Technical Handbook

Polypropylene Pressure Piping Systems

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GEORG FISCHER
PIPING SYSTEMS

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Overview

General Information

Polypropylene is a thermoplastic belonging to the polyolefin group. It is a semi-crystalline material. Its density is lower than that of other well-known thermoplastics. Its mechanical characteristics, its chemical resistance, and especially its relatively high heat deflection temperature have made polypropylene one of the most important materials used in piping installations today.

PP is formed by the polymerisation of propylene (C_3H_6) using Ziegler-Natta catalysts.

There are three different types which are conventionally supplied for piping installations:

- Isotactic PP Homopolymeride (PP-H)
- PP block co-polymeride (PP-B)
- PP random co-polymeride (PP-R).

Because of its high internal pressure resistance, PP-H is preferred for industrial applications. On the other hand, PP-R is used predominantly in sanitary applications because of its low e-modulus (flexible piping) and its high internal pressure resistance at high temperatures. PP-B is mainly used for sewage piping systems because of its high impact strength especially at low temperatures and its low thermal endurance.

PROGEF Standard Polypropylene (PP-H)

Most of the grades are offered with nucleating agents (crystallization seeds), because PP crystallizes at least 10 times slower than PE. This way, we achieve lower internal stress and a finer structure. We differentiate between α and β nucleation.

Nucleation is realized by merely adding ppm (parts per million) of nucleating agents. PP is one of the non-polar materials whose surface hardly swells or dissolves. Cementing is not possible without special surface treatment. On the other hand, PP welds very well. Pressure piping systems can use heating element socket welding, heating element butt welding or the no-contact infrared (IR-Plus®) fusion technology developed by GF.

The internal pressure resistance is ensured through long-term testing in accordance with EN ISO 9080 and certified with the value of MRS 10 (minimum required strength).

The PP-H resin used by GF for PROGEF® Standard PP industrial piping systems is characterized by

Advantages

- good chemical resistance
- high internal pressure resistance
- high impact strength
- high thermal ageing and thermal forming resistance
- high stress fracture resistance
- outstanding weldability
- homogeneous, fine structure

PROGEF Natural Polypropylene (PP-R)

Specially for applications related to the BCF® Plus (bead and crevice-free) welding technology, such as the life science/pharmaceutical industry, GF offers the PROGEF® Natural PP system in addition to our PROGEF® Standard PP system. (GF PROGEF Natural is the only thermoplastic that is ASME Bio-Processing Equipment (BPE) listed).

For such requirements, the welding technology plays a decisive role. In using the BCF®Plus welding technology, beads and dead zones are avoided. This prevents micro-organisms from accumulating, thus improving the water quality.

For less demanding purity requirements and all other industrial applications, especially those involving aggressive media, high impact and temperature stress, GF recommends PROGEF Standard PP, which has an optimal characteristics profile.

The material used for PROGEF® Natural system is an unpigmented random copolymer, particularly distinguished by the following characteristics:

Advantages

- excellent resistance against certain disinfectants and chemicals (mainly alkaline solutions)
- translucence
- very high surface finish quality
- good weldability (BCF® Plus and IR Plus® weldable)
- high temperature resistance

PPro-Seal Natural Polypropylene (PP-R)

Specifically for applications such as lab grade DI water, reverse osmosis and chemical distribution systems where electrofusion or threaded joining is appropriate.

The material used for the PPro-Seal Natural system is an unpigmented random copolymer, particularly distinguished by the following characteristics:

Advantages

- excellent resistance against certain disinfectants and chemicals (mainly alkaline solutions)
- translucence
- very high surface finish quality
- electrofusion (same fusion machine that Fuseal® PP & Fuseal 25/50™ PVDF use)
- high temperature resistance

Mechanical Properties

PP-H has the highest crystallinity and therefore the highest hardness, tensile strength and stiffness, so the pipes hardly sag and a greater distance between supports is possible. PP-R has a very good long-term creep strength at higher temperatures, such as, for example, 80°C at continuous stress.

Unlike PE, PP is not as impact-resistant below 0°C. Because of this, GF recommends ABS or PE for low temperature applications.

The long-term behavior for internal pressure resistance is provided by the hydrostatic strength curve based on the EN ISO 15494 standard (see the Calculation and Long-Term Behavior section for PE). The application limits for pipes and fittings, as shown in the pressure-temperature diagram, can be derived from these curves.

Chemical, Weathering, and Abrasion Resistance

Due to its non-polar nature, polypropylene shows a high resistance against chemical attack.

The resistance of PP is nevertheless lower than that of PE because of its tertiary C atoms.

PP is resistant against many acids, alkaline solutions, solvents, alcohol and water. Fats and oils swell PP slightly. PP is not resistant to oxidizing acids, ketones, petrol, benzene, halogens, aromatic hydrocarbons, chlorinated hydrocarbons and contact with copper.

For detailed information, please refer to the detailed list of chemical resistance from GF or contact your local GF subsidiary.

If polypropylene is exposed to direct sunlight over a long period of time, it will, like most natural and plastic materials, be damaged by the short-wave UV portion of sunlight together with oxygen in the air, causing photo-oxidation.

PP fittings and valves are highly heat stabilized. As per approvals, polypropylene has no special additive against the effects of UV radiation. The same applies to PP piping. Piping which is exposed to UV light should therefore be protected. This is achieved by covering the pipes, e.g. with insulation or also by painting the piping system with a UV absorbing paint.

Thermal Properties

In general polypropylene can be used at temperatures from 0°C to +80°C, Beta-PP-H in the range from –10°C up to 95°C. Below –10°C, the outstanding impact strength of the material is reduced. On the other hand, the stiffness is even higher at low temperatures. Please consult the pressure-temperature diagram for your maximum working temperature. For temperatures below 0°C it must be ensured, as for every other material, that the medium does not freeze, consequently damaging the piping system.

As with all thermoplastics, PP shows a higher thermal expansion (0.16 to 0.18 mm/mK) than metal. As long as this is taken into account during the planning of the installation, there should be no problems in this regard.

The thermal conductivity is 0.23 W/mK. Because of the resulting insulation properties, a PP piping system is notably more economical in comparison to a system made of a metal like copper.

Combustion Behavior

Polypropylene is a flammable plastic. The oxygen index amounts to 19%. (Materials that burn with less than 21% of oxygen in the air are considered to be flammable).

PP drips and continues to burn without soot after removing the flame. Basically, toxic substances are released by all burning processes. Carbon monoxide is generally the combustion product most dangerous to humans. When PP burns, primarily carbon dioxide, carbon monoxide and water are by-products of combustion.

The following classifications in accordance with differing combustion standards are used:

According to UL94, PP is classified as HB (Horizontal Burning) and according to DIN 53438-1 as K2. According to DIN 4102-1 and EN 13501-1, PP is listed as B2 (normally flammable).

According to ASTM D 1929, the self-ignition temperature is 360°C.

Suitable fire-fighting agents are water, foam or carbon dioxide.

Electrical Properties

Since PP is a non-polar hydrocarbon polymer, it is an outstanding insulator. These properties, however, can be worsened considerably as a result of pollution, effects of oxidizing media or weathering.

The dielectric characteristics are essentially independent of temperature and frequency.

The specific volume resistance is > 10^{16} Ωcm; the dielectric strength is 75 kV/mm.

Because of the possible development of electrostatic charges, caution is recommended when using PP in applications where the danger of fires or explosion is given.

Complete System of Pipe, Valves and Fittings

Georg Fischer's Polypropylene piping system easily transitions between PE and PVC and is available with pipes, fittings and valves in sizes from 20mm to 500mm (metric), ½" to 3" (ASTM).

(For technical data on PP and PVC - please see GF's online technical data)

This system includes all commonly required pressure pipe fittings, including threaded adaptors and flanges for ease of mating to equipment or other piping materials. Ball valves are available in sizes up to 2" (PP), diaphragm valves up to 4" (PP) and butterfly valves in sizes up to 36" (metal external bodies with elastomer seals). Other valves, including check valves and metering valves are also available for this system.

See product guide for details on full line of available products.

Reliable Fusion Joining

Assembly and joining of this system is performed by heat fusion. Fusion joints are made by heating and melting the pipe and fitting together. This type of joint gives a homogeneous transition between the two components without the lowering of chemical resistance associated with solvent cement joining and without the loss of integrity and loss of pressure handling ability of a threaded joint.

Five different fusion methods for Georg Fischer's Polypropylene Piping Systems are available and commonly used in today's demanding applications. These include conventional socket fusion, electrofusion, conventional contact butt fusion, IR Plus® butt fusion and BCF® (Bead and Crevice Free) fusion.

Socket Fusion Joining

Socket Fusion Joining can be used to join socket fusion fittings available in sizes 16-110mm (⅜"–4"). The socket fusion method of joining uses a heated non-stick "female" bushing to melt the outside of the pipe end and a heated non-stick "male" bushing to heat the inside of the corresponding size of fitting. After several seconds, when the outside of the pipe and the inside of the fitting are melted, the bushings are removed and the pipe is pushed into the fitting. Due to the large area of pipe to fitting contact (3–5 times the cross sectional area of the pipe), the resulting joint is actually several times stronger than the pipe itself. The pipe and fittings for this system are also manufactured to have an interference fit; because of this interference, it is not possible to slide a fitting over the pipe without the use of heat to melt the surface to be joined. This feature prevents the possibility of inadvertently leaving a joint unfused, and more importantly, causes displacement of some material during fusion thereby guaranteeing a high strength, reliable, reproducible joint.

Advantages

- Fast fusion times
- Low installation cost
- Easiest fusion method
- Corrosion resistant

Contact (Conventional) Butt Fusion Joining

Georg Fischer's Contact Butt Fusion joining is a cost effective alternative to IR Butt Fusion for smaller dimension pipe, while also being an industry standard fusion method through 500mm (20").

Butt fusion pipe and fittings both have the same inside and outside diameters. To make a butt fusion joint, the pipe and fitting are clamped so that the ends to be joined are facing each other. The ends are then "faced" flat and parallel. A flat heating plate is used to simultaneously heat both faces to be joined. When each end is molten, the heating plate is removed and the pipe and fitting are brought together, joining the molten materials by fusion.

Advantages

- Repeatable weld parameters
- Controlled facing and joining pressure
- Automated fusion records
- Ease of operation due to cnc controller
- Eliminates operator dependant decisions

IR Plus® Infrared Butt Fusion Joining

IR Plus® Infrared Butt Fusion Joining is an ideal method to join IR fusion fittings in the size range of up to 8" to achieve the maximum joint consistency.

Using the computer process-controlled fusion machinery, high-strength butt fusion joints can be made with many advantages over the conventional, pressure type butt fusion methods. A non-contact IR heating plate is used, along with a predetermined overlap to join the pipe (or fitting) ends together eliminating the potential for operator error. Reliable, reproducible, high-strength joints with smaller internal and external beads can be achieved.

Advantages

- Non-contact heating
- Smaller internal and external beads repeatability
- Low stress joint
- Ease of operation due to fully automated fusion machinery
- Automatic fusion joining record (if desired) using optional printer or PC download
- Faster fusion and cooling time than conventional butt fusion

BCF® (Bead and Crevice Free) Fusion Joining

The Georg Fischer BCF (Bead and Crevice Free) joining system produces bead and crevice free joints for PROGEF Natural Polypropylene piping. It is used where there is extreme concern about the presence of small beads or crevices in the piping system. Such applications can be found in the Pharmaceutical (BPE Required Installations, fully drainable system requirements) and Food and Beverage Industries.

The BCF joining machine automatically clamps and aligns the pipe and fitting, and produces the seamless joint by a proprietary heat fusion method. The machine's electronic logic circuits provide temperature monitoring and heat sensing to automatically produce the proper weld for the particular pipe size. The BCF system is offered in 20mm through 110mm pipe diameters; with 90° elbows, tees, unions, diaphragm valves, zero static diaphragm valves, reducers, and flange adapters.

Advantages

- Completely smooth inner surface
- Low stress joint
- Ease of operation due to fully automated fusion machinery
- Automatic fusion joining record (if desired) using optional printer or PC download

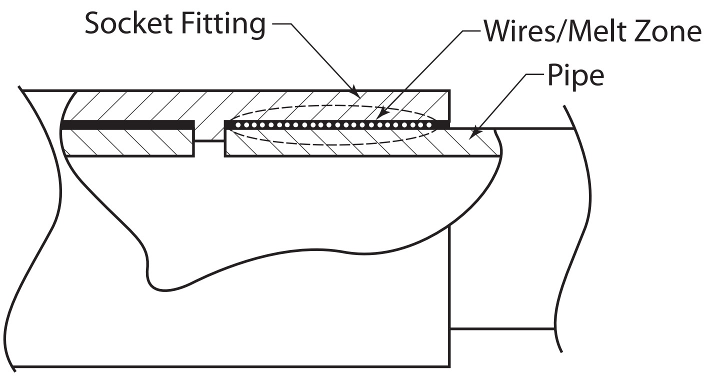
Electrofusion Joining

Electrofusion joining is an excellent joining solution that provides numerous advantages. The process of joining pipe to a fitting socket uses wires to transfer the heat energy to the plastic material. The heat energy is sufficient to melt the plastic surrounding the wires. This generates a zone called the "melt zone." This "melt zone" encapsulates the wires, which are at its origin along the center line.

These features makes this one of the safest and easiest fusion technologies on the market.

Advantages

- Fast fusion times
- Fuse multiple joints in one heat cycle
- Easiest fusion method
- Corrosion resistant



General Properties (Polypropylene)

Material Data

The following table lists typical physical properties of Polypropylene thermoplastic materials. Variations may exist depending on specific compounds and product.

Mechanical

Properties	Unit	PROGEF Standard PP-H	PROGEF Natural PP-R	PPro-Seal Natural PP-R	ASTM Test
Density	lb/in^3	0.0325	0.0325	0.0327	ASTM D792
Tensile Strength @ 73°F (Yield)	PSI	4,500	3,625	4,350	ASTM D638
Tensile Strength @ 73°F (Break)	PSI	5,600	4,500	5,000	ASTM D638
Modules of Elasticity Tensile @ 73°F	PSI	188,500	130,500	150,000	ASTM D638
Compressive Strength @ 73°F	PSI	6,500	5,500	5,500	ASTM D695
Flexural Modulus @ 73°F	PSI	181,250	130,500	130,000	ASTM D790
Izod Impact @ 73°F	Ft-Lbs/In of Notch	11.3	8.0	8.0	ASTM D256
Relative Hardness @ 73°F	Shore	70	70	70	ASTM D2240

Thermodynamics

Properties	Unit	PROGEF Standard	PROGEF Natural	PPro-Seal Natural	ASTM Test
Melt Index	gm/10min	0.25	0.30-0.40	0.40-0.80	ASTM D1238
Melting Point	°F	320	316	316	ASTM D789
Coefficient of Thermal Linear Expansion per °F	in/in/°F	0.5×10^{-4}	0.5×10^{-4}	0.61×10^{-4}	ASTM D696
Thermal Conductivity	$BTU\text{-}in/ft^2/hr/°F$	1.6	1.6	1.2	ASTM D177
Maximum Operating Temperature	°F	176	176	176	
Heat Distortion Temperature @ 264 PSI	°F	125	125	130	ASTM D648

Other

Properties	Unit	PROGEF Standard	PROGEF Natural	PPro-Seal Natural	ASTM Test
Water Absorption	%	<0.1%	<0.1%	<0.03%	ASTM D570
Poisson's Ratio @ 73°F		0.38	0.38	0.38	
Industry Standard Color		7032	Neutral	Neutral	RAL 9005
Food and Drug Association (FDA)		YES	YES	YES	CFR 21.177.1520
United States Pharmacopeia (USP)		YES	YES	YES	USP 25 Class VI

Note: This data is based on information compiled from multiple sources.

PROGEF® Standard (PP-H) Specification

PART 2 - PRODUCTS – MATERIALS

2.01 POLYPROPYLENE (PP-H) PIPE AND FITTINGS

A. Polypropylene Pipe shall be manufactured from a Group 1, Class 2 Beta Polypropylene Homopolymer material manufactured to SDR 11 dimensions with a pressure rating of 150 psi when measured at 68°F (20°C). Pipe internal surface finish shall be Ra ≤ 39.4µin. Pipe shall be manufactured in sizes from ½" through 16".

B. Polypropylene Fittings shall be manufactured from a Group I, Class 2 Beta Polypropylene Homopolypmer material manufactured to SDR 11 dimensions with a pressure rating of 150 psi when measured at 63°F (20°C). Fittings shall be available in sizes from ½" up to 16". Fittings shall be manufactured and cataloged for either IR®/Butt Fusion or socket fusion joining methods.

C. All components of the pipe and fitting system shall conform to the following applicable ASTM Standards, D4101, D 638, D2837, D2122, and shall conform to FDA CFR 21 177.1520, USP 25 Class VI and ASME-BPE. All pipe shall be marked with manufacturers name, pipe size, wall thickness, type, quality control mark and pressure rating information.

D. Piping shall be PROGEF® Standard PP Piping System as manufactured by GF Piping Systems.

2.02 VALVES

A. Ball Valves: Ball valves shall be full port, true union end constructed of polypropylene with EPDM or FPM seals available, manufactured for installation in PROGEF® Standard piping system, Type 546 as manufactured by GF Piping Systems.

B. Diaphragm Valves: Diaphragm valves shall be constructed of polypropylene with EPDM or PTFE Seal configurations, manufactured for installation in PROGEF® Standard piping system, Type 514, 515, 517 or 519 as manufactured by GF Piping Systems.

C. Three-Way Ball Valves: Ball valves shall be L-Port/T-Port type constructed of polypropylene with EPDM or FPM seats available, manufactured for installation in PROGEF® Standard Piping system, Type 543 as manufactured by GF Piping Systems.

D. Butterfly Valves: Butterfly valves shall be constructed of polypropylene with EPDM or FPM seats available, manufactured for installation in PROGEF® Standard Piping system, Type 567 (lug style) or Type 568 (wafer style) as manufactured by GF Piping Systems.

PART 3 - EXECUTION

3.1 HANDLING

A. Material shall be stored in original packaging and protected from environmental damage until installation. Pipe shall be supported sufficiently to prevent sagging. Care shall be taken not to gouge or otherwise notch the pipe in excess of 10% of the wall thickness.

3.2 INSTALLATION

A. System components shall be installed using the [Socket, IR® (Infrared) Butt Fusion or Standard Butt Fusion] joining method according to current installation instructions as delivered in print or documented online at www.gfpiping.com.

An on-site installation seminar shall be conducted by GF personnel who are certified to conduct said seminar. Seminar topics shall include all aspects of product installation (storage, set up, support spacing, fusion process, machine care, testing procedure, etc.). At the conclusion of the seminar, all installers will be given a written certification test and will be required to prepare and complete one fusion joint of the type being implemented on the project. Upon successful completion of said test, the installer will be issued a certification card verifying that they have met the requirements of the manufacturer with regards to knowledge of proper product installation and testing methods.

B. Only the following GF Piping Systems fusion units may be used to install the PROGEF® Standard piping system:

For Socket Fusion Installation – SG 110 Socket Fusion Machine or MSE hand tool

Butt Fusion Installation – SG 160, GF 160-315, GF 160-500, Butt Fusion Machine

For IR Fusion Installation – IR63 Plus, IR225 Plus, IR-315 Plus, Infrared Butt Fusion Machines

Under this specification, the contractor shall be responsible for the purchase or rental of the proper machine required to meet the intent of the specification and be used for installation of the product on site. NOTE: When using socket fusion joining, the installer shall use the proper socket fusion (bench) machine (SG-110, SG-160) per manufacturers' recommendations, for as many of the required fittings as possible, with minimal use of the MSA hand tool.

C. Installer shall ensure that all pipe and fittings used for Pure Water Piping are components of the same system. No mixing of various manufacturers' pipe and/or fittings shall be allowed.

