

CRP complement the lined piping with associated products that follow the PTFE or PFA lined theme. These include:

- **PFA lined Ball, Plug and Butterfly Valves for the UK market**
- **PFA lined Swing Check and Poppet Check Valves**
- **PFA lined Control Valves**
- **PFA lined Strainers**
- **PFA lined and unlined Tubular Sight Glasses and Level Gauges**
- **PTFE Bellows or Expansion Joints**

The business also produces a comprehensive range of standard and customised sampling systems for those that require safe and representative sampling, typically for sampling hazardous or expensive materials. These can be In-line, mounted directly to pipe work or reactor vessels or mounted to the top of

reactors. CRP distribute a range of Graphite and Silicon Carbide Heat Exchangers plus many pipeline complementary items including special earthing washers "Spikies" for lined systems, PTFE gaskets designed specifically for lined systems and a comprehensive range of safety shields.

Most importantly CRP positions itself as

a problem solving business and although we produce catalogues we spend much time developing specific products or product combinations to solve customer processing problems. Again, this is facilitated by having our own design and manufacturing capability.

Materials Introduction

Lining Materials

CRP manufactures product in both virgin and static-dissipating (also known as anti-static) fluoropolymer resins; principally in PTFE and PFA. These are supplied under the HiPerFlon label representing a combination of raw materials and processing choices. In addition we manufacture products in a modified PTFE that provides enhanced performance against permeation. This is termed Ultra HiPerFlon or abbreviated to UHP.

More background to lining materials is provided in the following section on Design Philosophy, but here is a very simple guide to our key fluoropolymer resins and where they are used.

Virgin PTFE HiPerFlon

CRP's Virgin PTFE is called HiPerFlon in order to recognise the unique combination of material - a fine powder PTFE and process - paste extrusion. It is used principally on pipe spools in straight lengths and some simple fittings without branches.

PTFE UHP (Ultra HiPerFlon)

This material is used for high performance requirements specifically for the management of permeation.

Static-Dissipating PTFE (Anti-static)

Here a small percentage of carbon black is used within the virgin PTFE which reduces the electrical resistance of the material to a level at which any electrical charge generated by static charging within a pipeline can flow through the PTFE to the adjoining

Lining Material Range							
Nominal Bore		Pipe Spools				Fittings	
		Virgin PTFE HiPerFlon	Static-Dissipating PTFE	UHP PTFE		Virgin PFA/PTFE	Static-Dissipating PFA/PTFE
Inches	mm	Heavy Duty	Heavy Duty	Heavy Duty	Superweight	Heavy Duty	Heavy Duty
½	15	✓	✓		✓	✓	✓
¾	20	✓	✓		✓	✓	✓
1	25	✓	✓		✓	✓	✓
1½	40	✓	✓		✓	✓	✓
2	50	✓	✓		✓	✓	✓
3	80	✓	✓		✓	✓	✓
4	100	✓	✓		✓	✓	✓
6	150	✓	✓		✓	✓	✓
8	200	✓	✓	✓		✓	✓
10	250	✓	✓	✓		✓	✓
12	300	✓	✓	✓		✓	✓
14	350	✓	✓	✓		✓	✓

Key Lining Choices	
Application	Product Choice
Most applications requiring lined pipe and fittings	HiPerFlon Virgin PTFE and PFA
Applications with known permeant chemicals	UltraHiPerFlon PTFE and PFA
Applications for high purity	HiPerFlon Virgin PTFE and PFA
Applications requiring management of static discharge; typically non-conducting solvents	HiPerFlon Static-Dissipating PTFE and PFA

steelwork and to earth.

Virgin PFA

PFA as a melt processable material with all of the performance characteristics of PTFE and some more is used as the material of choice for lined fittings, being capable of dealing with more complex geometries and having superior performance in the most challenging applications.

Static-Dissipating (Anti-static) PFA

This fulfills the same requirement for fittings as static-dissipating PTFE does for pipe spools.

Outer Housings

Pipe Spools and Fabricated Fittings

Pipe spools are manufactured using carbon steel rated for pressure containing purposes. These are either provided with integral stub ends behind which we mount a flange - referred to as Van Stone spools, or a welded flange or stub end combined with a loose or rotating flange. Fabricated

fittings are made from a combination of carbon steel pipe, forgings, flanges and stub ends. All welding activities are undertaken using "coded" welders.

Cast Fittings

Where CRP differs significantly from the competition is that the majority of pipe fittings are manufactured as steel lost wax investment castings. A number of product quality reasons have driven this choice, notably:

1. No fabrication welds, therefore no concerns about weld integrity
2. Greater strength
3. Precise close tolerance parts for installation fit
4. Dimensional accuracy for lining geometry
5. No flash or parting lines
6. Clear written casting detail for identification and traceability

Cast steel fittings are significantly - almost 50% - stronger than fabrications of a similar nominal bore and importantly do

not contain construction welds. The grade of steel used by CRP is ASTM A216 WCB with a minimum cast wall of 5.5mm at 25NB which is some 2.12 mm thicker than schedule 40 steel tube of the equivalent nominal bore

The dimensional accuracy gives improved lining control with lined faces which are square to the line axis of the fittings bores and bores that are concentric to the flange periphery and the body outside diameter. The extensive machining of the steel casting provides flat rear faces to flanges allows accurate torquing of bolts and assists in flanges being pulled up square. The fine ceramic powder used in creating the steel casting mould allows much greater detail to be cast and moreover be much more readable than that provided by sand cast ductile iron and such markings are not even possible with fabricated fittings - generally leaving them anonymous and untraceable.



Manufacturing

It is important to understand that CRP manufacture their own products in their manufacturing facility based just north of Manchester in the UK. CRP is unusual in the UK as the only direct manufacturer of the product from raw fluoropolymer through to the finished product. This gives the business great advantages of logistical control of delivery lead-times and due date adherence. It also means that we are fully in control of our own manufacturing processes and quality and can provide complete product traceability.

Process Expertise

CRP has been around for much of the time that PTFE and all of the time that PFA have existed on the planet. The company has had the benefit of growing up with these materials and has played a key role in their development for processing through working with the raw material manufacturers and developing their own processing equipment. All of the key machines and associated equipment at CRP for both PTFE and PFA production have been developed - and continue to be developed in-house. This enables us to continue to expand the product range, but as importantly gives us the certain knowledge of how products have been manufactured. This is critical when not all attributes of such products can be tested through routine production tests. CRP is the only manufacturer producing PFA moulded elbows and tees in sizes up to 14in diameter.

Our Materials and Processes

CRP are proud of their association with key materials manufacturers and have selected the top international suppliers of fluoropolymers for their materials providing both quality and technical support. Concerning PTFE there are two key material forms used in our industry, granular powders and fine powders

(technically known as coagulated dispersions.)

Paste Extrusion

CRP chooses to use fine powders combined with a pipe liner production process called paste extrusion. The powder has a base particle size of 0.18 - 0.25µm making them one hundred times smaller than the granular powders. Moreover, the particle size distribution is extremely narrow versus that of the granular powders. A combination of the two characteristics provides a packing density for the material of 55%, which is close to the theoretical maximum for spheres of equal size. However, the fine powder material has another attribute that really moves its processing on and this is the agglomeration of these base or primary particles into larger secondary particles of 400-600 µm in size.

