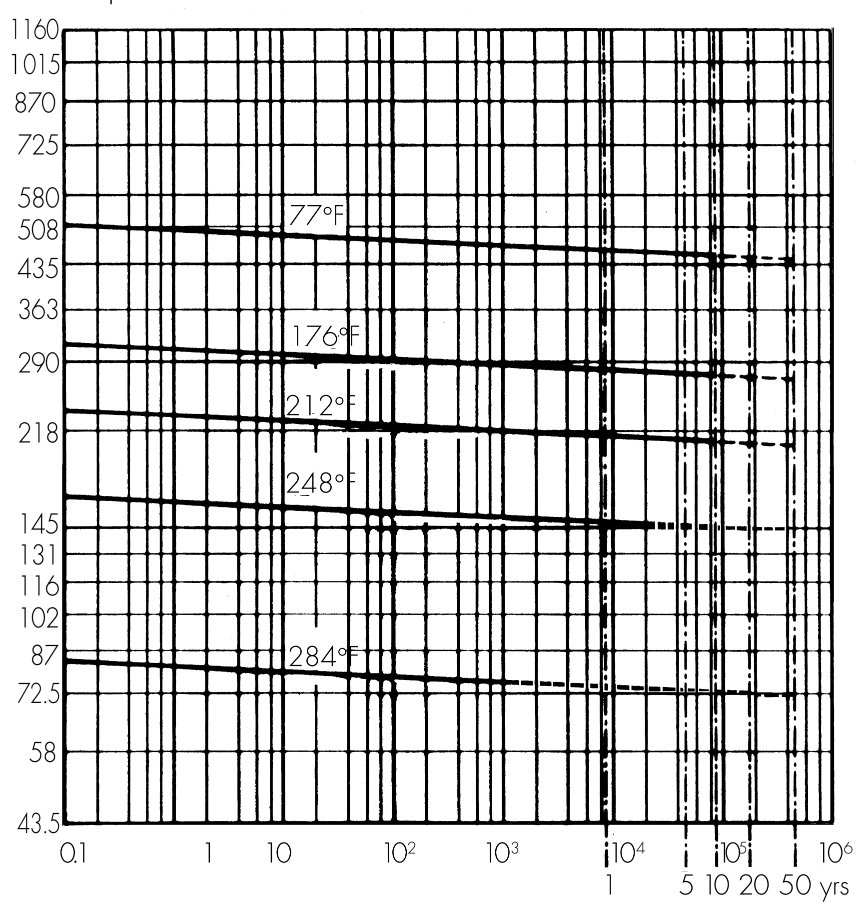
$$p = \frac{20 \cdot e \cdot \frac{K}{C}}{d - e}$$

For the sake of clarity, the calculations are carried out using the example above, but using the usual minimum safety factor for PVDF instead of the one calculated.

$$p = \frac{20 \cdot 0.169 \cdot \frac{275.5}{2}}{3.543 - 0.169} = 138 \text{ psi}$$

Long Term Strength of SYGEF-PVDF

Circumferential stress in psi



Safety factors are important in several areas, such as:

- *resistance to water hammer/pressure surge failures*
- *assuring that long term creep rates do not jeopardize the safety of a piping system (protection against creep rupture)*
- *accommodate weaknesses due to aging tendencies*
- *when high stresses due to compressive or contractive forces occur*

Safety Consideration

The safety of a piping system in any kind of service may only be as good as the integrity of the joining method and joint design itself.

For a safe, trouble free installation it's recommended to only work with trained and certified installers. Please contact your local George Fischer representative for a training session on state of the art welding technology and equipment.

Before putting a piping system into operation a hydraulic pressure test is strongly recommended. In section "Final Testing" a procedure for hydraulic testing is described.

Should during testing or during operation of the piping system the SYGEF pipe be overpressured hydraulically to the point of forced failure, the physical nature of the failure is that a relatively small blister or bubble forms, followed by a small slit forming at a right angle to the run of the pipe. Should other factors contribute to the failure, such as compressed air entrapped in the system, water hammer, incorrect designed support or hangers, miscalculated allowance for thermal expansion/ contraction, etc. the mode of failure may change.