3.3 TESTING

A. The system shall be tested in accordance with the manufacturers' recommendations

Following is a general test procedure for Georg Fischer plastic piping. It applies to most applications. Certain applications may require additional consideration. For further questions regarding your application, please contact your local GF representative

1 All piping systems should be pressure tested prior to being placed into operational service.

2 All pressure tests should be conducted in accordance with the appropriate building, plumbing, mechanical and safety codes for the area where the piping is being installed.

3 When testing plastic piping systems, all tests should be conducted hydrostatically and should not exceed the pressure rating of the lowest rated component in the piping system (often a valve). Test the system at 150% of the designed operational pressure, i.e.: If the system is designed to operate at 80PSI, then the test will be conducted at 120PSI.

4 When hydrostatic pressure is introduced to the system, it should be done gradually through a low point in the piping system with care taken to eliminate any entrapped air by bleeding at high points within the system. This should be done in four stages, waiting ten minutes at each stage (adding ¼ the total desired pressure at each stage).

5 Allow one hour for system to stabilize after reaching desired pressure. After the hour, in case of pressure drop, increase pressure back to desired amount and hold for 30 minutes. If pressure drops by more than 6%, check system for leaks.

Note: If ambient temperature changes by more than 10°F during the test, a retest may be necessary.

PROGEF® Natural (PP-R) Specification

PART 2 - PRODUCTS – MATERIALS

2.01 POLYPROPYLENE (PP-R) PIPE AND FITTINGS

A. Polypropylene Pipe shall be manufactured from a polypropylene random copolymer material, unpigmented and translucent. Pipe 63mm (2") and smaller shall be manufactured to SDR 11 dimensions with a pressure rating of 150 psi (PN10) when measured at 68°F (20°C). Pipe size 90mm (3") shall be manufactured to SDR 17.6 dimensions with a pressure rating of 90 psi (PN6) when measured at 68°F (20°C). Pipe internal surface finish shall be Ra ≤ 32.0µin. Pipe shall be manufactured in sizes from 20mm (½") to 63mm (2") and 90mm (3").

B. Polypropylene Fittings shall be manufactured from a polypropylene random copolymer material, unpigmented and translucent. Fittings 63mm (2") and smaller shall be manufactured to SDR 11 dimensions with a pressure rating of 150 psi (PN10) when measured at 68° F (20°C). Fitting size 90mm (3") shall be manufactured to SDR 17.6 dimensions with a pressure rating of 90 psi (PN6) when measured at 68°F (20°C). Fittings shall be available in sizes from 20mm (½") up to 63mm (2") and 90mm (3"). Fittings shall be manufactured and cataloged for either BCF® (Bead and Crevice Free), IR® (Infrared), butt or socket fusion joining methods.

C. All components of the pipe and fitting system shall conform to the following applicable ASTM Standards, D4101, D638, D2837, D2122, and shall conform to FDA CFR 21 177.1520, USP 25 Class VI and ASME-BPE. All pipes shall be marked with manufacturer's name, pipe size, wall thickness, type, quality control mark and pressure rating information. Fittings shall be embossed with a permanent identification during the production process to ensure full traceability.

D. Piping shall be PROGEF® Natural PP Piping System as manufactured by GF Piping Systems.

2.02 VALVES

A. Ball Valves: Ball valves shall be full port, true union end constructed of polypropylene with EPDM or FPM seals available, manufactured for installation in PROGEF® Natural Piping system, Type 546 as manufactured by GF Piping Systems.

B. Diaphragm Valves: Diaphragm valves shall be constructed of polypropylene with EPDM or PTFE Seal configurations, manufactured for installation in PROGEF® Natural piping system, Type 515, 517 and 519 (Zero Static) as manufactured by GF Piping Systems. Diaphragm valves shall be rated for 150 psi when measured at 68°F (20°C). Pneumatic valve actuators, if required, shall be supplied by GF Piping Systems to ensure proper system operation.

C. Three-Way Ball Valves: Ball valves shall be L-Port/T-Port type constructed of polypropylene with EPDM or FPM seats available, manufactured for installation in PROGEF® Natural piping system, Type 543 as manufactured by GF Piping Systems.

D. Butterfly Valves: Butterfly valves shall be constructed of polypropylene with EPDM or FPM seats available, manufactured for installation in PROGEF® Natural Piping system, Type 567 (lug style) or Type 568 (wafer style) as manufactured by GF Piping Systems.

PART 3 - EXECUTION

3.1 HANDLING

A. Material shall be stored in original packaging and protected from environmental damage until installation. Pipe shall be supported sufficiently to prevent sagging. Care shall be taken not to gouge or otherwise notch the pipe in excess of 10% of the wall thickness.

3.2 INSTALLATION

A. System components shall be installed using the BCF® (Bead and Crevice Free) joining methods according to current installation instructions as delivered in print or documented online at www.gfpiping.com.

An on-site installation seminar shall be conducted by GF personnel who are certified to conduct said seminar. Seminar topics shall include all aspects of product installation (storage, set up, support spacing, fusion process, machine care, testing procedure, etc.). At the conclusion of the seminar, all installers will be given a written certification test and will be required to prepare and complete one fusion joint of the type being implemented on the project. Upon successful completion of said test, the installer will be issued a certification card verifying that they have met the requirements of the manufacturer with regards to knowledge of proper product installation and testing methods.

B. Only the following GF Piping Systems fusion units may be used to install the PROGEF® Natural piping system:

For IR Fusion Installation – IR63 Plus, IR225 Plus, IR-315 Plus, Infrared Butt Fusion Machines

For BCF® Fusion Installations – BCF Plus

Under this specification, the contractor shall be responsible for the purchase or rental of the proper machine required to meet the intent of the specification and be used for installation of the product on site.

C. Installer shall ensure that all pipe and fittings used for Pure Water Piping are components of the same system. No mixing of various manufacturers pipe and or fittings shall be allowed.

3.3 TESTING

A. The system shall be tested in accordance with the manufacturers' recommendations

Following is a general test procedure for Georg Fischer plastic piping. It applies to most applications. Certain applications may require additional consideration. For further questions regarding your application, please contact your local GF representative

1 All piping systems should be pressure tested prior to being placed into operational service.

2 All pressure tests should be conducted in accordance with the appropriate building, plumbing, mechanical and safety codes for the area where the piping is being installed.

3 When testing plastic piping systems, all tests should be conducted hydrostatically and should not exceed the pressure rating of the lowest rated component in the piping system (often a valve). Test the system at 150% of the designed operational pressure, i.e.: If the system is designed to operate at 80PSI, then the test will be conducted at 120PSI.

PPro-Seal™ Natural (PP-R) Specification

PART 2 - PRODUCTS – MATERIALS

2.01 POLYPROPYLENE (PP-R) PIPE AND FITTINGS

A. Polypropylene Pipe shall be manufactured from natural virgin copolymer polypropylene material with no added plasticizers, pigments or re-grind, manufactured to Sch. 80 dimensions with a pressure rating of 150 psi when measured at 68°F (20°C). Pipe shall be capable of conveying fluids up to 176°F (80°C). Pipe shall be manufactured in sizes from ½" through 3".

B. Polypropylene Fittings shall be manufactured from natural virgin copolymer polypropylene material with no added plasticizers, pigments or re-grind, manufactured to Sch. 80 dimensions with a pressure rating of 150 psi when measured at 63°F (20°C). Fittings shall be capable of handling fluids up to 176°F (80°C). Fittings shall be produced in sizes from ½" up to 3". Fittings shall be manufactured and catalogued for coil fusion joining method.

C. All components of the pipe and fitting system shall conform to the following applicable ASTM Standards, D4101, D638, D1785, F1290, and shall conform to FDA CFR 21 177.1520 Sections A1, B and C. All pipes shall be marked with manufacturers name, product name, ASTM listing, size, schedule and material type. Fittings shall be legibly marked with molded letters showing manufacturers' trademark, pipe size of each socket, product name, ASTM listing, USA and symbol PP indicating the material type.

D. Each fusion coil shall consist of a polypropylene jacketed wire, mandrel wound, heat fused on the outer surface. The wire is inserted into the socket at the factory and is designed to have a snug fit. Wire leads from the coil shall be terminated via a duplex receptacle for attachment to the fusion unit cable. When required fittings shall be supplied with IPS threaded connections (up to 2" only). NOTE: Threaded fittings are not recommended for installation in a pressure system).

E. System components shall be packaged in polybags at the point of manufacturing to ensure product cleanliness.

F. Shall be PPro-Seal™ Natural PP Piping System as manufactured by GF Piping Systems.

2.02 VALVES

A. Ball Valves: Ball valves shall be floating ball design with full-port true union end constructed of natural virgin copolymer polypropylene with no added plasticizers, pigments or re-grind. All "O" rings shall be FPM and the valve seats shall be PTFE, manufactured for installation in PPro-Seal™ Natural PP Piping System, Type **375** as manufactured by GF Piping Systems. Valve shall have a pressure rating of 150 psi at 68°F.

B. Diaphragm Valves: Diaphragm valves upper body shall be glass filled polypropylene material connected to lower body with exposed stainless steel bolts. Lower bodies shall be natural virgin polypropylene with no plasticizers, pigments or re-grind. Diaphragms shall be fabricated of EPDM material with EPDM elastomer backing, manufactured for installation in PPro-Seal™ Natural PP Piping system, Type **315**, as manufactured by GF Piping Systems. Valve shall have a pressure rating of 150 psi at 68°F.

PART 3 - EXECUTION

3.1 HANDLING

A. Material shall be stored in original packaging and protected from environmental damage until installation. Pipe shall be supported sufficiently to prevent sagging. Care shall be taken not to gouge or otherwise notch the pipe in excess of 10% of the wall thickness.

3.2 INSTALLATION

A. Pipe and fittings shall be installed according to current PPro-Seal™ installation instructions as delivered in print or found online at www.gfpiping.com. An on-site installation seminar shall be conducted by GF Piping Systems personnel who are certified to conduct said installation seminar. Seminar topics shall include all aspects of product installation (storage, set-up, support spacing, fusion procedure, threaded joint installation procedure, product testing procedures, etc.). At the conclusion of the installation seminar, all installers will be given a certification test and, upon successful completion of the test, will be issued a certification card verifying they have met the requirements of the factory with regards to proper product installation methods thereby meeting the intent of the specifications.

B. Only the following GF Piping Systems fusion units MSA-250SE or "Electro Plus" may be used to install the PPro-Seal™ Natural PP piping system. GF Piping systems personnel shall also conduct an on site installation seminar with certification test for all installers using these fusion units. Under this section, the contractor shall purchase either an MSA-250SE or an "Electro Plus" fusion unit to be used in the installation of the pipe and fitting system. At the completion of the installation and testing of the system, the contractor shall turn over the fusion unit to the facility personnel for their use in future system upgrades.

C. Installer shall ensure that all pipe and fittings used for Pure Water Piping are components of the same system. No mixing of various manufacturers' pipe and or fittings shall be allowed.

3.3 TESTING

A. The system shall be tested in accordance with the manufacturers' recommendations

Following is a general test procedure for Georg Fischer plastic piping. It applies to most applications. Certain applications may require additional consideration. For further questions regarding your application, please contact your local GF representative

1 All piping systems should be pressure tested prior to being placed into operational service.

2 All pressure tests should be conducted in accordance with the appropriate building, plumbing, mechanical and safety codes for the area where the piping is being installed.

3 When testing plastic piping systems, all tests should be conducted hydrostatically and should not exceed the pressure rating of the lowest rated component in the piping system (often a valve). Test the system at 150% of the designed operational pressure, i.e.: If the system is designed to operate at 80PSI, then the test will be conducted at 120PSI.

This should be done in four stages, waiting ten minutes at each stage (adding 1/4 the total desired pressure at each stage).

Pressure/Temperature

Long-Term Stress

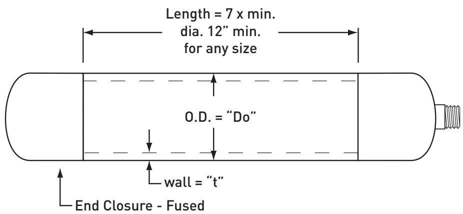
To determine the long-term strength of thermoplastic pipe, lengths of pipe are capped at both ends **(Figure 1)** and subjected to various internal pressures, to produce circumferential stresses that will predict failure in from 10 hours to 50 years. The test is run according to **ASTM D1598**, "Standard Test for Time to Failure of Plastic Pipe Under Long-Term Hydrostatic Pressure."

The resulting failure points are used in a statistical analysis (outlined in **ASTM D2837**) to determine the characteristic regression curve that represents the stress/time-to-failure relationship of the particular thermoplastic pipe compound. The curve is represented by the equation

$$\log T = a + b \log S$$

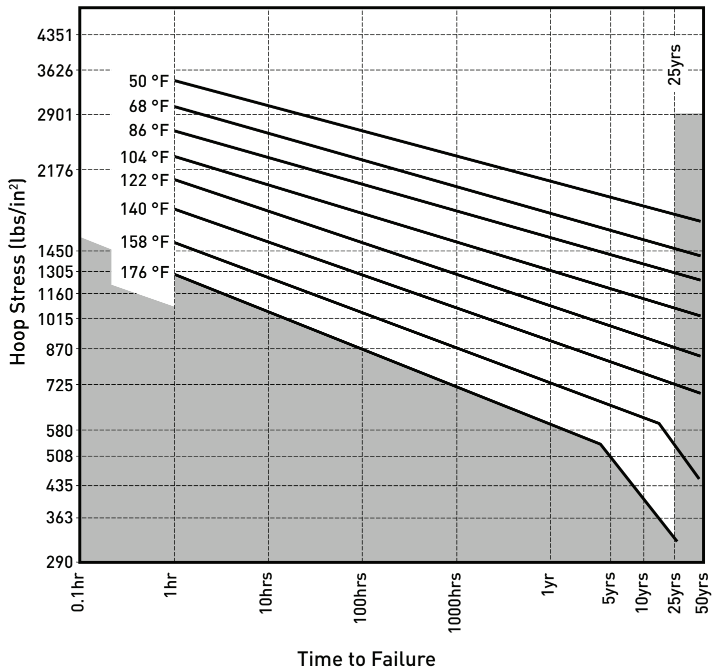
Where *a* and *b* are constants describing the slope and intercept of the curve, and T and S are time-to-failure and stress, respectively.

Figure 1

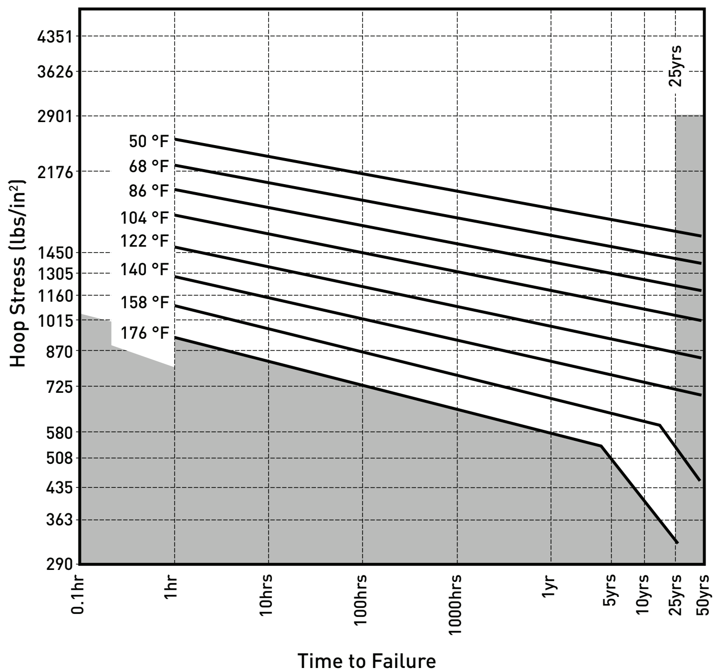


The regression curve may be plotted on log-log paper as shown in **Figure 2** and extrapolated from 5 years to 25 years. The stress at 25 years is known as the hydrostatic design basis (HDB) for that particular thermoplastic compound. From this HDB the hydrostatic design stress (HDS) is determined by applying the service factor multiplier.

PROGEF Standard (PP-H)
Polypropylene
Figure 2a.

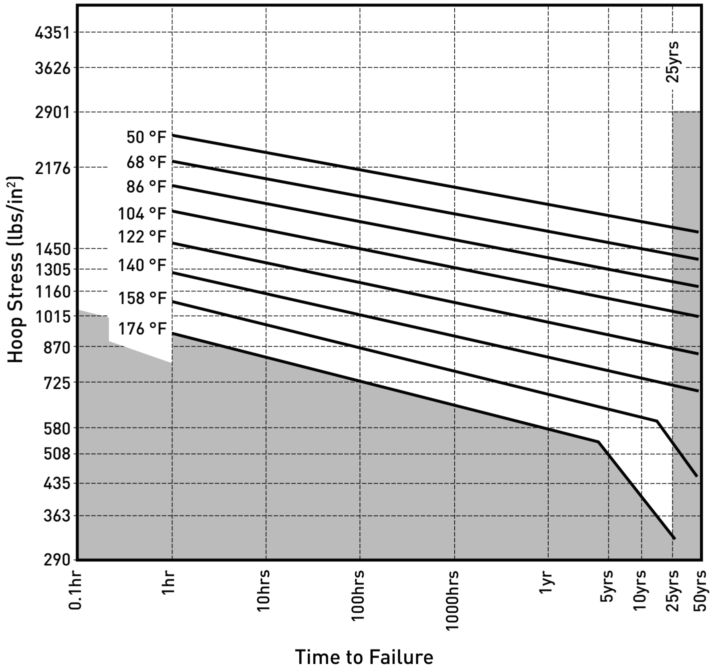


PROGEF Natural (PP-R)
Polypropylene
Figure 2b.



PPro-Seal Naural (PP-R) Polypropylene

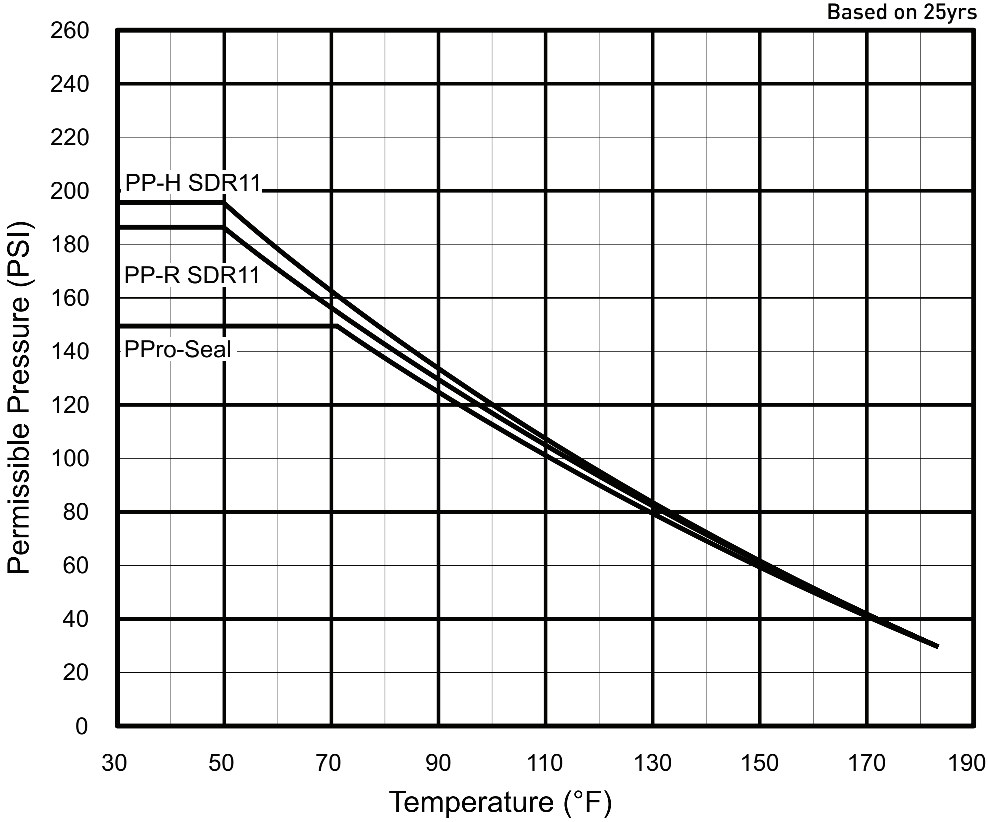
Figure 2c.