These features come into their own in the paste extrusion process. In this process the PTFE is extruded through a die with a pin inside providing the internal diameter and wall thickness of the soon to become pipe liner. The die has a smaller cross-sectional area than the PTFE billet being extruded and its form is gradual causing the flow velocity to increase as the material enters the die. This generates a shear gradient in the direction of the flow and forces the paste material into irreversible plastic deformation. The extruded material gains strength from the deformation, a process called fibrillation and the void content is further reduced. This is because the secondary particles are deformed into fibrils - a string like alignment of the primary particles, and have irreversibly deformed, but the primary particles are preserved intact although kneaded, bouncing back into their round form after extrusion. Once through the extrusion process the primary particles relax and return to their original spherical shape, leaving a more compact

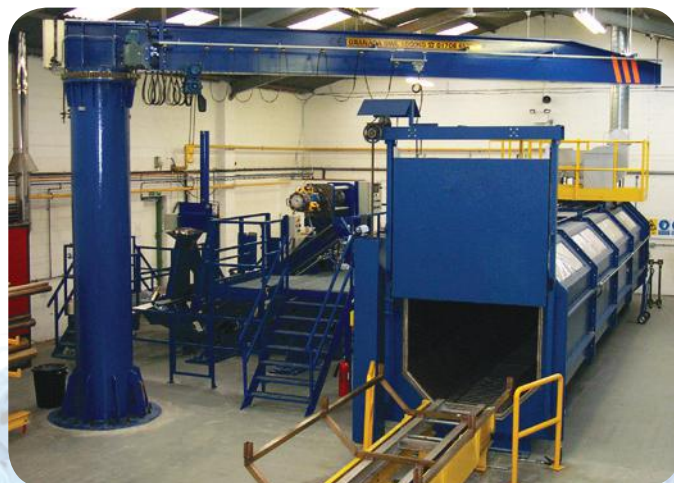
structure.

In terms of what this means for the user is that paste extruded fine powders, combined with the homogeneous nature of the liner and its uniform wall thickness provide the highest levels of permeation resistance and the smoothest material finish - aiding both service life and the cleanability of the product.

PFA Transfer Moulding

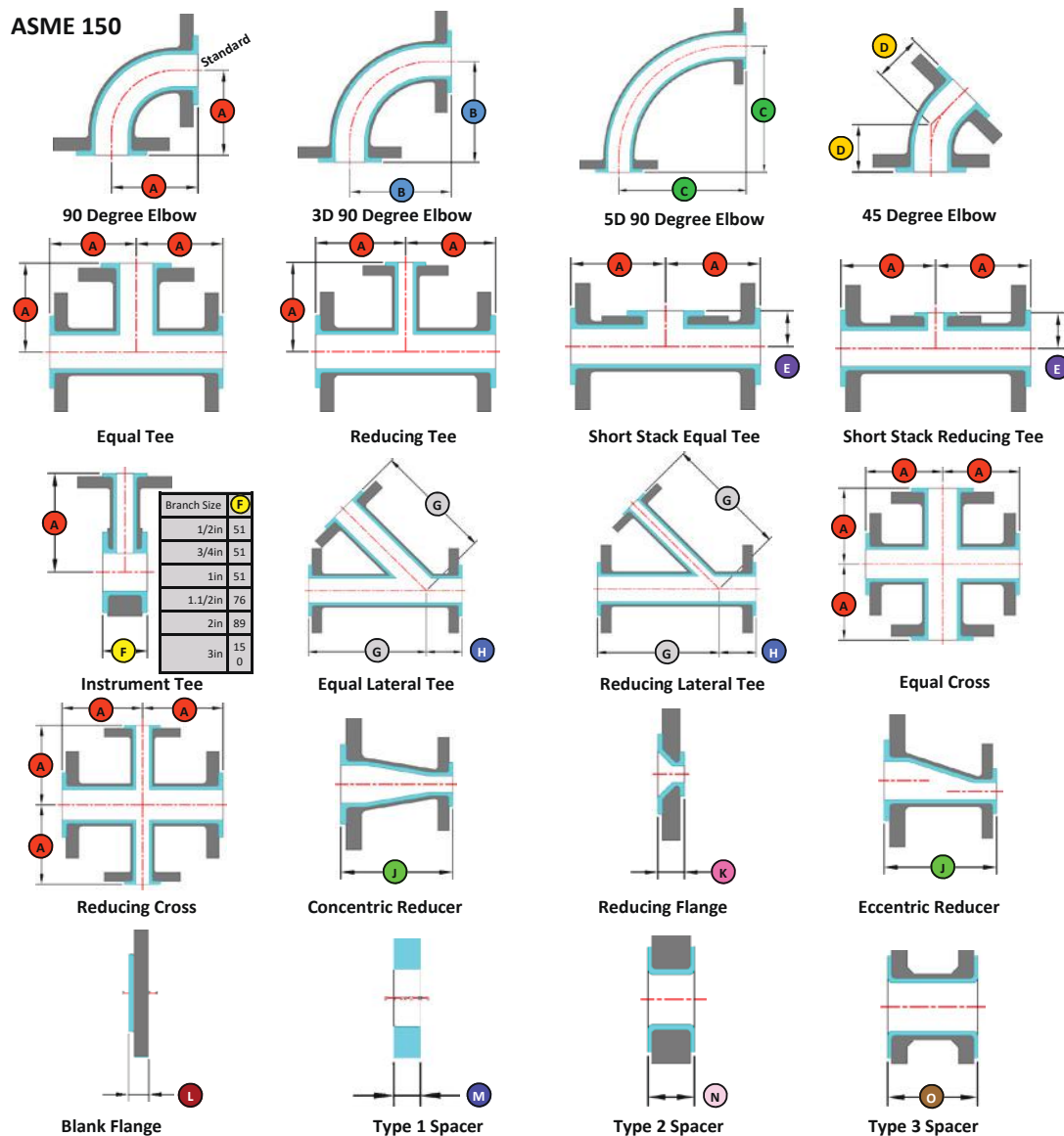
PFA was the outcome of years of research into creating a fluoropolymer that is a true thermoplastic and therefore melt processable. In production PTFE has the challenge of requiring very specialist techniques to create the shapes required for products. PFA does not have this disadvantage as it is capable of being melted and moulded into shape. Again CRP chooses PFA's that have the highest performance in corrosive applications - manifest by a low melt flow rate (MFR). Also high purity PFA's are also available for specific applications. The process for lining components in PFA is challenging, as the PFA has to be injected at high pressure and temperature into a void created inside the component in a stress free manner. The process is isothermal in that the component, its tooling and the PFA all have to be at the melt temperature of the PFA through the moulding process - called transfer moulding. A further challenge is that the PFA reduces in volume as it cools and this reduction has to be catered for through the introduction of further raw material.

The equipment for transfer moulding has been developed in-house and significant equipment development has been initiated recently with the use of the expertise of the Polymer Science department at a local university.



Summary Dimensional Table

Dimensions are generally to ASME B16.5 and expressed in millimetres.