Joint Strength

Several tests have been performed to test the ultimate SYGEF joint strength. The degree of safety factor found in SYGEF pipe is enhanced by an equally high degree of safety factor in the socket fusion joint, as evidenced by the following test results at 68°F/20°C:

Quick Burst
Joints are resistant to damage from 940 psi up to 1700 psi, varying with fitting diameter.

Pulsation Shock Test
Fully resistant beyond 500,000 cycles of pressure shock, with pulses from 60 psi to 232 psi, at a rate of one cycle per second.

Adherence to recommended joining procedures, with attention to good alignment of pipe and fitting will assure this same degree of joint strength in industrial installations.

Pressure Ratings

Operating temperature		Operating pressure for the following pressure ratings: 150 psi/10 bar		232 psi/16 bar	
°F	**°C**	**psi**	**bar**	**psi**	**bar**
-40	-40	150	10.0	232	16.0
68	20	150	10.0	232	16.0
104	40	117	8.1	190	13.1
140	60	96	6.6	152	10.5
176	80	75	5.2	117	8.1
212	100	58	4.0	90	6.2
248	120	42	2.9	67	4.6
284	140	27	1.9	13	3.0

Resistance to Creep

When a plastic is subjected to a constant static load, it deforms a certain amount quickly and then continues to deform at a lower rate indefinitely. If the loads is high enough, rupture will occur. This phenomenon, which occurs commonly in soft metals but also in structurally hard metals at high temperatures, is called creep. SYGEF exhibits an extremely low degree of creep which is virtually nil at full pressure ratings and loads. However, this is not so with other common thermoplastics. SYGEF exhibits such a low degree of creep even at high loads that it is difficult to find a basis for comparison to other fluoropolymers such as PTFE, FEP and PFA, since these materials exhibit such a high degree of creep. For example, at room temperature, at an applied stress of 3000 psi/207 bar, the degree of creep after 100 hours for FEP is 81%, whereas SYGEF measures 1.9%. This difference is also noticeable at higher temperatures, where a 500 psi/35 bar tensile load at 212°F/100°C will result in a creep rate of 20% for FEP, and just 3% for PVDF.

The practical importance of creep must be considered in terms of these points:

1. A solid piping system should not be manufactured out of a plastic which exhibits a high degree of creep. Unexpected long term burst failures could otherwise occur.
2. Safety factors are not predictable with materials of high creep rates.
3. A solid piping system manufactured from high creep rate materials could be rated only at a very low pressure.
4. The creep rate of the piping material at elevated temperatures should be tested and noted if exceedingly high. External piping reinforcement would be needed in such an application.

Final Testing

The completed system or section of piping should be hydrostatically low pressure tested before being put in service. Project specifications usually have a written procedure for testing. The generally accepted practice is to fill the system from the lowest point through a 1" or smaller line. The system should be completely vented to relieve entrapped air at the highest point. Once the test pressure is achieved the system should remain pressurized for at least 1 hour. The test pressure should exceed the maximum operating pressure but should not exceed 300 psi for a 232 psi rated system or 210 psi for a 150 psi rated system.

A pressure drop in the course of the test due to elongation is to be expected. If constancy of pressure throughout the test is important, we recommend a preliminary test with the same test pressure for at least as long a duration as the test itself. The main test must follow the preliminary test immediately.

The approximate rate of drop in pressure induced by elongation of PVDF pipes is 0.8 bar/h during a leak test without preliminary test.

A written record should be kept of the leak test.

CAUTION
Remaining air in the system is to be avoided under any circumstances; it may lead to a potentially dangerous situation should system failure occur. Testing with gaseous media or any other introduction of compressed gaseous media must not be done.

Operational Test

When the pipeline contains valves with actuators, and when measuring, control or inspection equipment is also installed, the equipment must be checked to ensure that it operates correctly as designed.

We further recommend that an inspection to ensure that the installation of the pipe system is as planned and in the materials specified be incorporated in the handing over procedure. Special attention should be paid to check that the taking up of changes in length can take place unimpeded, that compensators have been correctly installed and that pipe supports have been properly placed.