Working Temperature and Pressures for PROGEF Standard (PP-H), PROGEF Natural (PP-R) and PPro-Seal (PP-R)

Based on 25-year service life. Service Factor C=2.0

Figure 3



Dimensional Pipe Size - Polypropylene Piping Systems

Pipe Size Comparison

Table 1

	Outside Dimensions			Wall Thickness			Inside Dimensions		
Nominal Outside Diameter, inch	PROGEF Standard	PROGEF Natural	PPro-Seal	PROGEF Standard	PROGEF Natural	PPro-Seal	PROGEF Standard	PROGEF Natural	PPro-Seal
½" (20mm)	20.0mm	20.0mm	0.840in	1.9mm	1.9mm	0.147in	16.2mm	16.2mm	0.546in
¾" (25mm)	25.0mm	25.0mm	1.050in	2.3mm	2.3mm	0.154in	20.4mm	20.4mm	0.742in
1" (32mm)	32.0mm	32.0mm	1.315in	2.9mm	2.9mm	0.179in	26.2mm	26.2mm	0.957in
1¼" (40mm)	40.0mm	40.0mm	—	3.7mm	3.7mm	—	32.6mm	32.6mm	—
1½" (50mm)	50.0mm	50.0mm	1.900in	4.6mm	4.6mm	0.200in	40.8mm	40.8mm	1.500in
2" (63mm)	63.0mm	63.0mm	2.375in	5.8mm	5.8mm	0.218in	51.4mm	51.4mm	1.939in
2½" (75mm)	75.0mm	—	—	6.8mm		—	61.4mm	—	—
3" (90mm)	90.0mm	90.0mm	3.500in	8.2mm	5.1mm	0.300in	73.6mm	79.8mm	2.900in
4" (110mm)	110.0mm	—	—	10.0mm	—	—	90.0mm	—	—
6" (160mm)	160.0mm	—	—	14.6mm	—	—	130.8mm	—	—
8" (200mm)	200.0mm	—	—	18.2mm	—	—	163.6mm	—	—
9" (225mm)	225.0mm	—	—	20.5mm	—	—	184.0mm	—	—
10" (250mm)	250.0mm	—	—	22.7mm	—	—	204.6mm	—	—
12" (315mm)	315.0mm	—	—	28.6mm	—	—	257.8mm	—	—
14" (355mm)	355.0mm	—	—	32.2mm	—	—	290.6mm	—	—
16" (400mm)	400.0mm	—	—	36.3mm	—	—	327.4mm	—	—
18" (450mm)	450.0mm	—	—	40.9mm	—	—	368.2mm	—	—
20" (500mm)	500.0mm	—	—	45.4mm	—	—	409.2mm	—	—

Calculating Pipe Size

Friction Loss Characteristics

Sizing for any piping system consists of two basic components: fluid flow design and pressure integrity design. Fluid flow design determines the minimum acceptable diameter of pipe and pressure integrity design determines the minimum wall thickness required. For normal liquid service applications an acceptable velocity in pipes is 7.0 ±3.0 (ft/sec), with a maximum velocity of 10.0 (ft/sec) at discharge points.

Pressure drops throughout the piping network are designed to provide an optimum balance between the installed cost of the piping system and the operating cost of the pumps.

Pressure loss is caused by friction between the pipe wall and the fluid, minor losses due to obstructions, change in direction, etc. Fluid pressure head loss is added to elevation change to determine pump requirements.

Hazen and Williams Formula

The head losses resulting from various water flow rates in plastic piping may be calculated by means of the Hazen and Williams formula. **(Located in Figure 4):**

C Factors

Tests made both with new pipe and pipe that had been in service revealed that **(C)** factor values for plastic pipe ranged between 160 and 165. Thus the factor of 150 recommended for water in the equation **(located in Figure 4)** is on the conservative side. On the other hand, the **(C)** factor for metallic pipe varies from 65 to 125, depending upon the time in service and the interior roughening. The obvious benefit is that with Polyethylene piping systems, it is often possible to use a smaller diameter pipe and still obtain the same or even lower friction losses.

Independent variable for these tests are gallons per minute and nominal pipe size (OD). Dependent variables for these tests are gallons per minute and nominal pipe size OD. Dependent variables are the velocity friction head and pressure drop per 100ft. of pipe, with the interior smooth.

Figure 4

- V - Fluid Velocity (ft/sec)
- ΔP - Head Loss (lb/in^2 /100 ft of pipe
- ΔH - Head Loss (ft of water /100 ft of pipe)
- L - Length of Pipe Run (ft)
- L_e - Equivalent Length of Pipe for minor losses (ft)
- D_i - Pipe Inside Diameter (in)
- Q - Fluid Flow (gal/min)
- C - Constant for Plastic Pipes (conservative - 150)

Hazen and Williams Formula:

$$\Delta H = (L + L_e) \cdot \left(\frac{V}{1.318 \cdot C \cdot (\frac{D_i}{4})^{0.63}} \right)^{1.852}$$

Step 1: Solve for V:

$$V = \frac{4Q(0.1337)}{60\pi \left(\frac{D_i}{12} \right)^2}$$

Step 2: Solve for ΔH:

$$\Delta H = (L + L_e) \cdot \left(\frac{V}{1.318 \cdot C \cdot (\frac{D_i}{4})^{0.63}} \right)^{1.852}$$

Step 3: Solve for ΔP:

$$\Delta P = \Delta H / 2.31$$

Flow Rate vs. Friction Loss - PROGEF Standard Polypropylene

Table 2

Flow Rate (GPM)	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	Flow Rate (GPM)
	20mm			25mm			32mm			40mm			
0.75	0.75	0.51	0.22										**0.75**
1	1.00	0.88	0.38	0.63	0.29	0.12							**1**
2	2.01	3.17	1.37	1.27	1.03	0.45	0.77	0.31	0.13				**2**
3	3.01	6.71	2.90	1.90	2.19	0.95	1.15	0.65	0.28	0.74	0.22	0.10	**3**
4	4.02	11.43	4.95	2.53	3.72	1.61	1.54	1.10	0.48	0.99	0.38	0.16	**4**
5	5.02	17.28	7.48	3.17	5.63	2.44	1.92	1.67	0.72	1.24	0.58	0.25	**5**
6	6.03	24.22	10.48	3.80	7.89	3.42	2.30	2.34	1.01	1.49	0.81	0.35	**6**
7	7.03	32.22	13.95	4.43	10.50	4.54	2.69	3.11	1.34	1.74	1.07	0.46	**7**
8	8.03	41.26	17.86	5.07	13.44	5.82	3.07	3.98	1.72	1.98	1.37	0.59	**8**
9	9.04	51.32	22.22	5.70	16.72	7.24	3.46	4.95	2.14	2.23	1.71	0.74	**9**
10	10.04	62.38	27.00	6.33	20.32	8.80	3.84	6.01	2.60	2.48	2.08	0.90	**10**
15	15.07	132.17	57.22	9.50	43.06	18.64	5.76	12.74	5.52	3.72	4.40	1.90	**15**
20				12.67	73.35	31.75	7.68	21.71	9.40	4.96	7.50	3.25	**20**
30				19.00	155.43	67.29	11.52	46.00	19.92	7.44	15.88	6.88	**30**
40							15.36	78.38	33.93	9.92	27.06	11.72	**40**
50										12.40	40.91	17.71	**50**
60										14.88	57.34	24.82	**60**

Note: Caution should be taken when velocities fall within the shaded levels.

Flow Rate vs. Friction Loss - PROGEF Standard Polypropylene

Table 2 - continued

Flow Rate (GPM)	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	Flow Rate (GPM)
	50mm			63mm			75mm			90mm			
5	0.79	0.19	0.08										**5**
10	1.58	0.70	0.30	1.00	0.23	0.10							**10**
15	2.38	1.48	0.64	1.50	0.48	0.21	1.05	0.20	0.09				**15**
20	3.17	2.52	1.09	2.00	0.82	0.35	1.40	0.34	0.15	0.97	0.14	0.06	**20**
25	3.96	3.80	1.65	2.49	1.24	0.54	1.75	0.52	0.23	1.22	0.22	0.09	**25**
30	4.75	5.33	2.31	2.99	1.73	0.75	2.10	0.73	0.32	1.46	0.30	0.13	**30**
35	5.54	7.09	3.07	3.49	2.31	1.00	2.45	0.97	0.42	1.70	0.40	0.17	**35**
40	6.33	9.08	3.93	3.99	2.95	1.28	2.80	1.24	0.54	1.95	0.51	0.22	**40**
45	7.13	11.30	4.89	4.49	3.67	1.59	3.15	1.55	0.67	2.19	0.64	0.28	**45**
50	7.92	13.73	5.94	4.99	4.46	1.93	3.50	1.88	0.81	2.43	0.78	0.34	**50**
55	8.71	16.38	7.09	5.49	5.33	2.31	3.85	2.24	0.97	2.68	0.93	0.40	**55**
60	9.50	19.25	8.33	5.99	6.26	2.71	4.20	2.63	1.14	2.92	1.09	0.47	**60**
65	10.29	22.32	9.66	6.48	7.26	3.14	4.54	3.06	1.32	3.16	1.27	0.55	**65**
70	11.08	25.61	11.09	6.98	8.32	3.60	4.89	3.51	1.52	3.41	1.45	0.63	**70**
75				7.48	9.46	4.09	5.24	3.98	1.72	3.65	1.65	0.71	**75**
80				7.98	10.66	4.61	5.59	4.49	1.94	3.89	1.86	0.80	**80**
95				9.48	14.65	6.34	6.64	6.17	2.67	4.62	2.55	1.11	**95**
100				9.98	16.11	6.98	6.99	6.79	2.94	4.87	2.81	1.22	**100**
125				12.47	24.36	10.55	8.74	10.26	4.44	6.08	4.25	1.84	**125**
150				14.97	34.15	14.78	10.49	14.38	6.22	7.30	5.95	2.58	**150**
175							12.24	19.13	8.28	8.52	7.92	3.43	**175**
200										9.73	10.14	4.39	**200**
225										10.95	12.61	5.46	**225**
250										12.16	15.33	6.64	**250**

Note: Caution should be taken when velocities fall within the shaded levels.

Flow Rate vs. Friction Loss - PROGEF Standard Polypropylene

Table 2 - continued

Flow Rate (GPM)	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	Flow Rate (GPM)
	110mm			160mm			200mm			225mm			
20	0.65	0.05	0.02										20
25	0.81	0.08	0.04										25
30	0.98	0.11	0.05										30
35	1.14	0.15	0.07	0.54	0.02	0.01							35
40	1.30	0.19	0.08	0.62	0.03	0.01							40
45	1.46	0.24	0.10	0.69	0.04	0.02							45
50	1.63	0.29	0.13	0.77	0.05	0.02	0.49	0.02	0.01				50
75	2.44	0.62	0.27	1.16	0.10	0.04	0.74	0.03	0.01	0.58	0.02	0.01	75
100	3.25	1.06	0.46	1.54	0.17	0.07	0.98	0.06	0.02	0.78	0.03	0.01	100
125	4.07	1.60	0.69	1.93	0.26	0.11	1.23	0.09	0.04	0.97	0.05	0.02	125
150	4.88	2.24	0.97	2.31	0.36	0.16	1.48	0.12	0.05	1.17	0.07	0.03	150
200	6.51	3.81	1.65	3.08	0.62	0.27	1.97	0.21	0.09	1.56	0.12	0.05	200
250	8.14	5.76	2.49	3.85	0.93	0.40	2.46	0.31	0.14	1.95	0.18	0.08	250
300	9.76	8.08	3.50	4.62	1.31	0.57	2.95	0.44	0.19	2.34	0.25	0.11	300
350	11.39	10.74	4.65	5.39	1.74	0.75	3.45	0.59	0.25	2.72	0.33	0.14	350
400	13.02	13.76	5.96	6.16	2.23	0.97	3.94	0.75	0.33	3.11	0.42	0.18	400
500				7.70	3.37	1.46	4.92	1.14	0.49	3.89	0.64	0.28	500
600				9.24	4.73	2.05	5.91	1.59	0.69	4.67	0.90	0.39	600
700				10.78	6.29	2.72	6.89	2.12	0.92	5.45	1.20	0.52	700
800				12.33	8.06	3.49	7.88	2.71	1.17	6.23	1.53	0.66	800
900							8.86	3.37	1.46	7.01	1.90	0.82	900
1000							9.85	4.10	1.77	7.79	2.31	1.00	1000
1250							12.31	6.20	2.68	9.73	3.50	1.51	1250
1500							14.77	8.69	3.76	11.68	4.90	2.12	1500
1750										13.62	6.52	2.82	1750

Note: Caution should be taken when velocities fall within the shaded levels.

Flow Rate vs. Friction Loss - PROGEF Standard Polypropylene

Table 2 - continued

Flow Rate (GPM)	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	Flow Rate (GPM)
	250mm			315mm			355mm			400mm			
100	0.63	0.02	0.01										100
150	0.94	0.04	0.02	0.59	0.01	0.01							150
200	1.26	0.07	0.03	0.79	0.02	0.01	0.62	0.01	0.01				200
250	1.57	0.11	0.05	0.99	0.03	0.01	0.78	0.02	0.01	0.61	0.01	0.00	250
300	1.89	0.15	0.06	1.19	0.05	0.02	0.94	0.03	0.01	0.74	0.02	0.01	300
350	2.20	0.20	0.09	1.39	0.06	0.03	1.09	0.04	0.02	0.86	0.02	0.01	350
400	2.52	0.25	0.11	1.59	0.08	0.04	1.25	0.05	0.02	0.98	0.03	0.01	400
500	3.15	0.38	0.17	1.98	0.12	0.05	1.56	0.07	0.03	1.23	0.04	0.02	500
750	4.72	0.81	0.35	2.97	0.26	0.11	2.34	0.15	0.06	1.84	0.08	0.04	750
1000	6.30	1.38	0.60	3.97	0.45	0.19	3.12	0.25	0.11	2.46	0.14	0.06	1000
1250	7.87	2.09	0.90	4.96	0.68	0.29	3.90	0.38	0.16	3.07	0.21	0.09	1250
1300	8.19	2.25	0.97	5.16	0.73	0.32	4.06	0.41	0.18	3.20	0.23	0.10	1300
1350	8.50	2.41	1.04	5.35	0.78	0.34	4.21	0.44	0.19	3.32	0.24	0.11	1350
1400	8.82	2.58	1.11	5.55	0.84	0.36	4.37	0.47	0.20	3.44	0.26	0.11	1400
1500	9.44	2.93	1.27	5.95	0.95	0.41	4.68	0.53	0.23	3.69	0.30	0.13	1500
1750	11.02	3.89	1.69	6.94	1.26	0.55	5.46	0.71	0.31	4.30	0.40	0.17	1750
2000	12.59	4.99	2.16	7.93	1.62	0.70	6.24	0.90	0.39	4.92	0.51	0.22	2000
2500				9.92	2.45	1.06	7.80	1.37	0.59	6.15	0.77	0.33	2500
3000				11.90	3.43	1.49	9.36	1.92	0.83	7.38	1.07	0.46	3000
3500				13.88	4.56	1.98	10.92	2.55	1.10	8.61	1.43	0.62	3500
4000							12.49	3.26	1.41	9.84	1.83	0.79	4000
4500										11.07	2.27	0.98	4500
5000										12.30	2.76	1.20	5000

Note: Caution should be taken when velocities fall within the shaded levels.

Flow Rate vs. Friction Loss - PROGEF Standard Polypropylene

Table 2 - continued

Flow Rate (GPM)	V	ΔH	ΔP	V	ΔH	ΔP	Flow Rate (GPM)
	450mm			500mm			
350	0.68	0.01	0.00				350
400	0.78	0.01	0.01	0.63	0.01	0.00	400
450	0.87	0.02	0.01	0.71	0.01	0.00	450
500	0.97	0.02	0.01	0.79	0.01	0.01	500
750	1.46	0.05	0.02	1.18	0.03	0.01	750
1000	1.94	0.08	0.03	1.57	0.05	0.02	1000
1250	2.43	0.12	0.05	1.97	0.07	0.03	1250
1500	2.92	0.17	0.07	2.36	0.10	0.04	1500
1750	3.40	0.22	0.10	2.75	0.13	0.06	1750
2000	3.89	0.29	0.12	3.15	0.17	0.07	2000
2500	4.86	0.43	0.19	3.94	0.26	0.11	2500
3000	5.83	0.61	0.26	4.72	0.36	0.16	3000
3500	6.80	0.81	0.35	5.51	0.48	0.21	3500
4000	7.78	1.03	0.45	6.30	0.62	0.27	4000
4500	8.75	1.28	0.56	7.08	0.77	0.33	4500
5000	9.72	1.56	0.68	7.87	0.93	0.40	5000
5500	10.69	1.86	0.81	8.66	1.11	0.48	5500
6000	11.67	2.19	0.95	9.44	1.31	0.57	6000
6500				10.23	1.52	0.66	6500
7000				11.02	1.74	0.75	7000

Note: Caution should be taken when velocities fall within the shaded levels.

Flow Rate vs. Friction Loss - PROGEF Natural Polypropylene
Table 3

Flow Rate (GPM)	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	Flow Rate (GPM)
	20mm			25mm			32mm			40mm			
0.75	0.75	0.51	0.22										**0.75**
1	1.00	0.88	0.38	0.63	0.29	0.12							**1**
2	2.01	3.17	1.37	1.27	1.03	0.45	0.77	0.31	0.13				**2**
3	3.01	6.71	2.90	1.90	2.19	0.95	1.15	0.65	0.28	0.74	0.22	0.10	**3**
4	4.02	11.43	4.95	2.53	3.72	1.61	1.54	1.10	0.48	0.99	0.38	0.16	**4**
5	5.02	17.28	7.48	3.17	5.63	2.44	1.92	1.67	0.72	1.24	0.58	0.25	**5**
6	6.03	24.22	10.48	3.80	7.89	3.42	2.30	2.34	1.01	1.49	0.81	0.35	**6**
7	7.03	32.22	13.95	4.43	10.50	4.54	2.69	3.11	1.34	1.74	1.07	0.46	**7**
8	8.03	41.26	17.86	5.07	13.44	5.82	3.07	3.98	1.72	1.98	1.37	0.59	**8**
9	9.04	51.32	22.22	5.70	16.72	7.24	3.46	4.95	2.14	2.23	1.71	0.74	**9**
10	10.04	62.38	27.00	6.33	20.32	8.80	3.84	6.01	2.60	2.48	2.08	0.90	**10**
15	15.07	132.17	57.22	9.50	43.06	18.64	5.76	12.74	5.52	3.72	4.40	1.90	**15**
20				12.67	73.35	31.75	7.68	21.71	9.40	4.96	7.50	3.25	**20**
30				19.00	155.43	67.29	11.52	46.00	19.92	7.44	15.88	6.88	**30**
40							15.36	78.38	33.93	9.92	27.06	11.72	**40**
50										12.40	40.91	17.71	**50**
60										14.88	57.34	24.82	**60**

Note: Caution should be taken when velocities fall within the shaded levels.