Nominal Bore	DN	A	B	C	D	E	G	H	J	K	L	M Max.	N Max.	O Max.	Van Stone Spool Min.	Fixed/ Rotating Spool Min.	Spool Max.
1/2 in	DN 15	65*									14	25	60	100	250	90	6000
3/4 in	DN 20	75								30	15	25	60	100	250	90	6000
1 in	DN 25	89	n/a	127	44	30	146	44		30	16	25	60	100	250	90	6000
1 1/2 in	DN 40	102	114	191	57	37	178	51	114	30	19	25	60	100	250	95	6000
2 in	DN 50	114	152	254	63	43	203	64	127	30	21	25	70	150	250	110	6000
3 in	DN 80	140	229	381	76	56	254	76	152	35	26	25	70	150	250	120	6000
4 in	DN 100	165	305	508	102	67	305	76	178	35	26	25	70	150	250	125	6000
6 in	DN 150	203	457	762	127	105	368	89	229	40	27	25	80	150	500	140	6000
8 in	DN 200	229	610	1016	140	125	444	114	279	40	31	25	80	200	500	150	3000
10 in	DN 250	279	762	1270	165	165	521	127	305	35	32	25	80	200	n/a	165	3000
12 in	DN 300	305	914	1524	190	190	622	140	356	40	34	25	80	200	n/a	170	3000
14 in	DN 350	356	1067	1778	190	210			406	40	37	25	80	200	n/a	190	3000

*Please note that 1/2in 90 Degree Elbow is 100mm. The Face to face Dimension of reducing fittings is normally defined by the nominal bore of the larger size. Special dimensions are available on request. For further information go to our website at www.crp.co.uk or call us on +44(0)1706 756400. Please note, no warranties are given on the accuracy of the data, which may be subject to revision, for confirmation please refer to the appropriate standards documents. CRP's dimensions may vary from those of other manufacturers and not all components

Dimensional Table CRP ASME 150 Rev.5 2-16

to dissipate them. This is considered elsewhere in relation to static-dissipating materials.

Low Friction

PTFE has a very low coefficient of friction and for all calculation purposes it can be considered hydraulically smooth,

Thermal Stability

PTFE retains useful properties (i.e. not more than 15% loss of chemical resistance) at up to 200°C and sometimes beyond depending upon the application. In fact it has the highest retention of its chemical properties of any known plastic like material. (Please be wary of materials performance data stating that PTFE has an upper service limit of 260°C. This is true in a laboratory situation, but in service most material properties such as mechanical strength will have been lost preventing it from performing a useful duty.)

PTFE Paste Extrusion

CRP uses the most expensive grades of PTFE to produce the uniquely manufactured HiPerFlon. These are coagulated dispersions, often referred to as fine powders. These have a very close process control of grain size range and are uniquely capable of being sheared by lubricated paste extrusion into a coherent fibrous matrix with useful structural integrity. Pipe liners for the chemical and pharmaceutical industry are almost universally manufactured from HiPerFlon. The paste extrusion process provides the highest level of surface finish, the

highest resistance to permeation and the closest dimensional control of all of the methods of lining in PTFE. This serves to differentiate what we manufacture from processing technologies using lower quality and priced materials - being ram extrusion, mandrel wrapping and isostatic moulding.

Paste extrusion however is only suitable for making straight lengths of PTFE tubing colloquially known as pipe liners in our industry. It can be subsequently manipulated into bends and other simple forms, but is not capable of lining complex shapes without joints.

PFA

PFA (Perfluoroalkoxy) was developed in order to achieve a true melt-processable fluoropolymer. Its characteristics are such that in service it can be considered as interchangeable with PTFE in terms of its chemical service and temperature and pressure duty. It has the highest permeation resistance of the fluoropolymers, exceeding that even of paste extruded PTFE. It also provides the smoothest and least wettable finish of all of the Fluoropolymers. Unfortunately the trade-off is cost, the material being more expensive than PTFE. CRP uses PFA in the production of most of its lined fittings and the Flowserve range of Atomac and Durco valves are available lined in PFA.

FEP

Standard FEP (Fluorinated Ethylene Propylene) is another melt-processable Fluoropolymer. It does not have the

almost universal chemical resistance of PTFE and PFA and its maximum operating temperature in service is 150°C. CRP uses the material occasionally for the manufacture of "sheet lined products". This is essentially a lining made up of sheet and tube elements of FEP welded together in situ. Sheet lining allows one to line complex articles without the use of expensive moulding tools, to cope with the inevitable tolerance errors of welded fabricated steelwork and with the use of bonded linings to provide a degree of vacuum performance. Where the chemical performance and temperature duty are not an issue, the material provides a less expensive alternative to PFA, however it is not used in lined pipe and fittings.

PVDF

PVDF (Polyvinylidene difluoride) is an engineering fluoropolymer and has a more limited range of chemicals performance and an upper temperature limit of 120°C. It has been replaced in many applications by the improved performance of PTFE resins and is not well supported in the market.

Materials Suppliers

It is worth stating that CRP only use fluoropolymers from well respected global producers. This provides confidence in the raw materials in terms of their standards, both quality and consistency of materials and product traceability.



Pressure

The pressure rating of CRP's Class 150 lined piping system is generally driven by the pressure rating of the flanges used. These pressure ratings are detailed in the US standard ASME B16.5, and specifically Class 150 flanges. Within this standard, the pressure rating of flanges is also dependent upon the material of construction, and the operating temperature. Typically, at ambient temperature, the pressure rating of a carbon steel flange is 19.6 bar(g), with stainless steel flanges having a slightly lower pressure rating, the exact values depending upon the grade used. In all cases the pressure rating of flanges also reduces with increasing temperature. Please refer to the pressure temperature

curves below for more detail.

ASME B16.5 Class 300

In reality many chemical processes are much more benign running at only a few bars of pressure. However, if a higher rated pressure system is required, CRP can offer a Class 300 flanged piping system, although the pressure rating in this case is driven by the joint integrity of the PTFE to PTFE flare faces between the flanges, rather than the pressure rating of the flanges themselves. Please consult CRP for more details.

Exceptions

There are three exceptions to this general rule:

Blanking Spades

Here the pressure rating is limited due to the necessity to keep the spade

thin enough to be fitted between two flanges. Particularly at larger sizes, this significantly limits the allowable pressure.