Flow Rate vs. Friction Loss - PROGEF Natural Polypropylene

Table 3 - continued

Flow Rate (GPM)	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	Flow Rate (GPM)
	50mm			63mm			90mm			
5	0.79	0.19	0.08							5
10	1.58	0.70	0.30	1.00	0.23	0.10				10
15	2.38	1.48	0.64	1.50	0.48	0.21	0.62	0.06		15
20	3.17	2.52	1.09	2.00	0.82	0.35	0.83	0.10	0.04	20
25	3.96	3.80	1.65	2.49	1.24	0.54	1.03	0.15	0.06	25
30	4.75	5.33	2.31	2.99	1.73	0.75	1.24	0.20	0.09	30
35	5.54	7.09	3.07	3.49	2.31	1.00	1.45	0.27	0.12	35
40	6.33	9.08	3.93	3.99	2.95	1.28	1.66	0.35	0.15	40
45	7.13	11.30	4.89	4.49	3.67	1.59	1.86	0.43	0.19	45
50	7.92	13.73	5.94	4.99	4.46	1.93	2.07	0.53	0.23	50
55	8.71	16.38	7.09	5.49	5.33	2.31	2.28	0.63	0.27	55
60	9.50	19.25	8.33	5.99	6.26	2.71	2.48	0.74	0.32	60
65	10.29	22.32	9.66	6.48	7.26	3.14	2.69	0.85	0.37	65
70	11.08	25.61	11.09	6.98	8.32	3.60	2.90	0.98	0.42	70
75				7.48	9.46	4.09	3.10	1.11	0.48	75
80				7.98	10.66	4.61	3.31	1.25	0.54	80
95				9.48	14.65	6.34	3.93	1.72	0.75	95
100				9.98	16.11	6.98	4.14	1.90	0.82	100
110				10.97	19.23	8.32	4.55	2.26	0.98	110
125				12.47	24.36	10.55	5.17	2.87	1.24	125
150							6.21	4.02	1.74	150
175							7.24	5.34	2.31	175
200							8.28	6.84	2.96	200
225							9.31	8.51	3.68	225
250							10.35	10.34	4.48	250
275							11.38	12.34	5.34	275

Note: Caution should be taken when velocities fall within the shaded levels.

Flow Rate vs. Friction Loss - PPro-Seal Natural Polypropylene

Table 4

Flow Rate (GPM)	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	V	ΔH	ΔP	Flow Rate (GPM)
	1/2"			3/4"			1"			1 1/2"			
1	1.43	4.02	1.74	0.74	0.86	0.37							1
2	2.95	8.03	3.48	1.57	1.72	0.74	0.94	0.88	0.33	0.38	0.10	0.041	2
5	7.89	45.23	19.59	3.92	9.67	4.19	2.34	2.78	1.19	0.94	0.30	0.126	5
7	10.34	83.09	35.97	5.49	17.76	7.59	3.23	5.04	2.29	1.32	0.55	0.24	7
10				7.84	33.84	14.65	4.68	9.61	4.16	1.88	1.04	0.45	10
15				11.76	71.70	31.05	7.01	20.36	8.82	2.81	2.20	0.95	15
20							9.35	34.68	15.02	3.75	3.75	1.62	20
25							11.69	52.43	22.70	4.69	5.67	2.46	25
30							14.03	73.48	31.62	5.63	7.95	3.44	30
35										6.57	10.58	4.58	35
40										7.50	13.55	5.87	40
45										8.44	16.85	7.30	45
50										9.38	20.48	8.87	50
60										11.26	28.70	12.43	60

Flow Rate vs. Friction Loss - PPro-Seal Natural Polypropylene

Table 4 - continued

Flow Rate (GPM)	V	ΔH	ΔP	V	ΔH	ΔP	Flow Rate (GPM)
	2”			3”			
5	0.56	0.10	0.040	0.25	0.02	0.009	**5**
7	0.78	0.15	0.088	0.35	0.023	0.013	**7**
10	1.12	0.29	0.13	0.50	0.04	0.017	**10**
15	1.63	0.62	0.27	0.75	0.09	0.039	**15**
20	2.23	1.06	0.46	1.00	0.15	0.055	**20**
25	2.79	1.60	0.69	1.25	0.22	0.095	**25**
30	3.35	2.25	0.97	1.49	0.31	0.13	**30**
35	3.91	2.99	1.29	1.74	0.42	0.13	**35**
40	4.47	3.86	1.66	1.99	0.54	0.23	**40**
45	5.03	4.76	2.07	2.24	0.67	0.29	**45**
50	5.58	5.79	2.51	2.49	0.81	0.35	**50**
60	6.70	8.12	3.52	2.98	1.14	0.49	**60**
70	7.82	10.80	4.68	3.49	1.51	0.65	**70**
75	8.38	12.27	5.31	3.74	1.72	0.74	**75**
80	8.93	13.83	5.99	3.99	1.94	0.84	**80**
90	10.05	17.20	7.45	4.48	2.41	1.04	**90**
100	11.17	20.90	9.05	4.98	2.93	1.27	**100**
125	-	-	-	6.23	4.43	1.92	**125**
150	-	-	-	7.47	6.20	2.68	**150**
175	-	-	-	8.72	8.26	3.58	**175**
200	-	-	-	9.97	10.57	4.58	**200**
250	-	-	-	12.46	16.00	8.93	**250**

Note: Caution should be taken when velocities fall within the shaded levels.

Friction Loss Through Fittings

Table 5

Fitting or Valve Type	90 Elbow (Molded)	45 Elbow (Molded)	Standard Tee Flow thru run	Standard Tee Flow thru branch	Reducer Bushing (Single Reduction)	Male/Female Adapter	Ball Valve, Full Bore, Full Open	For Industry Standard Elastomer Butterfly Valve, Full Open
PROGEF Standard/Natural Polypropylene								
Nominal Pipe Size, mm	Equivalent Length of Pipe (ft.)							
20	1.5	0.5	1.0	4.0	1.0	1.0	0.1	1.7
25	2.0	0.8	1.4	5.1	1.1	1.3	0.2	2.5
32	2.7	1.0	1.7	6.0	1.2	1.6	0.3	3.3
40	3.5	1.3	2.3	6.9	1.4	2.2	0.3	4.2
50	4.2	1.7	2.7	8.1	1.7	2.6	0.4	5.0
63	5.5	2.1	4.3	12.0	2.6	3.5	0.5	6.7
75	7.0	2.7	5.1	14.3	3.6	—	0.8	10.0
90	8.0	3.5	6.3	16.3	4.4	—	1.0	13.3
110	11.0	4.0	8.3	22.1	5.2	—	1.5	20.0
160	16.0	5.5	13.0	32.0	7.0	—	2.0	26.7
200	20.0	8.0	16.5	40.0	10.0	—	2.5	33.3
225	22.5	10.0	18.6	45.0	11.2	—	3.0	40.0
250	29.3	11.2	23.3	58.5	14.6	—	3.5	46.7
315	38.0	14.6	30.3	76.1	18.9	—	4.6	60.7
355	49.4	18.9	39.4	98.9	24.6	—	5.9	78.9
400	64.3	24.6	51.2	128.5	32.0	—	7.7	102.6
450	83.5	32.0	66.5	167.1	41.6	—	10.0	133.4
500	108.6	41.6	86.5	217.2	54.1	—	13.0	173.4
PPro-Seal Natural Polypropylene								
Nominal Pipe Size, in.	Equivalent Length of Pipe (ft.)							
½	1.5	0.8	1.0	3.8	1.0	1.0	0.1	1.7
¾	2.0	1.1	1.4	4.9	1.1	1.3	0.2	2.5
1	2.5	1.4	1.7	6.0	1.2	2.2	0.3	4.2
1½	4.0	2.1	2.7	8.4	1.7	2.6	0.4	5.0
2	5.7	2.6	4.0	12.0	2.6	3.5	0.5	6.7
3	7.9	4.0	6.1	16.4	4.4	7.5	1.0	13.3

Gravity Drain Systems

Flow Rate for Gravity Drain Systems

Drainage flow is caused by gravity due to slope of all drainage piping. Drainage piping is deliberately designed to run only partially full; a full pipe, particularly a stack, could blow out or suck out all the trap seals in the system. For a given type of pipe (friction,) the variables in drainage flow are slope and depth of liquid. When these two factors are known, the flow velocity V and flow rate Q can be calculated. The approximate flow rates and velocities can be calculated as follows:

Q - Flow Rate (gpm)
A - Section Area Pipe (ft^2)
n - Manning Friction Factor 0.009
R - Hydraulic Radius of pipe OD(ft)/4
S - Hydraulic Gradient - Slope (in/ft)

$$Q = A \cdot \frac{1.486}{n} \cdot R^{2/3} \cdot S^{1/2}$$

$$V = \frac{1.486}{n} \cdot R^{2/3} \cdot \frac{S^{1/2}}{12}$$

Example Problem

System Information

Material:	**160mm PROGEF Standard (PP-H)**
Outer Diameter:	**160.0 (mm)**
Inside Diameter:	**130.8 (mm)**

Q - Flow Rate (gpm)
A - Section Area Pipe 0.1446 full = **0.0723** ½full (ft^2)
n - Manning Friction Factor **0.009**
R - Hydraulic Radius of pipe **0.1073** (ft)
S - Hydraulic Gradient - Slope **1/8** (in/ft) = 0.0104
Slope **1/4** (in/ft) = 0.0208
Slope **1/2** (in/ft) = 0.0416

$$Q = .0723 \cdot \frac{1.486}{0.009} \cdot (0.1073)^{2/3} \cdot (0.0208)^{1/2}$$

$$Q = 11.94 \cdot 0.226 \cdot 0.144$$

$$Q = 0.102\ (ft^3/sec)$$

$$Q = 123.4\ (gpm)$$

$$V = \frac{1.486}{0.009} \cdot (0.1073)^{2/3} \cdot \frac{0.144}{12}$$

$$V = 165.1 \cdot 0.226 \cdot 0.012$$

$$V = 0.32\ (ft/sec)$$

Table 6
Approximate Discharge Rates and Velocities in Sloping Drains Flowing Half-Full

Nominal Pipe Diameter (mm)	PROGEF Standard/Natural Polypropylene					
	1/8 (in/ft) Slope		1/4 (in/ft) Slope		1/2 (in/ft) Slope	
	Flowrate (gpm)	Velocity (fps)	Flowrate (gpm)	Velocity (fps)	Flowrate (gpm)	Velocity (fps)
20	0.5	0.08	0.7	0.11	0.9	0.16
25	0.9	0.09	1.2	0.13	1.7	0.18
32	1.7	0.11	2.4	0.15	3.4	0.22
40	3.0	0.13	4.3	0.18	6.1	0.25
50	5.5	0.15	7.8	0.21	11.0	0.29
63	10.2	0.17	14.5	0.24	20.4	0.34
75	16.4	0.19	23.2	0.27	32.8	0.38
90	26.6	0.22	37.7	0.31	53.3	0.43
110	45.5	0.25	64.4	0.35	91.1	0.49
160	123.4	0.32	174.5	0.45	246.8	0.63
200	224.1	0.37	316.9	0.52	448.2	0.74
225	306.6	0.40	433.6	0.56	613.1	0.80
250	406.9	0.43	575.4	0.60	813.7	0.85
315	753.5	0.50	1065.7	0.70	1507.1	1.00
355	1037.1	0.54	1466.6	0.76	2074.1	1.08
400	1425.3	0.58	2015.6	0.83	2850.5	1.17
450	1949.4	0.63	2756.9	0.89	3898.9	1.26
500	2583.3	0.68	3653.4	0.96	5166.7	1.36

Nominal Pipe Diameter (inch)	PPro-Seal Natural Polypropylene					
	1/8 (in/ft) Slope		1/4 (in/ft) Slope		1/2 (in/ft) Slope	
	Flowrate (gpm)	Velocity (fps)	Flowrate (gpm)	Velocity (fps)	Flowrate (gpm)	Velocity (fps)
½	0.3	0.07	0.4	0.10	0.6	0.14
¾	0.7	0.09	1.0	0.12	1.4	0.17
1	1.4	0.10	2.0	0.15	2.8	0.21
1½	4.6	0.14	6.5	0.20	9.2	0.28
2	9.1	0.17	12.9	0.23	18.2	0.33
3	26.7	0.22	37.7	0.31	53.4	0.43

Surge Pressure (Water Hammer)

Surge Pressure (Water Hammer)

Surge pressure, or water hammer, is a term used to describe dynamic surges caused by pressure changes in a piping system. They occur whenever there is a deviation from the steady state, i.e.; when the velocity of the fluid is increased or decreased, and may be transient or oscillating. Waves of positive or negative pressure may be generated by any of the following:

- Opening or closing of a valve
- Pump startup or shutdown
- Change in pump or turbine speed
- Wave action in a feed tank
- Entrapped air

The pressure waves travel along at speeds limited by the speed of sound in the medium, causing the pipe to expand and contract. The energy carried by the wave is dissipated and the waves are progressively damped (**see Figure 5**).

The pressure excess to water hammer must be considered in addition to the hydrostatic load, and this total pressure must be sustainable by the piping system. In the case of oscillatory surge pressures, extreme caution is needed as surging at the harmonic frequency of the system could lead to catastrophic damage.

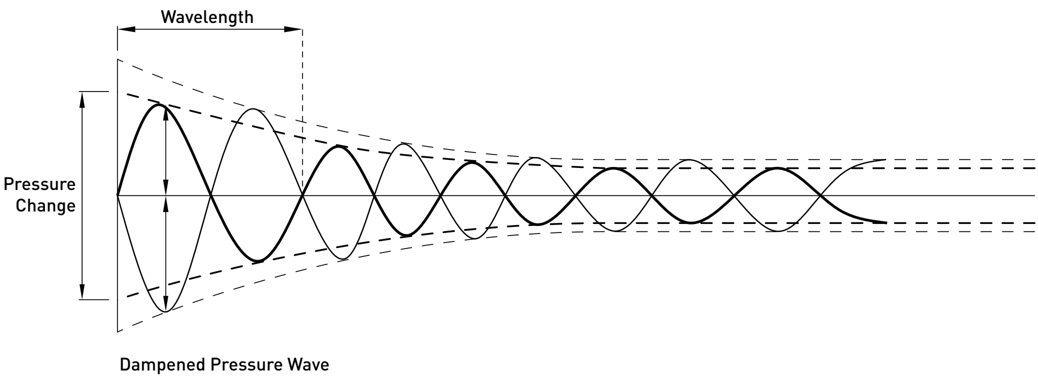


Figure 5

The maximum positive or negative addition of pressure due to surging is a function of fluid velocity, fluid density, bulk fluid density and pipe dimensions of the piping system. It can be calculated using the following steps.

Step 1

Determine the velocity of the pressure wave in pipes.

V_w - Velocity of Pressure Wave (ft./sec)
K - Bulk Density of Water 3.19 x 10^5 (lb/in^2)
n_i - Conversion Factor 1/144 (ft^2/in^2)
δ - Fluid Density of Water 1.937 ($slugs/ft^3$)

$$V_w = \sqrt{\frac{K}{n_i \cdot \delta}}$$

Step 2

Critical time for valve closure.

$$t_c = \frac{2L}{V_w}$$

t_c - Time for Valve Closure (sec)
V_w - Velocity of Pressure Wave (ft/sec)
L - Upstream Pipe Length (ft)

Step 3

Maximum pressure increase; assume valve closure time is less than the critical closure time and fluid velocity goes to 0.

$$P_i = \delta \cdot V \cdot V_w n_i$$

P_i - Maximum Total Pressure (lb/in^2)
δ - Fluid Density ($slugs/ft^3$)
V - Fluid Velocity (ft/sec)
V_w - Velocity of Pressure Wave
n_i - Conversion Factor 1/144 (ft^2/in^2)

Special Consideration

Calculate the Maximum Instantaneous System Pressure.

$$P_{max} = P_i + P_s$$

P_{max} - Maximum System Operating Pressure (lb/in^2)
P_i - Maximum Pressure Increase (lb/in^2)
P_s - Standard System Operating Pressure (lb/in^2)

Cautionary Note

Caution is recommended if P_{max} is greater than the maximum system design pressure multiplied by a safety factor of 2x.

e.g. - Pipe is rated at 150 psi. If P_{max} exceeds 300psi (150psi x 2 safety factor), then precaution must be implemented in case of maximum pressure wave (i.e. water hammer) to prevent possible pipe failure.

Step 4

Determine the Maximum System Pressure Increase with Gradual Valve Closure

P_g - Gradual Pressure Increase with Valve Closure (lb/in^2)
L - Upstream Pipe Length (ft.)
V - Fluid Velocity (ft./sec)
n_i - Conversion Factor 1/144 (ft^2/in^2)
t_c - Time of Valve Closure (sec)

$$P_g = \frac{2 \cdot \delta \cdot L \cdot V \cdot n_i}{t_v}$$

Example Problem

A water pipeline from a storage tank is connected to a master valve, which is hydraulically actuated with an electrical remote control. The piping system flow rate is 300 (gal/min) with a velocity of 4 (ft./sec); thus requiring a 160mm nominal pipeline. The operating pressure of the system will be 50 (lb/in^2), the valve will be 500 (ft.) from the storage tank and the valve closing time is 2.0 (sec). Determine the critical time of closure for the valve, and the internal system pressure should the valve be instantaneously or suddenly closed vs. gradually closing the valve (10 times slower).

Pipe Details

System Information		Other Information	
Material:	**160mm PROGEF Standard (PP-H)**	Bulk Water Density **(K)**	**3.19 x 10^5 (lb/in^2)**
Flow Rate:	**300 (gal/min)**	Fluid Density **(δ)**	**1.937 (slugs/ft^3)**
Pipeline Length:	**500 (ft)**	Valve Closing Time	**2.0 (sec)**
Operating Pressure:	**50 (lb/in^2)**	Water Velocity	**4.0 (ft/sec)**

Step 1 - Velocity of Pressure Wave

Determine the Velocity of the Pressure Wave

V_w - Velocity of Pressure Wave (ft/sec)
K - Bulk Density of Water **3.19 x 10^5** (lb/in^2)
n_i - Conversion Factor **1/144** (ft^2/in^2)
δ - Fluid Density **1.937** (slugs/ft^3)

$$V_w = \sqrt{\frac{K}{n_i \cdot \delta}} \qquad V_w = \sqrt{\frac{3.19 \times 10^5}{\frac{1}{144} \cdot 1.937}}$$

$$V_w = 4870 \text{ (ft/sec)}$$

+GF+

Step 2 - Critical Valve Closure Time

Determine the Critical Closure Time

t_c - Critical Closure Time (sec)

V_w - Velocity of Pressure Wave **4870** (ft/sec)

L - Upstream Pipe Length **500** (ft)

$$t_c = \frac{2L}{V_w} \qquad t_c = \frac{2 \cdot 500}{4870}$$

$$t_c = 0.2 \text{ (sec)}$$

Step 3 - Maximum Pressure Increase

Determine the Maximum Pressure Increase; Assume: Valve Closure Time < Critical Closure Time t_c and Fluid Velocity goes to 0.

P_i - Maximum Pressure Increase (lb/in²)

δ - Fluid Density **1.937** (slugs/ft³)

V - Fluid Velocity **4** (ft/sec)

V_w - Velocity of Pressure Wave **4870** (ft/sec)

n_i - Conversion Factor **1/144** (ft²/in²)

$$P_i = \delta \cdot V \cdot V_w \, n_i$$

$$P_i = \frac{1.937 \cdot 4 \cdot 4870}{144}$$

$$P_i = 262 \text{ (lb/in}^2\text{)}$$

Consideration: Maximum Instantaneous System Pressure

Determining the Maximum Instantaneous System Pressure: Caution is recommended if P_{max} is greater than the Maximum System Operating Pressure multiplied by a 2x Service Factor.

P_{max} - Maximum Instantaneous Operating Pressure (lb/in²)

P_i - Valve Pressure (instantaneous) (lb/in²)

P_s - Standard System Operating Pressure (lb/in²)

In this case, 160mm PROGEF Standard Polypropylene pipe is rated at 150psi. Therefore, the system design is outside safety limits (300psi max).

$$P_{max} = P_i + P_s$$

$$P_{max} = 262 + 50$$

$$P_{max} = 312 \text{ (lb/in}^2\text{)}$$

Step 4 - Maximum Change in Pressure with Gradual Valve Closure

Determine the Maximum Change in System Pressure with Gradual Valve Closure (2 Second Close Time).

P_g - Maximum Gradual Pressure Change (lb/in²)

t_v - Valve Closing Time **2** (sec)

L - Upstream Pipe Length **500** (ft)

V - Fluid Velocity **4** (ft/sec)

n_i - Conversion Factor **1/144** (ft²/in²)

δ - Fluid Density **1.937** (slugs/ft³)

$$P_g = \frac{2 \cdot \delta \cdot L \cdot V \cdot n_i}{t_v}$$

$$P_g = \frac{2 \cdot 1.937 \cdot 500 \cdot 4 \cdot \frac{1}{144}}{2}$$

$$P_g = 26.9 \text{ (lb/in}^2\text{)}$$

Expansion/Contraction

Allowing for Length Changes in PP Pipelines

Variations in temperature cause greater length changes in thermoplastic materials than in metals. In the case of above ground, wall or duct mounted pipe work, particularly where subjected to varying working temperatures, it is necessary to make suitable provision for length changes in order to prevent additional stresses.

Calculation and Positioning of Flexible Sections

It is possible to take advantage of the very low modulus of elasticity (**Figure 6**) of Polypropylene by including special sections of pipe which compensate thermal length changes. The length of the flexible section mainly depends upon the pipe diameter and the extent of the length change to be compensated. In order to simplify planning and installation, the third influencing factor— the pipe wall temperature —is not taken into account, particularly as installation usually takes place in the temperature range between 37°F and 77°F.

Where the pipe work changes direction or branches off, there is always a natural flexible section.

There are two primary methods of controlling or compensating for thermal expansion of plastic piping systems: taking advantage of offsets and changes of direction in the piping and expansion loops.

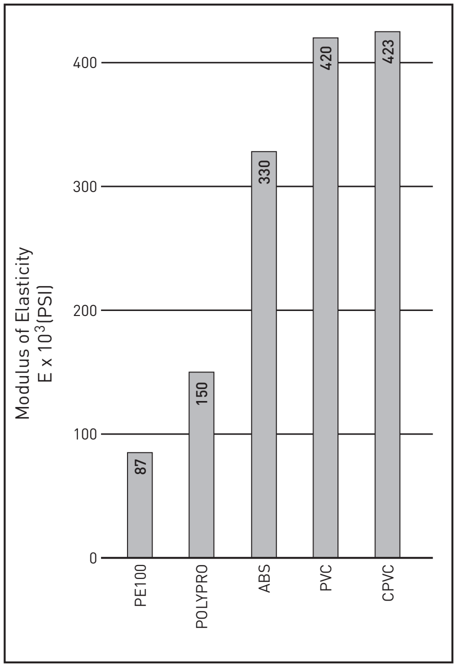
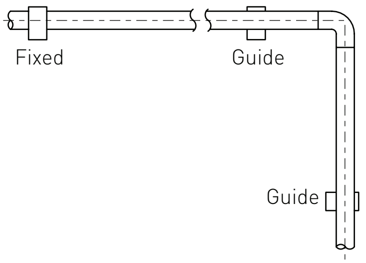


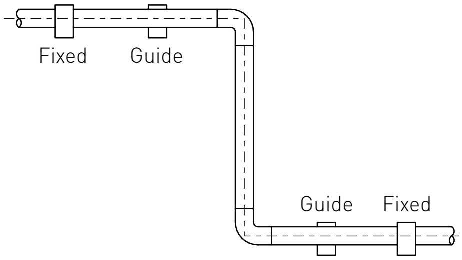
Figure 6

Type 1 - Offsets/Changes in Direction

Most piping systems have occasional changes in directions which will allow the thermally included length changes to be taken up in offsets of the pipe beyond the bends. Where this method is employed, the pipe must be able to float except at anchor points.



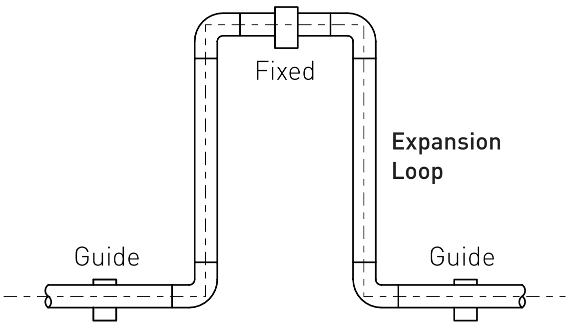
Changes in Direction



Offsets

Type 2 - Expansion Loops

For expansion loops the flexible section is broken into two offsets close together. By utilizing the flexible members between the legs and 4 elbows the "a" length is slightly shorter than the "a" in the standalone offset.



Determining the Length Change (ΔL) (Example 1)

In order to determine the length of flexible section (a) required, the extent of the length change must be ascertained first of all, by means of the following formula where

$$\Delta L = L \cdot \Delta T \cdot \delta$$

$$(\text{inch}) = (\text{inch}) \cdot (^{\circ}F) \cdot (\text{inch/inch}^{\circ}F)$$

ΔL = Length change in inches

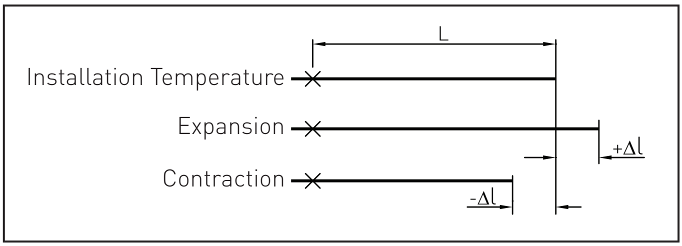
L = Length in inches of the pipe or pipe section where the length change is to be determined

ΔT = Difference between installation temperature and maximum or minimum working temperature in °F

δ = Coefficient of linear expansion - 0.000083 in/in°F

Important:

If the operating temperature is higher than the installation temperature, then the pipe becomes longer. If, on the other hand, the operating temperature is lower than the installation temperature, then the pipe contracts its length. The installation temperature must therefore be incorporated into the calculation, as well as the maximum and minimum operating temperatures.



Problem

The procedure is explained using a coolant pipe as an example: Length of the pipe from the fixed point to the branch where the length change is to be taken up: L = 315 inch

Installation temperature: $T_v = 73°F$
Temperature of the coolant: $T_1 = 40°F$
Temperature when defrosting and cleaning: $T_2 = 95°F$
Material: 250mm PROGEF Standard (PPH)

Difference in Contraction Temperature

$\Delta T_1 = T_v - T_1 = 73°F - 40°F = 33°F$

Difference in Expansion Temperature

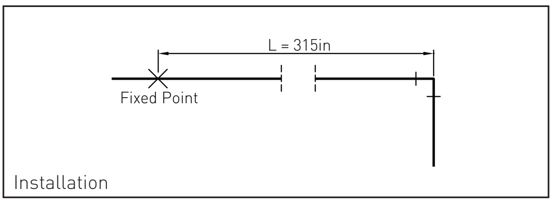
$\Delta T_2 = T_2 - T_v = 95°F - 73°F = 22°F$

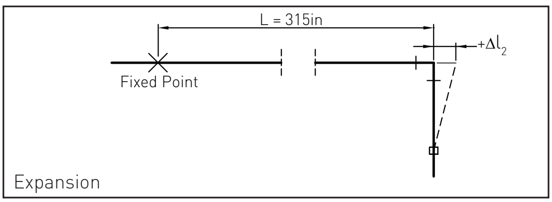
Contraction during service with coolant

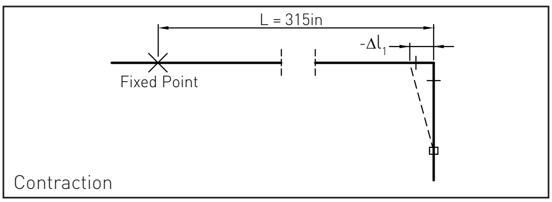
$-\Delta L_1 = L \cdot \Delta T_1 \cdot \delta = 315in \cdot 33 \cdot (0.000083) = 0.86in$

Expansion during defrosting and cleaning

$+\Delta L_2 = L \cdot \Delta T_2 \cdot \delta = 315in \cdot 22 \cdot (0.000083) = 0.58in$







Length Change (ΔL) in Inches

Table 7

		Length of Pipe Section (ft)																		
		5	10	15	20	25	30	35	40	45	50	55	60	65	70	80	85	90	95	100
Temperature Change in (°F)	5			0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5
	10		0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1.0
	15	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.0	1.2	1.3	1.3	1.4	1.5
	20	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.7	1.8	1.9	2.0
	25	0.1	0.2	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.2	1.4	1.5	1.6	1.7	2.0	2.1	2.2	2.4	2.5
	30	0.1	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.3	1.5	1.6	1.8	1.9	2.1	2.4	2.5	2.7	2.8	3.0
	35	0.2	0.3	0.5	0.7	0.9	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3	2.4	2.8	3.0	3.1	3.3	3.5
	40	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.2	3.4	3.6	3.8	4.0
	45	0.2	0.4	0.7	0.9	1.1	1.3	1.6	1.8	2.0	2.2	2.5	2.7	2.9	3.1	3.6	3.8	4.0	4.3	4.5
	50	0.2	0.5	0.7	1.0	1.2	1.5	1.7	2.0	2.2	2.5	2.7	3.0	3.2	3.5	4.0	4.2	4.5	4.7	5.0
	55	0.3	0.5	0.8	1.1	1.4	1.6	1.9	2.2	2.5	2.7	3.0	3.3	3.6	3.8	4.4	4.7	4.9	5.2	5.5
	60	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2	4.8	5.1	5.4	5.7	6.0
	65	0.3	0.6	1.0	1.3	1.6	1.9	2.3	2.6	2.9	3.2	3.6	3.9	4.2	4.5	5.2	5.5	5.8	6.2	6.5
	70	0.3	0.7	1.0	1.4	1.7	2.1	2.4	2.8	3.1	3.5	3.8	4.2	4.5	4.9	5.6	5.9	6.3	6.6	7.0
	80	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.4	6.8	7.2	7.6	8.0
	90	0.4	0.9	1.3	1.8	2.2	2.7	3.1	3.6	4.0	4.5	4.9	5.4	5.8	6.3	7.2	7.6	8.1	8.5	9.0
	100	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	8.5	9.0	9.5	10.0

Determining the Length of the Flexible Section (a) (Example 2)

The values required to determine the length of the flexible **(a)** section are:

The maximum length change ΔL in comparison with the zero position during installation, (which can be either an expansion or a contraction), and the pipe diameter **(d)**.

If values ΔL and **(d)** are known, **Table 8** shows the length of flexible section **(a)** required.

Formula for Flexible Sections (a)

$$a = k\sqrt{\Delta L \cdot d}$$

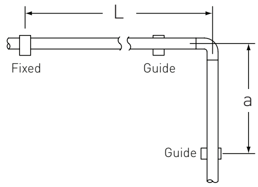
a = Length of Flexible Section
k = Constant (k = 30)
ΔL = Change in Length
d = Outside Diameter of Pipe

Table 8: Flexible Sections (a) in Inches

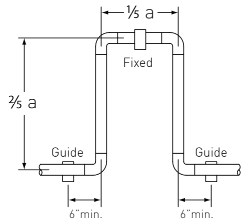
Length Change - ΔL (in)	PROGEF Standard/Natural Polypropylene Nominal Pipe Diameter																	
	20mm	25mm	32mm	40mm	50mm	63mm	75mm	90mm	110mm	160mm	200mm	225mm	250mm	315mm	355mm	400mm	450mm	500mm
0.1	8	9	11	12	13	15	16	18	20	24	27	28	30	33	35	38	40	42
0.2	12	13	15	17	19	21	23	25	28	34	38	40	42	47	50	53	56	60
0.3	15	16	18	21	23	26	28	31	34	41	46	49	52	58	61	65	69	73
0.4	17	19	21	24	27	30	33	36	39	48	53	56	60	67	71	75	80	84
0.5	19	21	24	27	30	33	36	40	44	53	60	63	67	75	79	84	89	94
0.6	21	23	26	29	33	37	40	44	48	58	65	69	73	82	87	92	98	103
0.7	22	25	28	31	35	40	43	47	52	63	70	75	79	88	94	100	106	111
0.8	24	27	30	34	38	42	46	51	56	67	75	80	84	94	100	106	113	119
0.9	25	28	32	36	40	45	49	54	59	71	80	85	89	100	106	113	120	126
1.0	27	30	34	38	42	47	52	56	62	75	84	89	94	106	112	119	126	133
2.0	38	42	48	53	60	67	73	80	88	106	119	126	133	149	159	168	179	188
3.0	46	52	58	65	73	82	89	98	108	130	146	155	163	183	194	206	219	231
4.0	53	60	67	75	84	94	103	113	125	151	168	179	188	211	224	238	253	266
5.0	60	67	75	84	94	106	115	126	140	168	188	200	210	236	251	266	282	298
6.0	65	73	82	92	103	116	126	138	153	184	206	219	231	259	275	292	309	326
7.0	70	79	89	100	111	125	137	149	165	199	223	236	249	280	297	315	334	352
8.0	75	84	95	106	119	134	146	160	177	213	238	253	266	299	317	337	357	376
9.0	80	89	101	113	126	142	155	169	187	226	253	268	282	317	336	357	379	399
10.0	84	94	106	119	133	149	163	179	197	238	266	282	298	334	355	376	399	421

Length Change - ΔL (in)	PPro-Seal Natual Polypropylene Nominal Pipe Diameter					
	1/2in	3/4in	1in	1 1/2in	2in	3in
0.1	9	10	11	13	15	18
0.2	12	14	15	18	21	25
0.3	15	17	19	23	25	31
0.4	17	19	22	26	29	35
0.5	19	22	24	29	33	40
0.6	21	24	27	32	36	43
0.7	23	26	29	35	39	47
0.8	25	27	31	37	41	50
0.9	26	29	33	39	44	53
1.0	27	31	34	41	46	56
2.0	39	43	49	58	65	79
3.0	48	53	60	72	80	97
4.0	55	61	69	83	92	112
5.0	61	69	77	92	103	125
6.0	67	75	84	101	113	137
7.0	73	81	91	109	122	148
8.0	78	87	97	117	131	159
9.0	82	92	103	124	139	168
10.0	87	97	109	131	146	177

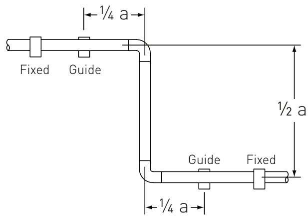
Change of Direction



Expansion



Offeset



Installation Hints

The length changes in pipe sections should be clearly controlled by the arrangement of fixed brackets. It is possible to distribute the length changes in pipe sections using proper positioning of fixed brackets (see adjoining examples).

If it is not possible to include a flexible section at a change of direction or branch, or if extensive length changes must be taken up in straight sections of pipe work, expansion loops may also be installed. In this case, the length change is distributed over two flexible sections.

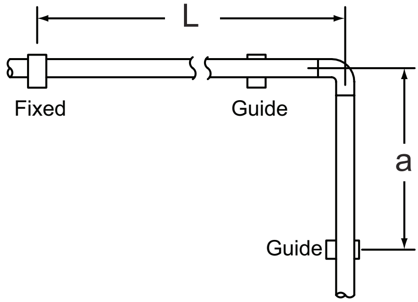
Note

To eliminate bilateral expansion thrust blocks are recommended at intersections.

For an expansion loop, (taking **Example 1**), the length change of **1.28in** would require a flexible section length of **a = 42.6in**. A single flexible section on the other hand, would need to be **106.5in.** in length.

Pre-Stressing

In particularly difficult cases, where the length changes are large and acting in one direction only, it is also possible to pre-stress the flexible section during installation, in order to reduce the length of a. This procedure is illustrated in the following example:



Installation conditions

L = **315in.**

d = **250mm.** (nominal)

Installation temperature: **73°F**

Max. working temperature: **35°F**

Material: **PP-H**

1 . Length change

+ΔL = L • ΔT • ∝ = 315 • 38 • (0.000083) = 0.99in.

2. Flexible section required to take up length change of ΔL = 0.99in according to **Table 7**:

a = approx. 94in.

3. If, on the other hand, the flexible section is pre-stressed to ΔL/2, the required length of flexible section is reduced to approx. 1500mm (59in.). The length change, starting from the zero position, then amounts to

±ΔL/2 = 0.99in/2 = 0.50in.

a = approx. 67in. (per Table 7)

In special cases, particularly at high working temperatures, pre-stressing of a flexible section improves the appearance of the pipeline in service, as the flexible section is less strongly deflected.

Installation

The Incorporation of Valves

Valves should be mounted as directly as possible; they should be formed as fixed points. The actuating force is thus transmitted directly, and not through the pipeline. The length changes, starting from the valve, are to be controlled as described previously.

For safe mounting of plastic valves, Georg Fischer valves are equipped with metal threaded inserts for direct mounted installation.

Vibration Dampeners

There are two principal ways to control stress caused by vibration. You can usually observe the stability of the system during initial operation and add restraints or supports as required to reduce effects of equipment vibration. Where necessary restraint fittings may be used to effectively hold pipe from lifting or moving laterally.

In special cases where the source of vibration is excessive (such as that resulting from pumps running unbalanced), an elastomeric expansion joint or other vibration absorber may be considered. This may be the case at pumps where restricting the source of vibration is not recommended.

The Installation of Pipe Work under Plaster or Embedded in Concrete

Padded Pipe Work

Where pipe work installed under plaster or embedded in concrete changes direction or branches off, the flexible section under consideration must be padded along the length a, which is based on the calculated length change. The accompanying tees or elbows must, of course, also be included in the padding. Only flexible materials, such as glass wool, mineral wool, foam plastic or similar may be used for padding.

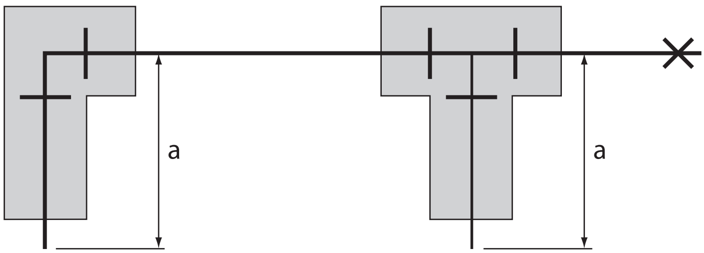


Figure 7

Pipe Bracket Support Centers and Fixation of Plastic Pipelines

General Pipe Supports and Brackets

PE pipelines need to be supported at specific intervals, depending upon the material, the average pipe wall temperature, the specific gravity of the medium, and the diameter and wall thickness of the pipe. The determination of the pipe support centers has been based on the permissible amount of deflection of the pipe between two brackets. The pipe bracket centers given in **Table 9** are calculated on the basis of a permissible deflection of max. 0.25 cm (0.01 inch) between two brackets.

Pipe Bracket Spacing in the Case of Fluids with Specific Gravity ≤ 1.0 (62.4 Lb/Ft^3)

Where fluids with a specific gravity exceeding 1g/cm3 are to be conveyed, pipe spacing can be adjusted by dividing the support spacing by the specific gravity (See example next page).

Installation of Closely Spaced Pipe Brackets

A continuous support may be more advantageous and economical than pipe brackets for small diameter horizontal pipe work, especially in a higher temperature range. Installation in a "V"-or "U"-shaped support made of metal or heat-resistant plastic material has proven satisfactory.

Pipe Bracket Requirements

When mounted, the inside diameter of the bracket must be greater than the outside diameter of the pipe, in order to allow length changes of the pipe at the specified points. The inside edges of the pipe bracket must be formed in such a way that no damage to the pipe surface is possible. George Fischer pipe brackets meet these requirements. They are made of plastic and may be used under rugged working conditions and also in areas where the pipe work is subjected to the external influence of aggressive atmospheres or media. Georg Fischer pipe brackets are suitable for PVC, CPVC, PE, PP and PVDF pipes.

Arrangement of Fixed Brackets

If the pipe bracket is positioned directly beside a fitting, the length change of the pipeline is limited to one direction only (one-sided fixed point).

If it is, as in most cases, necessary to control the length change of the pipeline in both directions, the pipe bracket must be positioned between two fittings. The pipe bracket must be robust and firmly mounted in order to take up the force arising from the length change in the pipeline. Hanger type brackets are not suitable as fixed points.