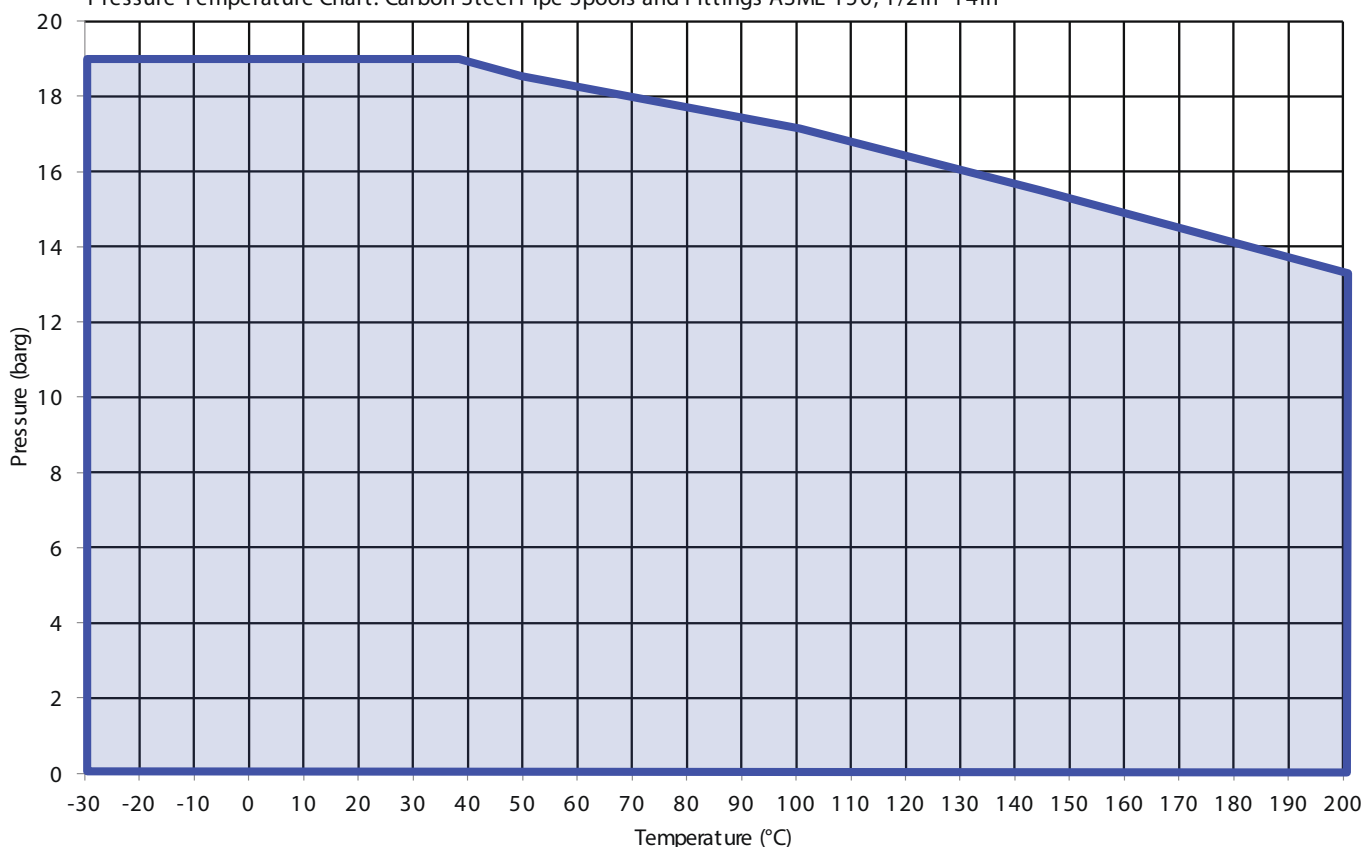
Solid PTFE Sliding Blinds

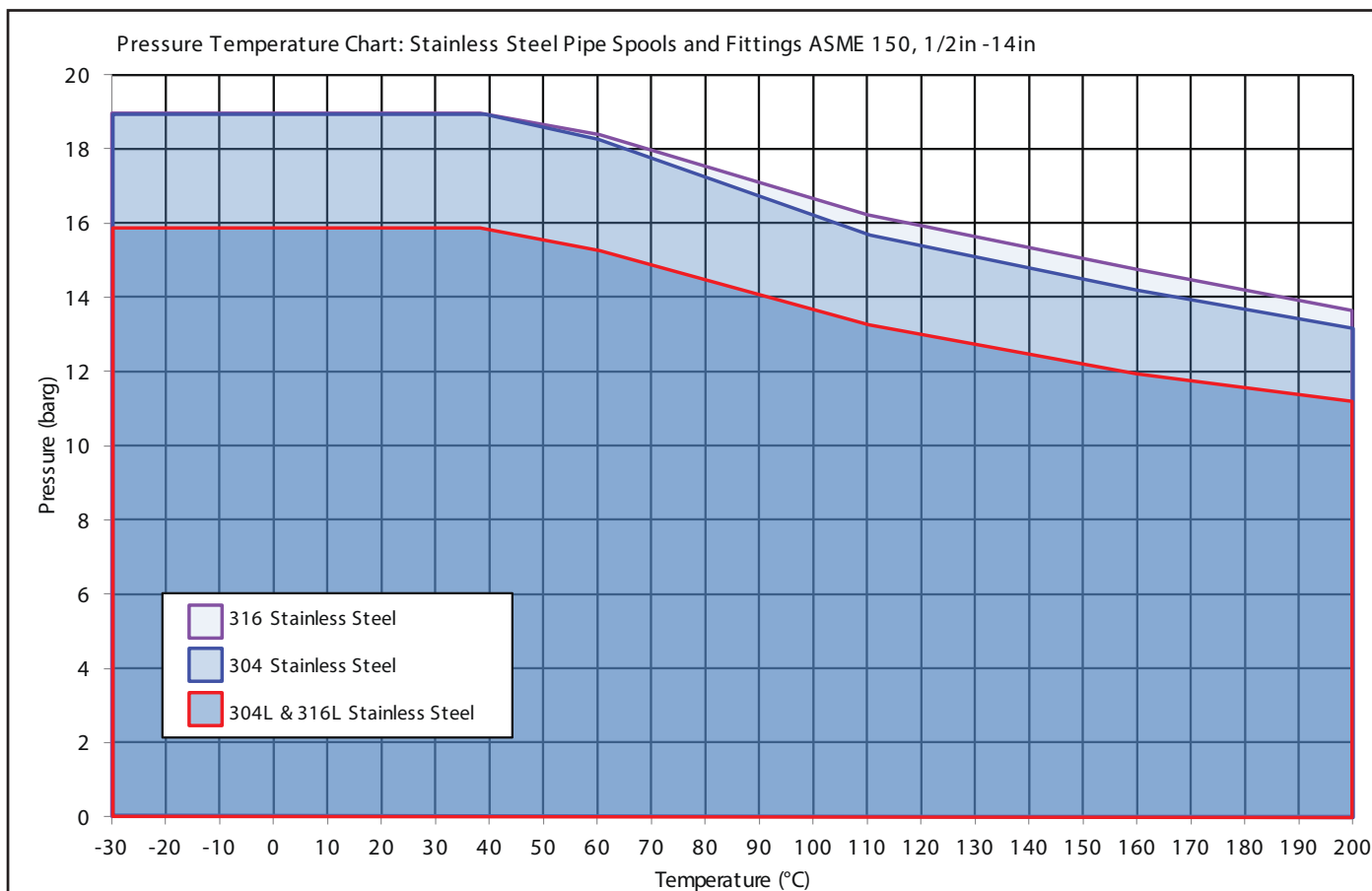
Here the pressure rating is limited by the fact that the strength of these components comes only from PTFE, there is no steel to provide mechanical strength. Once again, particularly at larger sizes, this imposes significant limits on the pressure rating of these components.

Hose Adapters

In this case the pressure rating is driven by the pressure rating of the hose connection end of the component, which is usually lower than the flange pressure rating.

Pressure Temperature Chart: Carbon Steel Pipe Spools and Fittings ASME 150, 1/2in -14in





Temperature

Lower Temperature Limit

For CRP's standard range of carbon steel lined piping, the lower temperature limit is set by the lower operating temperature of the steel housings, -30°C, as detailed in ASME B31.3. PTFE and PFA are both capable of operating down to cryogenic temperatures, and therefore, if operating temperatures below -30°C are required, CRP can offer lined piping systems manufactured using either low temperature carbon steel housings or, more commonly, using stainless steel

housings, which are typically rated to -195°C.

Upper Temperature Limit

This is determined by the mechanical strength of the PTFE/PFA linings used by CRP. While in laboratory conditions, PTFE and PFA retain excellent corrosion resistant properties up to 260°C, as with all polymers, their mechanical properties reduce with increasing temperature, and their thermal expansion rates far exceed those of steel. The consequence of these two factors is that at temperatures over 200°C, the integrity of the joints between individual lined items becomes questionable, as does their vacuum performance.

When specifying a lined piping system,

consideration should also be given to any situations of thermal shock, and the potential for upset conditions (both pressure and temperature).

Vacuum

Vacuum is the most often ignored aspect of lined piping systems and consequently one of the more common causes of failure.

The vacuum performance of a lined piping system is unrelated to the positive pressure rating of the system. Rather it is driven by a combination of: the liner thickness; the degree of interference between the liner and the steel housing; whether the liner is mechanically keyed onto the housing;

and operating temperature. In essence, thicker liners provide more hoop strength to the liner and so resist vacuum better.

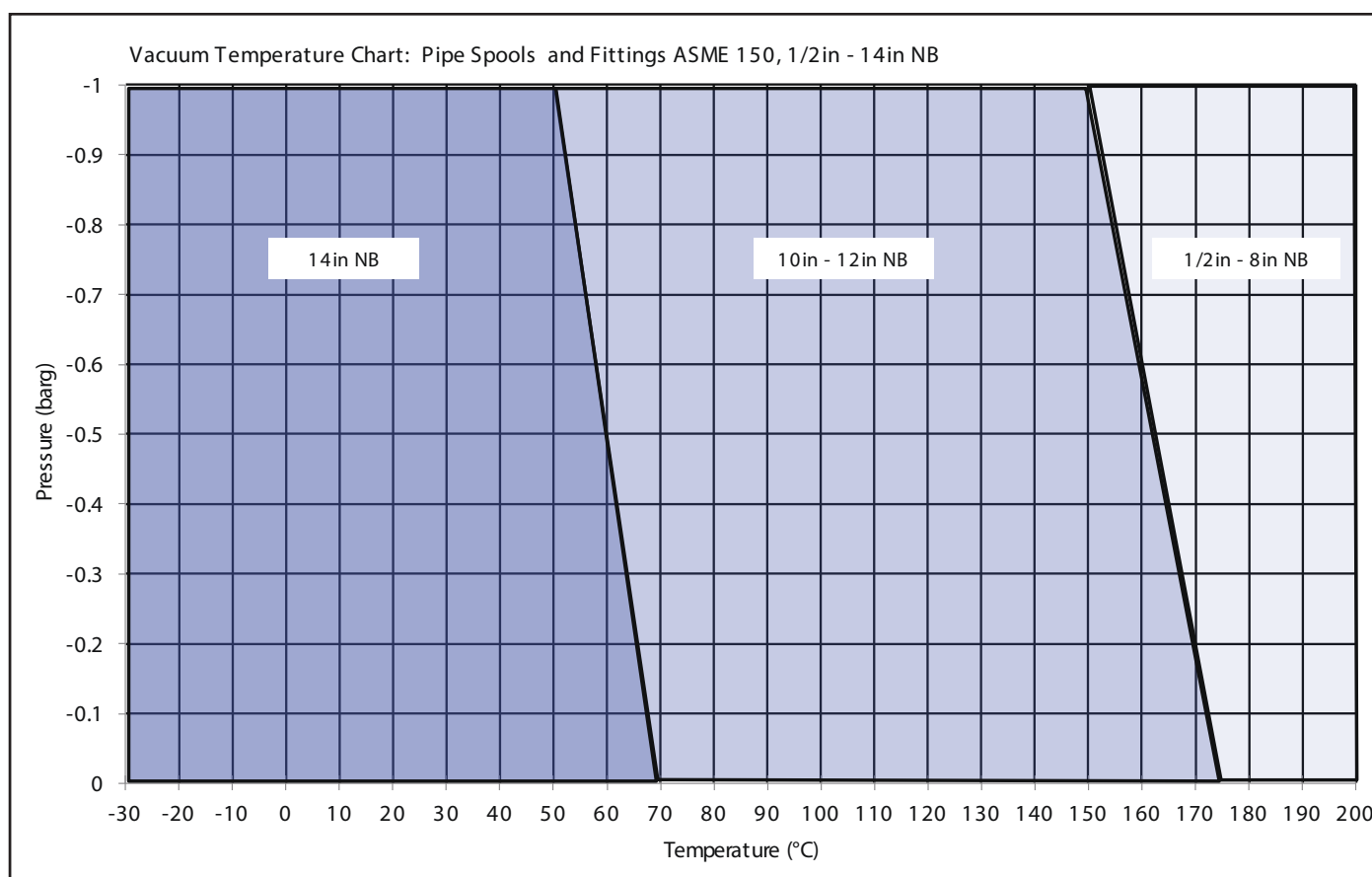
Secondly, liners that are tight in the bore of the housing have a higher vacuum performance than loose liners. This is because, for a tight liner, the steel housing helps prevent the liner from deforming and collapsing under vacuum.

Thirdly, if a liner is mechanically keyed onto the steel housing (only possible for PFA lined components), this provides

additional support for the liner and thus improved vacuum performance.

Fourthly, at higher temperatures, liners have less mechanical strength, and thus a reduced vacuum performance.

By adjusting each of the above factors, CRP's range of lined pipe have the vacuum performance detailed elsewhere in this catalogue.



Materials of Construction

Product			Specification ↓	Liner						Carbon Steel				Stainless Steel													
	Item ↓	Cast/Fabricated		Virgin PTFE	Static-dissipating PTFE	Virgin PTFE	Static-dissipating PTFE	Virgin PFA	Static-dissipating PFA	Fabrication				Cast	Fabrication				Cast								
										Pipe	Flange	Stub End	Vent Boss		Vent Extension ⁵	Body	Wrought Fitting	Profile		Casting	Pipe	Flange	Stub End	Vent Boss	Vent Extension ⁵	Body	Wrought Fitting
Pipe Spool Van Stone	F	✓	✓						✓	✓	✓	✓	✓					✓	✓	✓	✓	✓					
Welded Construction Fixed/Rotating Pipe Spool	F	✓	✓	✓					✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓				
Welded Construction Fixed/Fixed Pipe Spool	F	✓	✓	✓					✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓				
Field Flare	F																										
Spacer Type 1	-			✓	✓																						
Spacer Type 2	-	✓	✓	✓											✓									✓			
Spacer Type 3	-	✓	✓	✓						✓		✓							✓								
90° Elbow	C		✓				✓							✓													✓
90° Elbow	F	✓	✓	✓					✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓	✓		✓		
90° Elbow 3D	F	✓	✓	✓					✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓	✓		✓		
90° Elbow 5D	F	✓	✓	✓					✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓				
45° Elbow	C	✓	✓	✓						✓	✓	✓	✓	✓				✓									✓
45° Elbow	F	✓	✓	✓					✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓				
Equal Tee	C						✓	✓									✓										✓
Equal Tee	F						✓	✓									✓										✓
Reducing Tee	C						✓	✓									✓										✓
Reducing Tee	F						✓	✓										✓									
Short Stack Tee	C						✓	✓									✓										
Short Stack Tee	F						✓	✓																			
Strainer Tee	C			✓ ¹	✓ ¹		✓	✓									✓										✓
Equal Lateral Tee	C						✓	✓									✓										
Equal Lateral Tee	F						✓	✓										✓									
Reducing Lateral Tee	C						✓	✓									✓										
Reducing Lateral Tee	F						✓	✓										✓									
Instrument Tee	C						✓	✓									✓										
Instrument Tee	F						✓	✓																			✓
Double Branch Instrument Tee	F						✓	✓										✓									
Equal Cross	C						✓	✓									✓										
Equal Cross	F						✓	✓										✓									
Reducing Cross	F						✓	✓										✓									
Short Stack Cross	F						✓	✓										✓									
Concentric Reducer	C	✓ ²	✓ ²				✓	✓									✓										✓
Concentric Reducer	F	✓	✓				✓ ³	✓ ³										✓									
Reducing Flange Taper Bore	F	✓ ²	✓ ²				✓	✓									✓								✓		
Reducing Flange Parallel Bore	F	✓	✓				✓ ³	✓ ³									✓										✓
Eccentric Reducer	C	✓ ²	✓ ²				✓	✓										✓									
Eccentric Reducer	F	✓	✓				✓ ³	✓ ³																			
Blank Flange	-		✓	✓						✓																	
Blanking Spade	-		✓	✓																					✓		
Orifice Plate	-			✓	✓	✓	✓ ⁵	✓ ⁵									✓ ⁵								✓ ⁵		
Sliding Blind	-			✓	✓	✓																					
Spectacle Blind	-	✓	✓	✓	✓	✓	✓ ⁵	✓ ⁵									✓								✓		
Toughgask	-			✓																							✓