General Pipe Supports and Brackets for Liquids with a Specific Gravity ≤ 1.0 (62.4 lb/ft^3)

Table 9

Pipe Size (mm)	Pipe Bracket Intervals L (ft.) for PROGEF Standard					
	≤65°F	85°F	105°F	125°F	140°F	176°F
20	2.3	2.2	2.1	2.1	2.0	1.8
25	2.6	2.5	2.5	2.4	2.3	2.1
32	3.1	3.0	3.0	2.9	2.8	2.5
40	3.6	3.5	3.4	3.3	3.1	2.9
50	4.1	4.0	3.9	3.8	3.6	3.3
63	4.8	4.7	4.6	4.4	4.3	3.9
75	5.1	4.9	4.8	4.6	4.4	4.1
90	5.4	5.2	5.1	4.9	4.8	4.4
160	7.4	7.2	6.9	6.6	6.2	5.6
200	8.2	7.9	7.5	7.2	6.9	6.2
225	8.7	8.4	8.0	7.7	7.4	6.6
250	9.2	8.9	8.5	8.2	7.9	7.1
315	10.3	10.0	9.7	9.4	8.9	8.0
355	11.0	10.7	10.3	10.0	9.5	8.7
400	11.6	11.3	11.0	10.7	10.2	9.4
450	12.3	12.0	11.6	11.3	10.8	10.0
500	13.0	12.6	12.3	12.0	11.5	10.7

Pipe Size (mm)	Pipe Bracket Intervals L (ft.) for PROGEF Natural					
	≤65°F	85°F	105°F	125°F	140°F	176°F
20	1.7	1.6	1.6	1.6	1.5	1.4
25	2.0	1.9	1.9	1.8	1.7	1.6
32	2.4	2.3	2.2	2.1	2.1	1.9
40	2.7	2.6	2.6	2.5	2.4	2.1
50	3.1	3.0	3.0	2.9	2.4	2.5
63	3.6	3.5	3.4	3.4	3.3	3.1
90	4.1	3.9	3.8	3.8	3.6	3.3

Pipe Size (inch)	Pipe Bracket Intervals L (ft.) for PPro-Seal					
½	3.8	3.8	3.7	3.5	3.0	2.8
¾	4.0	4.0	3.9	3.8	3.5	3.0
1	4.5	4.5	4.3	4.0	3.8	3.3
1½	5.0	5.0	4.8	4.8	4.3	3.8
2	5.5	5.5	5.3	5.0	4.5	4.0
3	6.5	6.5	6.3	6.0	5.5	5.0

Note:

General rule of thumb: pipe spacing can be adjusted by dividing the support spacing by the specific gravity.

Example: 63mm pipe carrying media with a specific gravity of 1.6 – 4.8ft divided by 1.6 = approx. 3ft centers.

Mechanical Connections

Mechanical Joining of Piping Systems

Flange Connections	Flange adapters for butt fusion Coated Metal Flanges Backing Rings
Unions	Plastics-oriented connections between same plastics Transitions to other plastics Seal: O-ring
Threaded Fittings	Plastic fittings with reinforcement ring and tapered Female NPT threads. **(Note: PPro-Seal does not utilize a reinforcement ring)**

Threaded Connections

The following different types of threads are used

Designation of the thread	According to standard	Typical use	Description
G (Buttress Threads)	ISO 228	Unions	Parallel internal or external pipe thread, where pressure-tight joints are not made on the threads
NPT = National (American Standard) Pipe Taper	ASTM F1498	Transition and threaded fittings	Taper internal or external pipe thread for plastic pipes and fittings, where pressure-tight joints are made on the threads

Flanged Connections

Creating Flange Joints

When making a flange connection, the following points have to be taken into consideration:

There is a general difference between the connection of plastic pipes and so-called adapter joints, which represent the transition from a plastic pipe to a metal pipe or a metal valve. Seals and flanges should be selected accordingly.

Flanges with sufficient thermal and mechanical stability should be used. GF flange types fulfill these requirements.

A robust and effective seal can only be achieved if sufficient compressive forces are transmitted to the polyethylene stub end via the ductile iron backup ring. These compressive forces must be of sufficient magnitude to overcome fluctuating hydrostatic and temperature generated forces encountered during the lifetime of the joint. It is possible to achieve a good seal between polyethylene stub ends without the use of a gasket, but in some circumstances a gasket may be used. In assembling the stub ends, gasket and backup rings it is extremely important to ensure cleanliness and true alignment of all mating surfaces. The correct bolt tightening procedure must also be followed and allowance made for the stress relaxation characteristics of the polyethylene stub ends.

Alignment

1. Full parallel contact of the sealing faces is essential.
2. The backup ring must contact the stub end evenly around the circumference.
3. Misalignment can lead to excessive and damaging stresses in either the stub

Creating Flange Joints

When to Use a Flange?

Flanges may be used when:

- The piping system may need to be dismantled
- The installation is temporary or mobile
- Transitioning between dissimilar materials that can not be bonded together

Materials

Plastic Flanges

Visually inspect flanges for cracks, deformities or other obstructions on the sealing surfaces.

Gasket

A rubber gasket must be used between the flange faces in order to ensure a good seal. GF recommends a 0.125" thick, full-face gasket with Shore A scale hardness of 70±5, and the bolt torque values **(Table 12A)** are based on this specification. For other hardness requirements, contact GF Technical Services. Select the gasket material based on the chemical resistance requirements of your system. A full-face gasket should cover the entire flange-to-flange interface without extending into the flow path.

At increased working and testing pressures, the profile flange gasket is recommended. Compared to a flat gasket, the profile gasket is made of two components. One is the crowned flat gasket part, which is reinforced with steel, and the other is the profile part (O-ring, lip seal) on the seal inner side.

The stabilized profile flange gaskets have the following advantages:

- Reliable seal with minimum fastener torque
- Can be used with higher internal pressure or internal vacuum
- Easy to install
- Influenced less by the flange surface
- Safe when connecting pipes of different materials

ANSI Class 150 Flat Flange Gasket Dimensions (Recommended only up to a maximum operating pressure of 90 PSI)

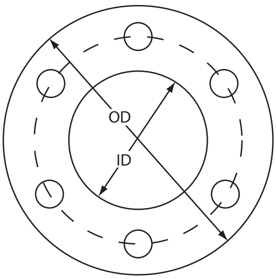


Figure 8

Size	O.D. (in)	PROGEF I.D. (in)	PPro-Seal I.D. (in)
20mm (½")	3.50	1.10	0.88
25mm (¾")	3.86	1.34	1.10
32mm (1")	4.25	1.65	1.38
40mm (1¼")	4.61	2.01	—
50mm (1½")	5.00	2.44	1.93
63mm (2")	5.98	3.07	2.44
75mm (2½")	7.01	3.62	—
90mm (3")	7.48	4.33	3.59
110mm (4")	9.02	5.24	—
160mm (6")	10.98	7.05	—
200mm (8")	13.50	9.30	—
225mm (8")	13.50	9.42	—
250mm (10")	16.00	11.35	—
315mm (12")	19.00	13.31	—
355mm (14")	21.00	14.80	—
400mm (16")	23.50	16.93	—

ANSI Class 150 Profile Flange Gasket Dimensions (For PROGEF Piping Only)

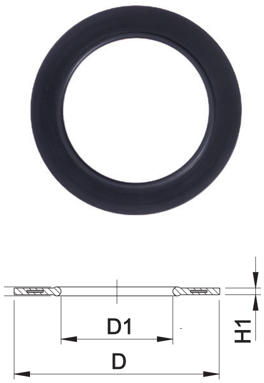


Figure 8

Size	D (in)	D1 (in)	H1 (in)
25mm (¾”)	2.13	1.06	0.12
32mm (1”)	2.52	1.30	0.12
40mm (1¼”)	2.87	1.65	0.12
50mm (1½”)	3.27	1.89	0.12
63mm (2”)	4.01	2.36	0.16
75mm (2½”)	4.76	2.87	0.16
90mm (3”)	5.23	3.50	0.16
110mm (4”)	6.73	4.53	0.2
160mm (6”)	8.58	6.30	0.24
200mm (8”)	10.86	8.62	0.24
225mm (8”)	10.86	8.62	0.24
250mm (10”)	13.26	10.74	0.24
315mm (12”)	15.98	12.79	0.24
355mm (14”)	17.63	14.36	0.27
400mm (16”)	20.15	15.98	0.27

Fasteners

It is critical to avoid excessive compression stress on a flange. Therefore, only low-friction fastener materials should be used. Low-friction materials allow torque to be applied easily and gradually, ensuring that the flange is not subjected to sudden, uneven stress during installation, which can lead to cracking.

Either the bolt or the nut, and preferably both, should be zinc-plated to ensure minimal friction. If using stainless steel bolt and nut, lubricant must be used to prevent high friction and seizing. In summary, the following fastener combinations are acceptable:

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

Cadmium-plated fasteners, while becoming more difficult to obtain due to environmental concerns, 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. Bolts must be long enough that two complete threads are exposed when the nut is tightened by hand. Using a longer bolt does not compromise the integrity of the flange connection, although it wastes material and may make tightening more difficult due to interference with nearby system components.

Table 11
Fastener Specifications - PROGEF Polypropylene

Flange Size (mm)	No. of Bolts	Length[1] (in)	Bolt Size (in) and Type	Washer Size (in) and Type[2]
20	4	3.75	1/2" SAE GRD 5	1/2" SAE
25	4	4.75	1/2" SAE GRD 5	1/2" SAE
32	4	5.00	1/2" SAE GRD 5	1/2" SAE
40	4	5.50	1/2" SAE GRD 5	1/2" SAE
50	4	6.25	1/2" SAE GRD 5	1/2" SAE
63	4	7.00	5/8" SAE GRD 5	5/8" SAE
75	4	7.50	5/8" SAE GRD 5	5/8" SAE
90	4	9.00	5/8" SAE GRD 5	5/8" SAE
110	8	6.25	5/8" SAE GRD 5	5/8" SAE
160	8	6.25	3/4" SAE GRD 5	3/4" SAE
200	8	5.25	3/4" SAE GRD 5	3/4" SAE
225	8	5.50	3/4" SAE GRD 5	3/4" SAE
250	12	5.25	3/4" SAE GRD 5	3/4" SAE
315	12	6.25	3/4" SAE GRD 5	3/4" SAE
355	12	5.75	1" SAE GRD 5	1" SAE
400	16	6.50	1" SAE GRD 5	1" SAE
450	16	8.00	1 1/8" SAE GRD 5	1 1/8" SAE
500	20	7.75	1 1/8" SAE GRD 5	1 1/8" SAE

Fastener Specifications - PPro-Seal Polypropylene

Flange Size (in)	No. of Bolts	Length[1] (in)	Bolt Size (in) and Type	Washer Size (in) and Type[2]
½	4	1.75	1/2" SAE GRD 5	1/2" SAE
¾	4	1.75	1/2" SAE GRD 5	1/2" SAE
1	4	2.00	1/2" SAE GRD 5	1/2" SAE
1½	4	2.25	1/2" SAE GRD 5	1/2" SAE
2	4	2.50	5/8" SAE GRD 5	5/8" SAE
3	4	3.00	5/8" SAE GRD 5	5/8" SAE

[1] Suggested bolt length for flange-to-flange connection with 0.125" thick gasket. Adjust bolt length as required for other types of connections.

[2] Minimum spec. Use of a stronger or thicker washer is always acceptable as long as published torque limits are observed.

[3] Also known as Type A Plain Washers, Narrow Series.

[4] ASTM F436 required for larger sizes to prevent warping at high torque.

A washer must be used under each bolt head and nut. The purpose of the washer is to distribute pressure over a wider area, reducing the compression stress under the bolt head and nut. Failure to use washers voids the GF warranty.

Torque Wrench

Compared to metals, plastics are relatively flexible and deform slightly under stress. Therefore, not only must bolt torque be controlled in order to avoid cracking the flange, but continuing to tighten the bolts beyond the recommended torque levels may actually make the seal worse, not better.

Because bolt torque is critical to the proper function of a flange, a current, calibrated torque wrench accurate to within ±1 ft-lb must be used when installing flanges.

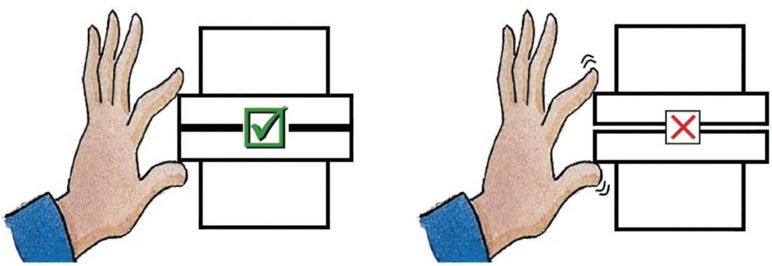
Experienced installers may be tempted to forgo the use of a torque wrench, relying instead on "feel." GF does not endorse this practice. Job-site studies have shown that experienced installers are only slightly better than new trainees at estimating bolt torque by feel. A torque wrench is always recommended.

Installation

Checking System Alignment

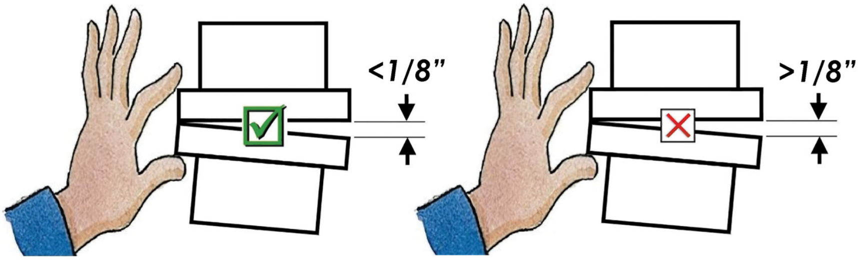
Before assembling the flange, be sure that the two parts of the system being joined are properly aligned. GF has developed a "pinch test" that allows the installer to assess system alignment quickly and easily with minimal tools. First check the gap between the flange faces by pinching the two mating components toward each other with one hand as shown below. If the faces can be made to touch, then the gap between them is acceptable.

Figure 9



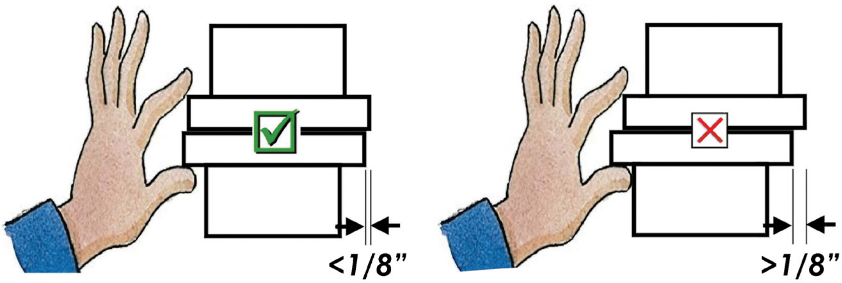
Next check the angle between the flange faces. If the faces are completely flush when pinched together, as shown above, then the alignment is perfect, and you may continue installation. Otherwise, pinch the faces together so that one side is touching, then measure the gap between the faces on the opposite side. The gap should be no more than 1/8".

Figure 10



To assess high-low misalignment, pull the flange faces flush together. If the faces are concentric within 1/8", then the high-low misalignment is acceptable

Figure 11

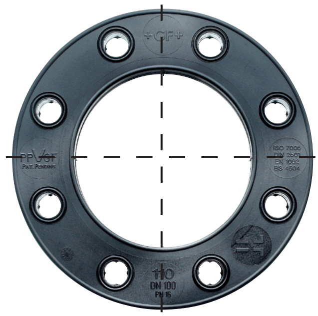


If the gap between the mating components can not be closed by pinching them with one hand, or if the angle or high-low misalignment between them is too large, then using the bolts to force the components together will result in excessive stress and possible failure during or after installation. In this case, inspect the system to find the greatest source of misalignment and refit the system with proper alignment before bolting.

Bolt Hole Alignment

Orientation of bolts should be outside of main axis. Horizontal pipelines should have the shown orientation of the bolts. This will avoid medium drops on the bolts in case of a leak.

To align the bolt holes of a fixed flange, use standard two-holing procedure.



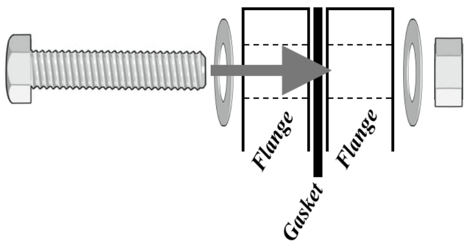
Placing the Gasket

Center the gasket between the flange adapter faces, with the bolt holes at the outer edge of the gasket. A gasket cut to the specified dimensions (see Tables 1 and 2) should come just to the inner edge of the flange adapter face near the flow path, or overlap the edge slightly.

Inserting the Bolts

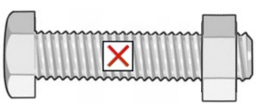
If using copper-graphite anti-seize lubricant as recommended, apply the lubricant evenly with a brush directly to the bolt threads, and to the nut if desired. Cover the bolt from its tip to the maximum extent to which the nut will be threaded. No lubricants can be used for high purity applications, only zinc-on-zinc or zinc-on-stainless steel fastener combinations are acceptable.

Insert bolts through washers and bolts holes as shown:



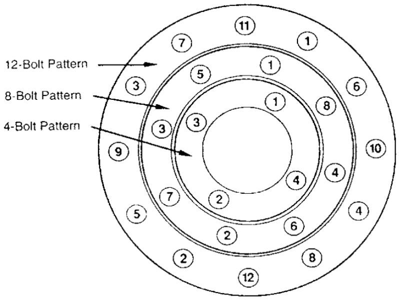
Tighten all nuts by hand. As you tighten each nut, the nuts on the other bolts will loosen slightly. Continue to hand-tighten all of the nuts until none remain loose. Now the flange assembly will remain in place as you prepare to fully tighten it.

Again, when hand-tightened, at least to threads beyond the nut should be exposed in order to ensure permanent engagement. If less than two threads are exposed, disassemble the flange and use longer bolts.



Tightening the Bolts

Tightening one bolt to the maximum recommended torque while other bolts are only hand-tight, or tightening bolts in the wrong order, produces uneven stresses that may result in poor sealing.



To ensure even distribution of stresses in the fully-installed flange, tighten the bolts in a star pattern as described in ANSI B16.5.

The torque required on each bolt in order to achieve the best seal with minimal mechanical stress has been carefully studied in laboratory and field installations, and is given in Table 12A.

To ensure even distribution of stresses and a uniform seal, tighten the bolts to the first torque value in the sequence (Table12B), using a star pattern, then repeat the star pattern while tightening to the next torque value, and so on up to the maximum torque value.

All thermoplastics deform slightly under stress. A final tightening after 24 hours is recommended, when practical, to ensure that any bolts that have loosened due to relaxation of the polymer are fully engaged.

If a flange leaks when pressure-tested, retighten the bolts to the full recommended torque and retest. Do not exceed the recommended torque before consulting an engineer or GF representative.

Table 12A		Max Torque ft-lbs	Bolt Tightening Torque (ft-lbs)	
Size (mm)	Size (in)		Flat Gasket	Profile Gasket
20	½	22	15	10
25	¾	22	15	10
32	1	22	15	10
40	1¼	22	15	10
50	1½	22	15	10
63	2	22	30	20
75	2½	30	30	20
90	3	30	40	30
110	4	30	30	20
160	6	44	50	33
200	8	58	50	33
225	9	58	50	33
250	10	75	60*	40
315	12	91	75*	53
355	14	106	N/A	44
400	16	140		44
450	18	150		65
500	20	160		50

*Note: Flat Gaskets should not be used at Operating Pressures above 90PSI.