1 - Strainer Plate

2 - Certain reductions may be PTFE Lined

3 - Certain reductions may be PFA Lined

4 - For fabricated fittings stub ends are only used with rotating flanges

5 - Optional component

PTFE and PFA Material Properties						
	Units	Virgin PTFE (paste extruded) [ASTM D4895 Type I] (Grades A or B)	Static Dissipating PTFE (paste extruded) [ASTM D4895 Type I] (Grades A or B)	Virgin UHP PTFE (paste extruded) [ASTM D4895 Type I] (Grades A or B)	Virgin PFA [ASTM D3307 Type II]	Static Dissipating PFA
Mechanical						
Minimum Tensile Strength	MPa	20.7	20.7	20.7	26.2	26.2
Minimum Elongation at Break	%	250	250	250	300	300
Hardness	Shore D	55-60	55-60	55-61	55	55
Physical						
Specific Gravity		2.16-2.19	2.16-2.19	2.16-2.19	2,12-2,17	2,12-2,17
Melt Flow Rate when tested to ASTM D3307 at 372°C	g/10 min	n/a	n/a	n/a	2	1.8-2.5
Liner Colour		White	Black	White	Translucent	Black
Water Absorption	%	< 0.01	< 0.01	< 0.02	<0.03	<0.03
FDA Compliant		Yes	Yes	Yes	Yes	No
Thermal						
Thermal Conductivity	W/(m·k)	0.25	0.25	0.25	0.19	0.19
Coefficient of Linear Thermal Expansion						
25°C to 100°C	mm/mm.K	124x10 ⁻⁶	124x10 ⁻⁶	109x10 ⁻⁶		
25°C to 150°C	mm/mm.K	135x10 ⁻⁶	135x10 ⁻⁶	141x10 ⁻⁶		
25°C to 200°C	mm/mm.K	151x10 ⁻⁶	151x10 ⁻⁶	141x10 ⁻⁶		
21°C to 100°C	mm/mm.K				140x10 ⁻⁶	140x10 ⁻⁶
100°C to 150°C	mm/mm.K				180x10 ⁻⁶	180x10 ⁻⁶
150°C to 208°C	mm/mm.K				220x10 ⁻⁶	220x10 ⁻⁶
Flammability		Non Flammable				
Electrical						
Volume Resistivity	Ω.m	>10 ¹⁶	-	10 ¹⁸	10 ¹⁶	0,15-0,25
Surface Resistivity	Ω/£	10 ¹⁷	<10 ⁹	10 ¹⁷	10 ¹⁷	Unavailable

PTFE Liner Dimensions							
Nominal Bore		Liner Type	Outside Diameter ²		Wall Thickness		Weight
Inches	mm		Nominal mm	Tolerance +/-mm	Nominal mm	Tolerance +/-mm	Per metre kg
½ ¹	15	Heavy Duty Virgin & Static Dissipating	25	1.0	2.3	0.2	0.5
¾	20		25	1.0	2.3	0.2	0.5
1	25		29	1.0	3.2	0.2	0.6
1½	40		44	1.0	3.2	0.2	0.9
2	50		55	1.5	3.2	0.2	1.2
3	80		82	1.5	3.2	0.2	1.0
4	100		107	3.0	4.5	0.2	3.5
6	150		159	3.0	5.5	0.2	6.8
8	200		208	3.0	8.5	0.2	13.1
10	250		259	4.0	9.1	0.2	15.9
12	300		319	5.0	10.4	0.4	23.4
14	350		343	5.0	8.3	0.2	21.6
½ ¹	15	UltraHiPerFlon®	25	1.0	2.3	0.2	0.5
¾	20	Superweight Virgin UHP	25	1.0	2.3	0.2	0.5
1	25		29	1.0	4.5	0.2	0.8
1½	40		43	1.0	4.5	0.2	1.3
2	50		54	1.0	4.5	0.2	1.7
3	80		81	1.5	4.8	0.2	2.5
4	100		107	1.5	5.0	0.2	3.5
6	150		159	1.5	6.0	0.2	6.8
8	200	UltraHiPerFlon®	208	3.0	8.5	0.2	13.1
10	250	Heavy Duty UHP	259	4.0	9.1	0.2	15.9
12	300		319	5.0	10.4	0.4	23.4
14	350		343	5.0	8.3	0.2	21.6

1 - 1/2in liners are too small, so a 3/4in size is used.

2 - When supplied as a separate pipe liner, NB when fitted into a steel pipe the liner will take on the id of the pipe.

The nature of PFA mouldings are such that the lining thickness is very dependent upon the internal diameter of the steelwork, whose standards give rise to large tolerances, therefore these are expressed as minimums.

PFA Lining Dimensions			
Nominal Bore		Wall Thickness	
Inches	mm	Nominal mm	Minimum mm
½	15	3.5	1.8
¾	20	3.5	1.8
1	25	3.5	2.4
1½	40	4.0	2.8
2	50	4.3	3.2
3	80	6.0	4.8
4	100	8.2	6.8
6	150	8.6	6.9
8	200	9.5	7.6
10	250	10.2	8.0
12	300	10.1	7.6
14	350	9.8	7.0

Spool & Fitting Bores

Please note that because of the method of manufacture and tolerances on steel materials these are a guide. Please consult if you require a precise dimension for instrument, mixer or other insertion or a calibrated volume.

Spool and Fitting Bores				
Nominal Bore		Nominal Lined Bore Diameters		
		Pipe Spool/PTFE Lined Fitting		Lined Fitting
		Heavy Duty	Superweight	PFA
Inches	mm	mm	mm	mm
½	15	16	16	12
¾	20	16	16	12
1	25	20	18	20
1½	40	34	32	33
2	50	46	44	44
3	80	70	68	66
4	100	93	91	86
6	150	143	142	137
8	200	188	-	186
10	250	247	-	237
12	300	286	-	287
14	350	319	-	317

Virgin PTFE and PFA Resins

CRP only uses virgin Polytetrafluoroethylene (PTFE) and Perfluoroalkoxy (PFA) resins that have the following status relative to food contact regulations.

European Union

Compliance with European Regulation EU No.10/2011 as amended. We can confirm that the raw materials and the subsequent products manufactured have been produced according to a quality management system which complies with the requirements of European Regulation EC No.2023/2006 on good manufacturing practice for materials and articles intended

to come into contact with food.

United States of America

Compliance with U.S. FDA 21 CFR 177.1550 (a)(2) and (b) Perfluorocarbon resins.

Static-Dissipating PTFE Resin

CRP also declares that the high purity furnace black used in the manufacture of static dissipating PTFE products has the following status relative to food contact regulations.

European Union

Compliance with European Regulation EU No.10/2011 as amended. We can confirm that the raw materials and the subsequent products manufactured have been produced according to a quality

management system which complies with the requirements of European Regulation EC No.2023/2006 on good manufacturing practice for materials and articles intended to come into contact with food.

United States of America

Compliance with U.S. FDA 21 CFR 178.3297 Colorants for polymers. We can confirm that the formulated carbon black levels do not exceed 2.5% by weight.

Static-Dissipating PFA

The carbon used in creating the static-dissipating properties of this PFA is not FDA compliant and nor does the amount used fall under the minimum percentage for compliance. At present there is no FDA compliant material available.

Static-Dissipating PTFE Performance

An independent inspection company and a specialist technical consultancy conducted the following tests with results.

Resistance Test

Measure BS2050 A4.5 modified for PTFE

Result- Measured resistance $2 \times 10^6 \Omega$

Resistivity Tests

Surface Resistivity

This is the resistance to leakage of a charge across a square area of surface.

Tested at ambient temperature and 50% relative humidity

Result - Measured value (inside liner) $1.8 \times 10^4 \Omega m$

Volume Resistivity

This is the internal resistance of an insulating material to current

flow. High volume resistivity guarantees that the material acts as an insulator and low volume resistivity demonstrates that the material is a conductor.

Tested at ambient temperature and 50% relative humidity.

Result - Measured value $2.1 \times 10^4 \Omega m$

Classification

The materials are classified as static-dissipative or anti-static and far exceed the minimum requirements. CRP's static dissipating materials exceed the requirements of the specification EDS. PIP.53.04A June 1989.

PTFE & PFA Material Standards

ASTM D4895 Type I: Standard Specification for Polytetrafluoroethylene : PTFE : Resin Produced From Dispersion

This is the most common global raw material specification for PTFE polymers which are produced by the controlled coagulation of dispersions. These PTFE's are called "Coagulated Dispersions, Fine Powders or Paste Polymers" and are much more precisely controlled than the coarse

granular materials. These types of PTFE are almost always mixed with a volatile processing aid and are used to make high quality extrusions. Type I grades are suitable for extruding the thick walled liners suitable for lining steel pipes.

ASTM D4894: Standard Specification for Polytetrafluoroethylene : PTFE: Granular Molding and Ram Extrusion Materials

This is the most common global raw

material specification for PTFE polymers used to make isostatically moulded PTFE lined pipework, ram extruded PTFE items and billets of PTFE which are machined to produce finished components. This is not a preferred material for lined piping components other than those machined

from solid.

ASTM D3307 Type II: Standard Specification for Perfluoroalkoxy (PFA)-Fluorocarbon Resin Molding and Extrusion Materials

This is the most common global raw material specification for the various types of PFA polymers giving full details of the physical and mechanical attributes of the PFA both as supplied by the manufacturer and after processing. The specification also contains details of test methods to be

used for PFA polymers.

Type II

In common with most ASTM Standard Specifications for materials ASTM D3307 is divided into many grades or in this case 13 types each destined for a different application. A type reference determines the mechanical and thermal properties of a particular grade or type. Whilst the mechanical properties are important it is the thermal properties which have the most significance when PFA is used as a corrosion resistant lining material. Corrosion resistance especially resistance to stress corrosion cracking at elevated

temperatures is determined by the molecular weight and structure of the PFA. The best lining materials have high molecular weights and are renowned for their extraordinarily high viscosity even when they are fully melted. It is a measure of the viscosity when melted referred to as melt flow index which is the principal method of determining a 'type' of PFA. The lower the melt flow index the greater the melt viscosity and performance in highly aggressive situations. CRP only uses PFA classified to type II which has the lowest melt flow index of all the PFA grades.

Steelwork Material Standards

API 5L Grade B: Specification for Lined Pipe

Material specification and some dimensional standards and tolerances for steel pipe. This is the most common standard for steel pipe and is readily recognised throughout the Petrochemical industry. This specification is widely used in the Grade B form as the standard pipe material for Lined Pipe and Fittings manufacture. It is now quite common to see steel pipes dual certified to this specification and to ASTM A106 Grade B.

ASTM A106 Grade B: Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

Material specification often seen as a combined specification with API 5L Grade B. Grade B is the most widely used of the three grades steel pipe referred to in ASTM A106. The term grade B determines the chemical composition and mechanical performance of the steel used to make the pipe.

ASTM A105: Carbon Steel Forgings for Piping Applications

Material specification for forgings - in our case flanges.

ASTM A182 Grades: F304/F304L/ F316/F316L/ Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service

Material specification for stainless flanges.

ASTM A216 Grade WCB: Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service

A material specification covering both

performance and composition. Grade WCB is used by CRP in their investment castings for the majority of their PFA lined fittings.

ASTM A234 Grade WPB: Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

Material specification. This standard covers wrought carbon steel fittings which are manufactured to the dimensional specifications of ASME B16.9 used in the fabrication of our flanged pipe fittings.

Grade WPB is the grade usually used for lined pipe and fittings.

ASTM A240 Grades: 304/304L/316/316L: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

Material specification. Stainless steel to this specification is used where plate materials are required in the manufacture of pipe spool stub ends, reducing flanges and bespoke flanges - anywhere plate may be used.

ASTM A276 Grades: 304L/316L: Standard Specification for Stainless Steel Bars and Shapes

A material specification used for machined

components.

ASTM A312 Grades: 304/304L/316/316L: Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes

/Specification for Castings, Austenitic, for Pressure-Containing Parts

ASTM A403 Grades: 304L/316L/ Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings

Material specification for stainless fittings used in fabricating pipe fittings.

ASTM A516 Grade 60: Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

A material specification. Steel to this specification is used where plate materials are required in the manufacture of pipe spool stub ends, reducing flanges and bespoke flanges - anywhere plate may be used. There are four grades specified in the standard with different composition and mechanical properties. Grade 60 is the most widely used for CRP's products.

BS970 Grade 080M40 (Free Machining Carbon Steel): Specification for wrought steels for mechanical and allied engineering purposes. General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels

A material specification used for machined components.

Design

CRP's products are all manufactured and tested to national and international standards where applicable, with fundamental design qualification having been undertaken via the approval process required to comply with the Pressure Equipment Directive 2014/68/EU. The primary design standards used by CRP are:

ASME B31.3: Process Piping

This contains requirements for piping typically found in petroleum refineries; chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants; and related processing plants and terminals. It covers materials and components, design, fabrication, assembly, erection, examination, inspection, and testing of piping. This represents the core of the design part of a lined piping system.

ASME B16.5: Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24

The standard covers pressure-temperature ratings, materials, dimensions, tolerances, marking, testing, and methods of designating openings for pipe flanges and flanged fittings. Key aspects are the design of flanges and the face to face dimensions of flanged fittings. There are a number of pressure classes detailed in the standard.

Class 150

The pressure classification and therefore

dimensional specification that the majority of lined piping is manufactured to is 150 pound (150lb) or in metric terms 10 bar. Therefore this specification is often referred to and is called ASME B16.5 Class 150, or abbreviated to ASME150.

It is possible to manufacture lined piping for Class 300 (300lb), but although this can be achieved dimensionally, it will not achieve the performance levels of Class 300 due to the creep effect on PTFE and PFA. Please note however that the pressure/temperature rating for a Class 150 flange depends on which raw materials you choose to make the flange from. In the case of CRP's ASTM A105 flanges the pressure rating at ambient is 19.6 bar.

ASTM F1545: Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges

This is the latest version of ASTM lined pipe specifications, setting out the materials to be used, methods of fabrication and testing both as type tests and production tests. It covers several plastic materials including PTFE.