Table 12B

Multiple Pass Bolt Torque
(Values based on a 70±5 Shore A hardness)

Final Torque Value ft-lbs	Torque Sequence* (ft-lb)			
	1st	2nd	3rd	4th
10	5	10	—	—
15	5	10	15	—
20	5	10	20	—
25	10	15	25	—
30	15	20	30	—
35	15	25	35	—
40	20	30	40	—
45	20	32	45	—
50	20	35	50	—
55	30	40	50	55
60	30	40	50	60
65	30	40	50	65
70	30	45	60	70
75	30	45	60	75

*Note: Assumes the use of SS, zinc- or cadmium-plated bolt and/or nut along with copper-graphite anti seize lubricant brushed directly onto the bolt threads. Never use unlubricated, uncoated bolts and nuts with vinyl flanges, as high friction and seizing lead to unpredictable torque and a high incidence of cracking and poor sealing.

The torques listed in Tables 5 and 6 are for flange adapter to flange adapter connections. For other types of connections, such as between a flange and a butterfly valve, where the full face of the flange is not in contact with the mating component, less torque will be required. Do not apply the maximum listed torque to the bolts in such connections, which may cause deformation or cracking, since the flange is not fully supported by the mating component. Instead, start with approximately two-thirds of the listed maximum torque and increase as necessary to make the system leak-free after pressure testing.

Documentation

Keep Instructions Available

Provide a copy of these instructions to every installer on the job site prior to beginning installation. Installers who have worked primarily with metal flanges often make critical mistakes when installing vinyl flanges. Even experienced vinyl installers will benefit from a quick review of good installation practices before starting a new job.

Installation Tags (Figure 12)

Best practices include tagging each flange with

- Installer's initials
- Installation date
- Final torque value (e.g., "29.2-31.5")
- Confirmation of 24-hour torque check ("y" or "n")

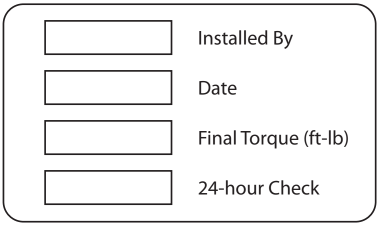


Figure 12

This information can be recorded on pre-printed stickers, as shown below, and placed on each flange immediately after installation.

Experience has shown that installation tags speed up the process of resolving system leaks and product failures, improve communication between the contractor and distributor or manufacturer, highlight training opportunities, and promote worker diligence.

Common Questions and Concerns

Q: Will my warranty be voided if these instructions are not followed precisely?

A: Not necessarily. We recognize that not every installation occurs under perfect conditions, and our flanges are designed to withstand reasonable variations in operating conditions and stress. If there is any doubt about the cause of a failure, contact your GF representative. We'll work with you to find a solution.

Q: What if the specified materials aren't available?

A: We perform our testing with the most commonly available bolts, lubricants, and gasket materials whenever possible. If you must use a material or component not mentioned in these instructions, call your GF representative to ask about acceptable substitutions.

Q: Can I purchase installation materials from GF?

A: We offer the profile flange gaskets, and recommend to buy it from GF to be sure you are using the correct type. GF does not offer bolts and lubricants. However, we will gladly review the materials you intend to use prior to installation.

Q: Is it possible to tell if a flange was installed incorrectly?

A: Yes, usually. Bolt torque is easy to verify with a torque wrench, and excessive force, rough handling, or use of non-specified components are often apparent from marks, indentations, discoloration, the microscopic appearance of cracks, etc. When in doubt, your GF representative can put you in touch with a factory expert who can help determine whether a flange has been installed correctly.

Q: I installed a flange as instructed, and it still leaks. Do I have to replace the flange?

A: First you should loosen and inspect the flange. Make sure there are no cracks, the gasket is in good condition, the bolts are well-lubricated (if applicable) and the system is properly aligned. Then reassemble the flange according to these instructions and test the system again. If you still have a problem, contact your GF representative for help.

Creating Union Joints

Introduction

Because unions and ball valves have similar, threaded nut connectors, these instructions have been written with both of these components in mind. GF unions and ball valves are designed to provide many years of service when installed properly.

As with any piping system component, unions and valves have particular considerations that must be kept in mind during installation in order to ensure best performance. Even experienced installers will benefit from reviewing these instructions before each installation.

Valve Support

Ball valves must be well-supported. Refer to the GF Engineering Handbook for detailed instructions on support installation. (www.gfpiping.com) An unsupported or insufficiently-supported valve body will twist when opened and closed, subjecting the union connection to torque stress that may cause cracking or distortion and subsequent leakage.

System Alignment

The major contributor to union nut failures is misalignment. Uneven compression of the o-ring will cause leaks to occur. Union nuts can be damaged by the stress of holding a misaligned system together.

Sealing Mechanism

GF union connections use an o-ring as the sealing mechanism which is highly effective under relatively low tightening force.

Dirt and Debris

An often overlooked issue is the presence of dirt and debris on the o-ring or sealing surface. This will prevent proper o-ring sealing; if it is present on the nut or body threads, it will clog the threads and prevent proper tightening.

Installation
Understand and carefully follow these installation steps in order to ensure a seal that is sufficient to guard against leaks while avoiding excessive forces that can damage the union nut.

End Connectors
Always remove the union nut and end connectors from the ball valve for installation. Make sure that you slide the union nut onto the pipe, with the threads facing the proper direction, BEFORE installing the end connector.

O-Ring Placement
Once the cement has cured, ensure that the o-ring is securely seated in its groove. The o-ring should rest securely in place without adhesive or other aids.

Never use any foreign substance or object to hold the o-ring in place.

Union Connection
There should be no gap between the mating components, so that the threaded nut serves only to compress the o-ring, thus creating the seal. However, a small gap (less than 1/8") between the mating components is acceptable.

Never use the union nuts to draw together any gaps between the mating faces of the components or to correct any system misalignment.

Hand-Tightening (all sizes) **(see Table 13)**
The next step is to hand-tighten the union nut. With the o-ring in place, engage the nut with its mating threads and turn clockwise with one hand. Continue turning with moderate force until the nut no longer turns.

Be careful to use reasonable force when tightening the nut. Your grip should be firm but not aggressive. The nut should turn easily until it bottoms out and brings the mating faces into direct contact.

It is recommended that you place an indexing mark with a permanent marker on the union nut and body to identify the hand tight position.

Do not use any form of lubricant on the threads of the union nut.

Union and ball valve sizes 3/8" through 1½" should be sufficiently sealed after hand-tightening, for the hydrostatic pressure test of the system.

Optional: Further Tightening (2") (see Table 13)

Based on experience, or system requirements, the installer may choose to turn the nut an additional 1/8 turn (approximately 45°) in order to ensure a better seal before hydrostatically pressure testing the system. To do this, use a strap wrench to turn the nut 1/8 turn past the index mark applied after assembly.

Do not exceed 1/8 turn past the index mark.

Do not use any metallic tools. (Tool marks on the union nut will void manufacturer's warranty.)

At this point, the system should be hydrostatically pressure tested before turning the union nut any farther.

Table 13
Tightening Guide for Union and Ball Valve Nuts

Nominal Size (inch)	Initial	Additional Pre-Test	Additional Post-Test
½	Hand-Tight	None	1/8 Turn (max)
¾	Hand-Tight	None	1/8 Turn (max)
1	Hand-Tight	None	1/8 Turn (max)
1½	Hand-Tight	None	1/8 Turn (max)
2	Hand-Tight	1/8 Turn (max)	1/8 Turn (max)

Post-Test Tightening (Sizes 1/2" to 1½" only) (see Table 1)

It is highly unlikely that any union nut connection; when tightened as instructed above, will leak under normal operating conditions.

In the unlikely event that a leak occurs, the union nut at the leaking joint may be tightened an additional 1/8 turn, as described above. The system should then be re-tested. If the joint still leaks after post-test tightening, do not continue to tighten the nut at the leaking joint. Disassemble the leaking joint, re-check system alignment, and check for obstructions in the sealing area. If the cause of a leak can not be determined, or if you suspect that the union or valve is defective, contact your GF representative at (800) 854-4090 for further instructions.

Quality Check After Assembly

To check if the union connections are installed in a stress-free manner, GF recommends that a random check of alignment be done by removing the nut on selected union connection one at a time. A properly installed system will not have any movement of the piping as the nut is loosened. If any springing action is noticed, steps should be taken to remove the stress prior to re-installing the union nut.

Documentation

Keep Instructions Available

Provide a copy of these instructions to every installer on the job site prior to beginning installation.

Installation Tags

Best practices include tagging each union with:

- Installer's initials
- Installation date

This information can be recorded on pre-printed stickers, as shown below, and placed on each union nut immediately after installation.

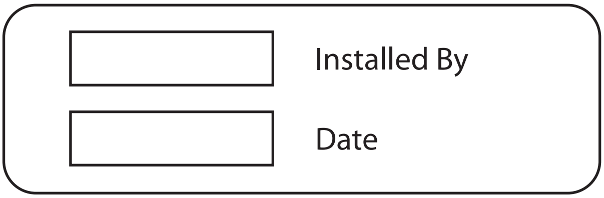


Figure 13

Experience has shown that installation tags speed up the process of resolving system leaks and product failures, improve communication between the contractor and distributor or manufacturer, highlight training opportunities, and promote worker diligence. See the GF vinyl technical manual for information on guides, support spacing, and allowance for thermal expansion.

Creating Threaded Joints

Introduction

NPT threaded connections are not recommended for high pressure systems or those greater than two inches. They also should be avoided in systems where leaks would be dangerous or costly.

When properly installed, threaded connections offer the benefit of an easy and inexpensive transition to metal systems. They can also be used for joining plastic where the installation is expected to be modified or moved later.

Design Considerations

Due to the difference in stiffness between plastic and metal, a metal male-to-plastic female joint must be installed with care and should be avoided if possible. Only Schedule 80 pipe may be threaded. Threading reduces the rated pressure of the pipe by one-half.

Preparation

Thread Sealant

A thread sealant (or "pipe dope") approved for use with plastic or PTFE ("Teflon") tape must be used to seal threads.

Installation

Thread Sealant

Use a thin, even coat of sealant.

PTFE tape must be installed in a clockwise direction, starting at the bottom of the thread and overlapping each pass.

Making the Connection

Start the threaded connection carefully by hand to avoid cross threading or damaging threads. Turn until hand tight. Mark the location with a marker. With a strap wrench on the plastic part, turn an additional half turn. If leakage occurs during pressure testing, consult the chart for next steps.

Table 14
Threaded Connection Guide

Connection Type	Next Step
Plastic to Plastic	Tighten up to 1/2 turn
Plastic Male to Metal Female	Tighten up to 1/2 turn
Metal Male to Plastic Female	Consult Factory

Alignment

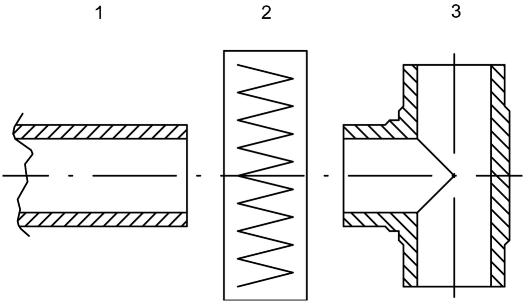
Threaded connections are susceptible to fracture or leaking due to misalignment. Pipe should be installed without bending. See the GF vinyl technical manual for information on guides, support spacing, and allowance for thermal expansion.

Infrared (IR) Butt Fusion

Infrared (IR) Fusion Joining Method

In infrared (IR) fusion joining the fusion areas of the components being joined (pipes, fittings, valves) are heated to fusion temperature without contact to the heating element and joined by means of mechanical pressure without using additional materials.

The Principle of Fusion Joining



1 Pipe
2 Heating element
3 Fitting

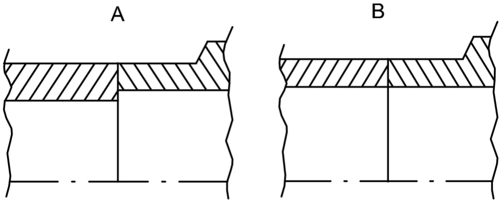
The resulting fusion joints are homogeneous and display the following characteristics:

- Non-contact heating of the joining components eliminates the risk of contamination and inhomogeneities;
- Smaller joining beads due to adjustment of joining pressure path prior to the fusion process itself, i.e.
  elimination of the equalization process
- Adjustment of the joining pressure path also ensures excellent reproducibility of the fusion joints
- Low-stress fusion joints due to very uniform heating by means of IR radiator

General Requirements

The basic rule is that only similar materials can be fusion joined. For the best results only components which have a melt flow index in the range from MFR 190/5 0.3 to 1.7 g/10 min should be fusion joined. The components to be joined must have the same wall thicknesses in the fusion area. Maximum permissible wall displacement: 10%.

Only same wall thicknesses in the fusion area



A incorrect
B correct

IR fusion joining must only be performed by personnel trained in the use of this method. Training is provided world-wide by qualified GF IR Plus® welding instructors.

Tools Required
Infrared fusion joining requires a special joining machine in addition to the tools normally used for plastic pipe work construction (pipe cutters, etc.).

GF Supplies Two Types of IR Plus® Fusion Joining Machines

IR 63 Plus®: for fusion joints 1/2" to 2"

IR 225 Plus®: for fusion joints 2" to 8"

General Conditions
Protect the area of the fusion joint from adverse weather conditions, such as rain, snow or wind. The permitted temperature range for IR Plus® fusion joining between +5°C and +40°C. Outside this range, suitable action must be taken to ensure that these conditions are maintained. It must also be ensured that the components being joined are in this temperature range.

Preparing the Fusion Joint and Operating the IR Fusion Joining Machine

In principle, IR fusion joining machines do not require any special preparation, but it should be ensured that the components being joined are clean. Operation of the IR machines is defined exactly in the operating instructions, but we strongly recommend attending a 1-day training course to become a qualified IR welder.

Properties and Characteristics of IR Fusion Joints

Non-Contact Heating

The components being joined are heated uniformly and without contact to the ideal fusion temperature by infrared radiation.

A defined gap between the heating element and the end faces minimizes the risk of contamination of the joining surface. Contamination of the heating element by plastic particles is thus also eliminated.

Reduced Bead Formation

The fusion bead produced during joining is considerably reduced without any loss of quality. Bead forming equalization is eliminated by non-contact softening of the end faces. The minimal, defined bead is only formed during the joining process. The fusion area thus has improved flow dynamics, low clearance volume, and greater throughput area.

Reproducible Joining Processes

The joining path controls the joining pressure and thus the fusion process. The high reproducibility of the joints is assured by the clearly defined and controlled process sequence.

Clear, Simple Operator Guidance

Clear, unambiguous operator guidance via the liquid crystal display leads the user interactively through the fusion process in logical operating steps.

Welding Report/Traceability

The welding parameters for the relevant welding operations can be read out directly via various interfaces on the machine. It is possible to print these out on paper (commercially available printers), on labels or to employ electronic data output (PCMCIA card).

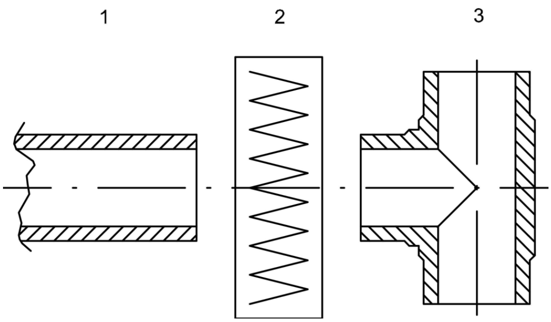
This automatically provides an accurate record with all essential fusion parameters for each individual fusion joint, as required.

Contact Butt Fusion

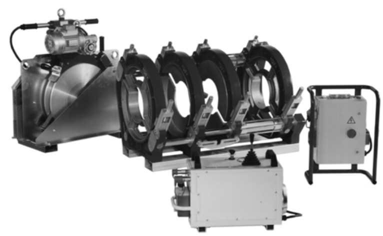
Butt Fusion Joining Method

The fusion areas of the pipes and fittings are heated to fusion temperature and joined by means of mechanical pressure, without using additional materials. A homogeneous joint results. Butt fusion must only be carried out with fusion joining machines which allow the joining pressure to be regulated. Details of the requirements for machines and equipment used for fusion joining thermoplastics are contained in DVS 2208 Part 1. The drawing to the right illustrates the principle of fusion joining.

The Principle of Fusion Joining



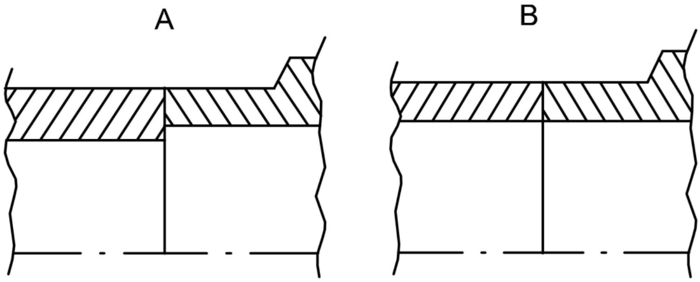
1 Pipe
2 Heating element
3 Fitting



General Requirements

The basic rule is that only similar materials can be fusion joined, i.e.: PE with PE. For best results, only components which have a melt flow index in the range from MFR 190/5 0.3 to 1.7 g/10 min should be fusion joined. This requirement is met by PE butt fusion fittings from GF. The components to be joined must have the same wall thicknesses in the fusion area.

Join only components with similar wall thicknesses



(A) incorrect (B) correct

Heated tool butt fusion joining may only be performed by adequately trained personnel.

Tools Required

Butt fusion joining requires a special joining machine in addition to the tools normally used for plastic piping construction (pipe cutters, saw with cutting guide). The fusion joining machine must meet the following minimum requirements:

The clamping equipment must hold the various parts securely without damaging the surfaces. Possible ovality can be largely compensated by centered clamping of the components to be joined. It must also be possible to hold all parts firmly in alignment.

The machine must also be capable of face planing the fusion surfaces of pipes and fittings.

The fusion joining machine must be sufficiently solid to be able to absorb the pressures arising during the fusion procedure without detrimentally deforming the joint.

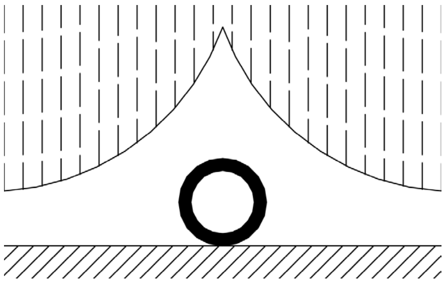
The heating surfaces of the heating element must be flat and parallel. The temperature variation over the working area must not exceed 10°C. The machine should be set up and operated according to the manufacturer's instructions.

The fusion procedure detailed below including the preparation is based on DVS 2207-1 Welding of thermoplastics - Heated tool welding of pipes, pipeline, components and sheets made from PE.

General Conditions

Protect the area of the fusion joint from adverse weather conditions, such as rain, snow and wind. At temperatures below +5°C or above +45°C, measures must be taken to ensure that the temperature in the working area is in the range required for satisfactory joining and does not hinder the necessary manual tasks.

Protect the Fusion Area

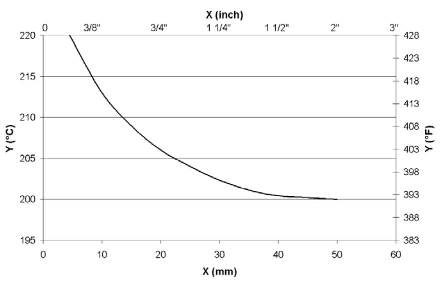


Screening the fusion area can ensure a more even temperature distribution on the entire circumference of a pipe subject to direct sunlight. The pipe ends at the opposite end of the fusion areas should be sealed whenever possible to reduce to a minimum the cooling of the fusion surfaces which can be caused by wind.

Preparation of the Fusion Joint

The quality of the fusion process is governed by the care with which the preparatory work is carried out. This part of the procedure therefore deserves special attention.

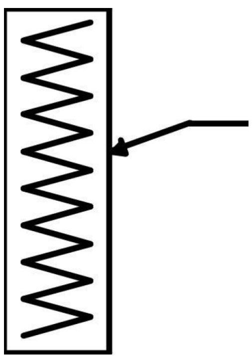
Heating Tool



X Wall thickness in mm

Y Heating tool temperature °C

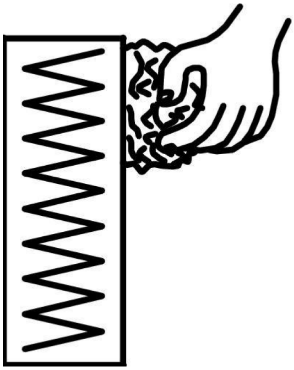
The fusion temperature should be between 204°C–232°C. In principle, the upper temperature should be aimed at for less thick walls and the lower temperature for thicker walls.



Check the Temperature

To test the thermostat, check temperature before commencing the fusion joining. This is best carried out with the help of a digital thermometer. But only thermometers with a sensor for measuring surface temperature are suitable.

To ensure it is being maintained at the correct level the fusion temperature should be checked from time to time during the joining work. The temperature of the heating element is particularly sensitive to wind.



Clean the Heating Element

Clean the heating element with dry, clean paper before each fusion joint!

Protect the working surface of the heating element from becoming soiled. Clean both faces of the heating element with dry, lint-free paper before each fusion joint. Protect the heating element from wind, damage and soiling during the intervals between making fusion joints.

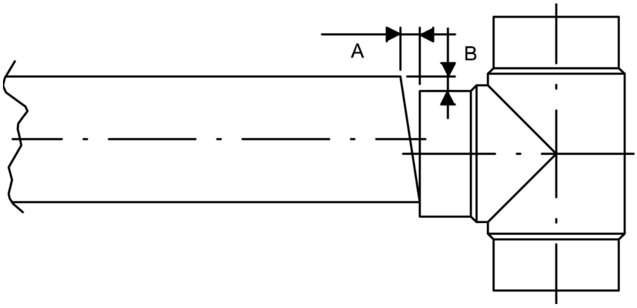
Planing and Subsequent Checking

Before machining the joining surfaces, make sure that the tools and the work pieces are clean and grease-free beyond the actual fusion zone; if necessary, clean with a cleaning fluid.

All the components clamped into the fusion joining machine are planed simultaneously with the planer provided. The shavings should not be thicker than d 0.2mm. This step is completed when there is no un-machined area left on either of the parts to be joined. This is normally the case when no more shavings come off the machined surface.

Remove any shavings which may have fallen into the pipe or fitting with a brush. The fusion surfaces should not be touched by hand under any circumstances. Otherwise they must be cleaned with cleaning fluid.

Once they have been machined, the parts are moved together until they touch. The gap between the two parts must not exceed 0.5 mm at any point.



A max. gap: 0.5 mm

B max. displacement: 10 % of wall thickness

Check the Wall Alignment and Gap

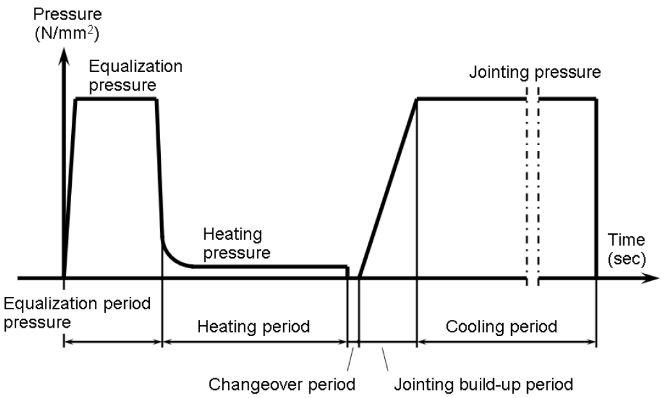
The alignment of the two parts should be checked at the same time. A possible misalignment on the outside must not exceed 10% of the thickness of the wall. If this limit is exceeded, a better clamping position is to be sought, e.g.: by rotating the pipe. In such a case, however, the surface must be re-planed.

Important: The fusion surfaces must be planed immediately prior to the joining.

Setting the Fusion Pressure

Fusion joining requires different pressures to be applied during equalization and joining on the one hand and during the heat soak period on the other. Please see the following diagram.

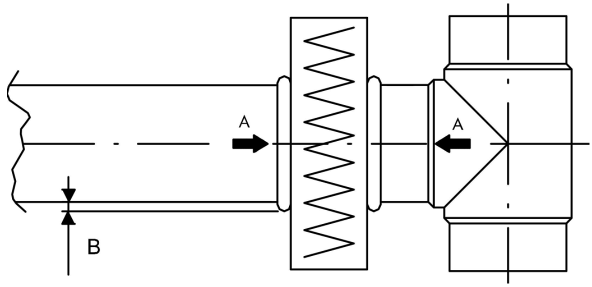
Pressure/Time Diagram



The specific joining pressure required for equalization and fusion can be found in the following table with the heating and cooling periods. The table lists the times for various wall thicknesses. Interpolate for intermediate values.

The force needed for equalization and joining (FA) is given by the product of the fusion area and the specific joining pressure (FA = A × p). The force (FB) required to move the pipe must be added to this. (F_{tot} = FA + FB). This latter force includes the intrinsic resistance of the machine and the resistance of the axially mobile pipe or fitting clamped in it. The resistance of longer pipes should be reduced as far as possible by placing rollers beneath them. The kinetic force (FB) should not exceed the joining force (FA).

Equalize and Heat



A Contact force

B Height of bead (see tabulated values)

Approximate Values for Butt Fusion of PP[1)]

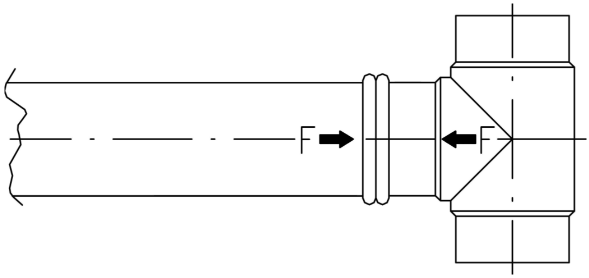
Wall Thickness (mm)	Equalisation at p= 0.10 N/mm2 Height of bead (mm)	Heating time ²) p= 0.01 N/mm2 (sec)	Changeover time max. (sec)	Time to reach full joining pressure (sec)	Cooling time ²) under joining p= 22 psi (min)
up to 6.9	0.5	65 ... 115	5	6 ... 8	6 ... 12
7.0 ... 11.4	1.0	115 ... 180	6	8 ... 10	12 ... 20
11.5 ... 18.2	1.0	180 ... 290	8	10 ... 15	20 ... 30
18.3 ... or greater	1.5	290 ... 330	10	15 ... 20	30 ... 40

1) in accordance with DVS 2207-1
2) The times are affected by the pipe wall thickness, the outside temperature and wind strength.

Determine the values to be set for equalization and joining on the basis of the information above, bearing in mind the instructions from the manufacturer of the fusion joining machine before commencing the fusion process.

Fusion Joining Procedure

Once it has attained the fusion temperature, position the heating element in the fusion joining machine. Press the parts to be joined against the heating element with the force required for equalisation until the entire circumference of each of the joining faces rests completely against it and a bead (see the table) has formed. Reduce the equalisation pressure almost to 0 (p ~ 0.01 N/mm²). The heating time listed in the table is measured from this moment.



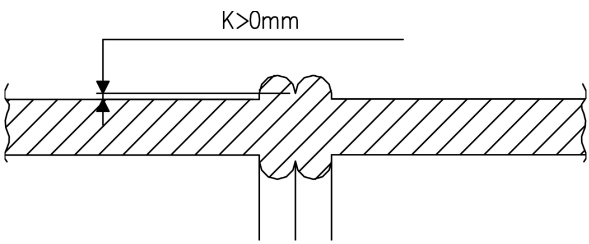
Join and Cool

Leave parts in the fusion joining machine at fusion pressure until the end of the cooling period!

Once the heating period has elapsed, remove the parts from the heating element which should then be removed without touching the joining surfaces and push the parts together immediately. The changeover time must not exceed the value listed in the table. Pay particular attention during joining that the parts be moved together swiftly until the surfaces are about to touch.

Then they should be moved together so that they are in contact along the entire circumference. Next the pressure should be increased rapidly to the present joining pressure within the period of time specified in the table. This pressure must be maintained during the entire cooling period. Adjustment may be necessary, especially shortly after the joining pressure has been attained.

The joined parts must stay in the fusion joining machine under joining pressure until the end of the cooling period specified in the table.



Fusion Check

A bead should form around the entire circumference of the pipe. K in the diagram to the left should always be positive.

Carrying Out the Pressure Test

All fusion joints must be allowed to cool completely before pressure testing, i.e.: as a rule wait about 1 hour after the last joint has been completed.

Electrofusion

Electrofusion Joining Method

The fusion area of the pipes and socket fittings are heated to fusion temperature and joined by means of an interference fit, without using additional materials. A homogeneous joint between socket and spigot is accomplished. Electrofusion must only be carried out with fusion joining machines by Georg Fischer that tightly control the fusion parameters. Details of the requirements for machines and equipment used for electrofusion joining of PPro-Seal Natural Polypropylene is included in the GF training manual and can be made available upon request.

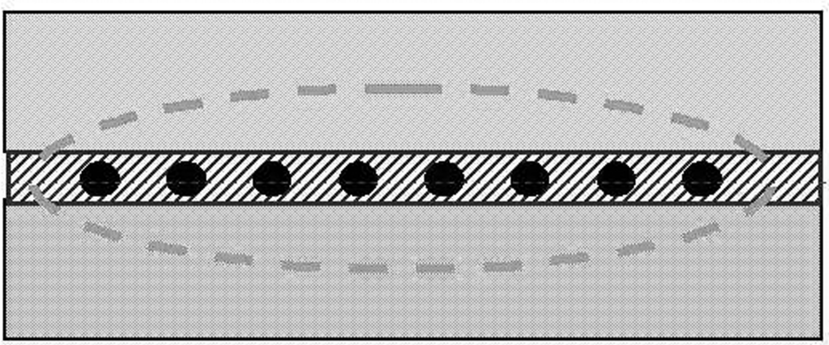
The Principle of Electrofusion Joining

The electrofusion process of joining a pipe to a socket uses wires to transfer the heat energy to the plastic material.

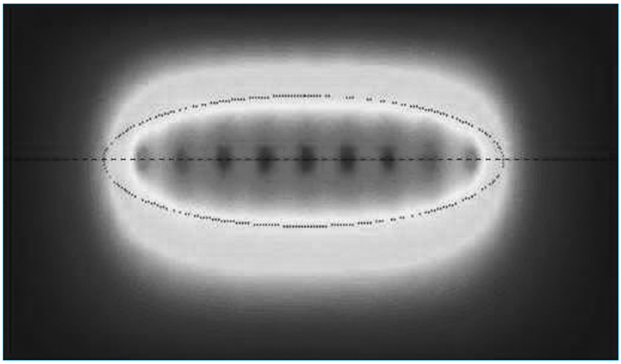
The heat energy will be sufficient to melt the plastic surrounding the wires. The will generate a zone called the “melt” zone.

The “melt” zone, by definition encapsulates the wires, which are at its origin along the center line.

The Computer Simulation on the bottom shows the heat distribution and the “melt” zone regional.

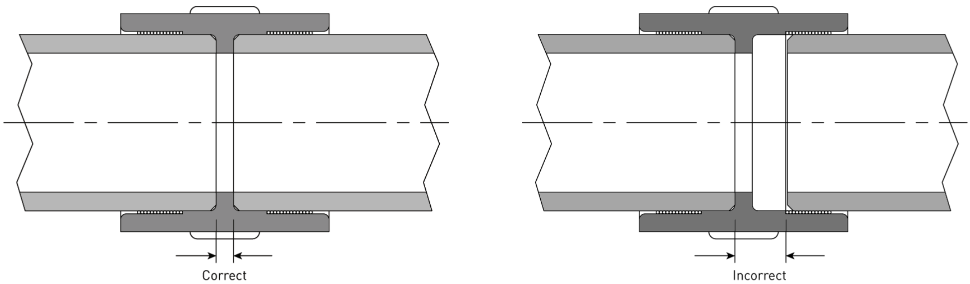


The Computer Simulation on the bottom shows the heat distribution and the “melt” zone regional.



General Requirements

The basic rule is that only similar materials can be fusion joined, i.e. PP with PP. The components must be joined with the fitting inserted to the full socket depth for the joint to be considered acceptable. Should this not be the case, failure to meet the depth requirement could result in joint failure, overheating and intrusion of the heating coil.

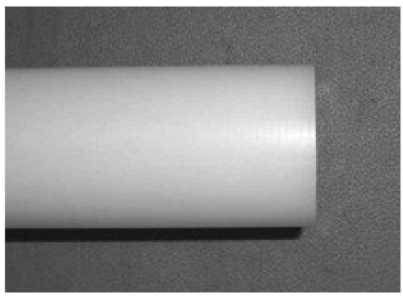


Electrofusion should only be performed by GF trained and certified personnel.

Step 1: Cut Pipe End Square with Axis of Pipe

Use a fine tooth hand saw and miter box, a power cutoff saw with blade for plastic or a wheel type pipe cutter for plastic.

****Ratchet Type pipe cutters are not recommended**



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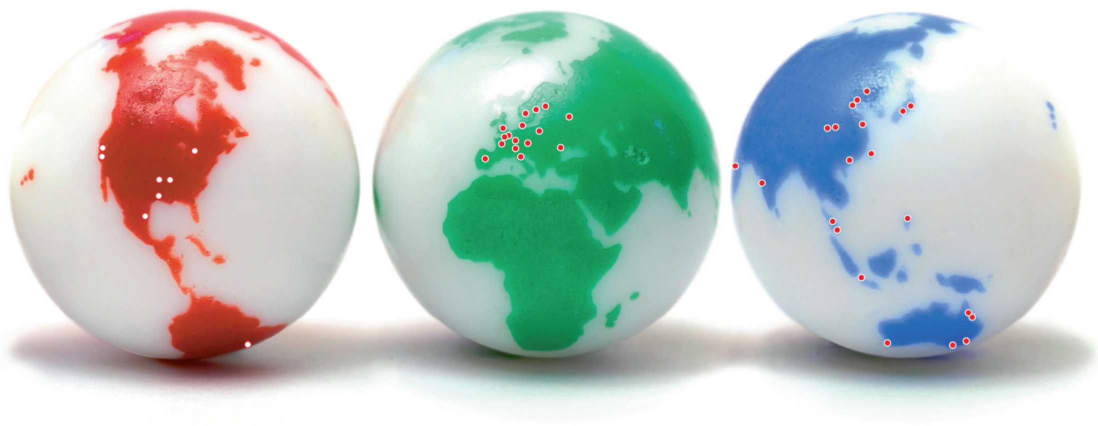

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Argentina / Southern South America
Georg Fischer Central Plastics
Sudamérica S.R.L.
Buenos Aires, Argentina
Phone +5411 4512 02 90
gfcentral.ps.ar@georgfischer.com

Australia
George Fischer Pty Ltd
Riverwood NSW 2210 Australia
Phone +61(0)2 9502 8000
australia.ps@georgfischer.com
www.georgefischer.com.au

Austria
Georg Fischer
Rohrleitungssysteme GmbH
3130 Herzogenburg
Phone +43(0)2782 856 43-0
austria.ps@georgfischer.com
www.georgfischer.at

Belgium / Luxembourg
Georg Fischer NV/SA
1070 Bruxelles/Brüssel
Phone +32(0)2 556 40 20
be.ps@georgfischer.com
www.georgfischer.be

Brazil
George Fischer Ltda
04795-100 São Paulo
Phone +55(0)11 5525 1311
br.ps@georgfischer.com
www.georgefischer.com.br

Canada
Georg Fischer Piping Systems Ltd
Brampton, ON L6T 4E3
Phone +1(905)792 8005
Fax +1(905)792 6667
ca.ps@georgfischer.com
www.georgfischer.ca

China
Georg Fischer
Piping Systems Ltd Shanghai
Pudong, Shanghai 201319
Phone +86(0)21 58 13 33 33
china.ps@georgfischer.com
www.georgfischer.cn

Denmark / Iceland
Georg Fischer A/S
2630 Taastrup
Phone +45 (0)70 22 19 75
info.dk.ps@georgfischer.com
www.georgfischer.dk

France
Georg Fischer SAS
95932 Roissy Charles de Gaulle Cedex
Phone +33(0)1 41 84 68 84
fr.ps@georgfischer.com
www.georgfischer.fr

Germany
Georg Fischer GmbH
73095 Albershausen
Phone +49(0)7161 302-0
info.de.ps@georgfischer.com
www.georgfischer.de

India
Georg Fischer Piping Systems Ltd
400 076 Mumbai
Phone +91 224007 2001
in.ps@georgfischer.com
www.georgfischer.in

Italy
Georg Fischer S.p.A.
20063 Cernusco S/N (MI)
Phone +3902 921 861
it.ps@georgfischer.com
www.georgfischer.it

Japan
Georg Fischer Ltd
556-0011 Osaka,
Phone +81(0)6 6635 2691
jp.ps@georgfischer.com
www.georgfischer.jp

Korea
Georg Fischer Piping Systems
463824, South Korea
Phone +82 (0)31 8017 1450~3
Fax +82 (0)31 8017 1454
kor.ps@georgfischer.com
www.georgfischer.kr

Malaysia
George Fischer (M) Sdn. Bhd.
40460 Shah Alam, Selangor Darul Ehsan
Phone +60 (0)3 5122 5585
my.ps@georgfischer.com
www.georgfischer.my

Mexico / Northern Latin America
Georg Fischer S.A. de C.V.
Apodaca, Nuevo Leon
CP66636 Mexico
Phone +52 (81)1340 8586
Fax +52 (81)1522 8906
mx.ps@georgfischer.com
www.georgfischer.mx

Middle East
George Fischer Piping Systems
Dubai, United Arab Emirates
Phone +971 4 289 49 60
info.export@georgfischer.com
www.export.georgfischer.com

Netherlands
Georg Fischer N.V.
8161 PA Epe
Phone +31(0)578 678 222
nl.ps@georgfischer.com
www.georgfischer.nl

Norway
Georg Fischer AS
1351 Rud
Phone +47(0)67 18 29 00
no.ps@georgfischer.com
www.georgfischer.no

Poland
Georg Fischer Sp. z o.o.
05-090 Sekocin Nowy
Phone +48(0)22 31 31 0 50
poland.ps@georgfischer.com
www.georgfischer.pl

Romania
Georg Fischer
Piping Systems Ltd
020257 Bucharest - Sector 2
Phone +40(0)21 230 53 80
ro.ps@georgfischer.com
www.export.georgfischer.com

Russia
Georg Fischer Piping Systems
Moscow 125047
Tel. +7 495 258 60 80
ru.ps@georgfischer.com
www.georgfischer.ru

Singapore
George Fischer Pte Ltd
528 872 Singapore
Phone +65(0)67 47 06 11
sgp.ps@georgfischer.com
www.georgfischer.sg

Spain / Portugal
Georg Fischer S.A.
28046 Madrid
Phone +34(0)91 781 98 90
es.ps@georgfischer.com
www.georgfischer.es

Sweden / Finland
Georg Fischer AB
117 43 Stockholm
Phone +46(0)8 506 775 00
info.se.ps@georgfischer.com
www.georgfischer.se
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Switzerland
Georg Fischer
Rohrleitungssysteme (Schweiz) AG
8201 Schaffhausen
Phone +41(0)52 631 30 26
ch.ps@georgfischer.com
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Taiwan
Georg Fischer Piping Systems
San Chung City, Taipei Hsien
Phone +886 2 8512 2822
Fax +886 2 8512 2823
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United Kingdom / Ireland
George Fischer Sales Limited
Coventry, CV2 2ST
Phone +44(0)2476 535 535
uk.ps@georgfischer.com
www.georgfischer.co.uk

USA / Caribbean
Georg Fischer LLC
Tustin, CA 92780-7258
Phone +1(714) 731 88 00
Toll Free 800 854 40 90
us.ps@georgfischer.com
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International
Georg Fischer
Piping Systems (Switzerland) Ltd.
8201 Schaffhausen/Switzerland
Phone +41(0)52 631 30 03
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