It has over the years been used as the bench mark quality standard for the manufacture of PTFE Lined pipe and fittings throughout most of the world with only central Europe preferring the

DIN equivalent.

ASTM F423 is the original lined piping specification which had a little more detail and only referred to PTFE. It is still referred to in some user specifications although withdrawn in 2002. CRP refers to it, in that our product type testing was mainly done against this specification.

ASME Boiler & Pressure Vessel Code Section IX. Welding, Brazing, and Fusing Procedures: Welders: Brazers: and Welding, Brazing and Fusing Operators

The title is self-explanatory and applies to welding activities principally on spools and fittings.

BS EN ISO 9606-1: Qualification testing of welders -- Fusion welding -- Part 1: Steels

This standard applies to the approvals held by CRP's welding operators.

BS EN ISO 15641-1: Specification And Qualification Of Welding Procedures For Metallic Materials - Welding Procedure Test - Part 1: Arc And Gas Welding Of Steels And Arc Welding Of Nickel And Nickel Alloys

This applies to weld procedure qualification.

Quality

ISO 9001:2015

CRP is an ISO 9001:2015 approved company. Originally accredited to BS5750 Part 1 in 1992, CRP maintains this accreditation through a process of continuous third party surveillance with, six monthly, annual and triennial audits taking place. All of the company's manufacturing and test procedures fall within this regime.

Pressure Equipment Directive

CRP's products are all manufactured and tested to national and international standards where applicable, with fundamental design qualification having been undertaken via the approval process

required to comply with the Pressure Equipment Directive 2014/68/EU.

TSG

CRP has Chinese TSG (Manufacturing License of Special Equipment of The Peoples Republic of China) licence approval from the GuangZhou Special Pressure Equipment Inspection and Research Institute, for many of its products, including its range of PTFE/PFA lined pipe and fittings. This is often referred to as a China Stamp.



Welding

Standard

For CRP's range of products with welded construction steel housings, the company employs coded welders (to ASME IX and/or ISO 9606-1) following procedures in compliance with the requirements of the

PED, and either ASME IX or EN15614-1.

Options

If required, welding can be carried out by welding sub-contractors compliant with the requirements of ISO 3834-2.

Welded fabrications can be supplied with

individual weld maps.

Appropriate types and levels of NDT can be offered, including radiography, magnetic particle inspection, dye penetrant, etc.

Product Finishing

CRP's standard paint finish is a two component low VOC, high solids fast curing epoxy primer/finish containing zinc phosphate anti-corrosive pigmentation. The standard colour is RAL 5015 - Blue Semi-Gloss, with a typical application thickness of 60 microns.

This paint system is intended as a primer coat and would not be considered as falling within any of the environmental/durability classifications of ISO 12944 Parts 1 and 2. However as a primer it should provide sufficient durability for site installation and subsequent over

coating. It will perform as a primer coat for the majority of paint systems applied.

CRP can also apply multi-coat wet paint systems in ISO 12944 compliant paint systems based on selecting the corrosive environment and durability requirement. Typically customers require protection for the C4, C5I and C5M environments and Medium or High durability. CRP are able to provide such finishes or apply customer specified paint systems.

Because of the health hazards associated with paints containing free isocyanate CRP are not able to apply these, but can

offer alternatives.

Steel components are abrasive blast cleaned using non-ferrous media to Sa 2½ ISO 8501-1 - "very thorough blast cleaning". A surface profile Medium (G) ISO 8503-1 is achieved.

Product Testing

All virgin PTFE/PFA lined products are subject to an electrostatic spark test at 25kV. All pipe spools and certain fittings are also subject to Hydrotest at 29 bar(g) for three minutes, followed by a relaxation dwell to atmospheric pressure and a repeat.

All spools and fittings lined in static dissipating PTFE/PFA are subject to Hydrotest at 29 bar(g) for three minutes,

followed by a relaxation dwell to atmospheric pressure and a repeat.

Ultrasonic testing is conducted on large diameter PFA lined fittings to determine the liner thickness.

All spools and fittings are visually examined, particularly the flare faces, to ensure that there are no defects that would prevent the item sealing against

adjacent items.

The mechanical properties and the specific gravity of representative samples of PTFE liner, selected from each sinter batch, are tested to confirm that they comply with the PTFE specification detailed elsewhere in this document.

Permanent Product Marking

CRP is proud of what we manufacture and wherever possible the product is identified as having been manufactured by us. This is as permanent as practicable - in contrast to much other product on the market which is anonymous. Castings have the CRP logo, together with the web address, our notified body number (CE mark), the product class (ASME 150), the material standard e.g. A216 WCB and the

product size e.g. 40 x 25 (1½" x 1").

Those products subject to PED compliance which are not castings have a high temperature cable tie added with the notified body number and company details.

Some products have a stainless steel data plate riveted containing basic product data, serial numbers and in some cases basic performance limits.

Shipment Product Marking

To enable easy identification of product on delivery - particularly when delivering a mixed collection of product for a project, CRP has developed some simple systems which enable items to be matched to delivery documentation. As standard pipe spools are identified with their nominal bore and length in indelible marker pen. Timber end boards are identified with the customer name, CRP order number, order line item number and which one of the

item it is - in the case of multiple identical items on the same line of the order e.g. 1 of 20.

On consultation with the customer, information such as the isometric drawing number or plant item tag can be added both the item and the delivery paperwork, making it easier to select items.

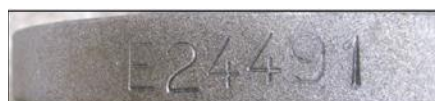
Product Traceability

All CRP manufactured Lined Pipe and Fittings are backwards traceable from the finished component to the manufacturing tests, processes and lining materials.

Pipe Spools

Each spool has one flange stamped with the reference of the liner batch used in its construction. This provides traceability back to the liner manufacture, the tests undertaken and the materials certification

of the polymer.



PFA Moulded Fittings

PFA moulded items likewise are stamped with a mould reference which again provide traceability back to the

manufacturing and test activities and the material certification of the polymers used.



Type 2.2. material certification can be provided as routine. Type 3.1 certification can be provided on request.

Installation

CRP has a comprehensive User Manual which gives extensive guidance on the installation of lined piping systems. Please ensure that those charged with installing the product read this guide and familiarise themselves with the special requirements of lined piping. There is nothing particularly complicated, but there are a few basic rules that must be followed in order to have a successful installation. CRP can also provide comprehensive training

in the installation of lined equipment and our field sales team are trained in providing practical support. Copies of the User Guide are shipped with all product and it is also available to download from the website.



Non-Destructive Testing

Non-destructive testing is also referred to by the acronym NDT or in the USA as non-destructive examination (NDE). It is the process by which materials – usually metals are examined without destroying them. Usually this is for searching for defects. In the case of CRP it would principally be specified for the examination of welds.

CRP Experience

It is worth commenting that in

the history of CRP, no product has ever failed because of a lack of weld integrity. In CRP's product the welds are not in contact with the process fluid and therefore do not need to retain the liquid or gas, they are serving to hold the housing together and to support the lining. As routine, all PFA lined fittings are subject to at least 70 Bar and 370°C as part of the moulding process.

Appropriate Non-Destructive Testing					
Weld Type	Material	Radiography	Ultrasonic	Magnetic Particle Inspection	Liquid (Dye) Penetrant
Butt Weld	Carbon Steel	✓	✓	✓	✓
Butt Weld	Stainless Steel	✓	✓	✗	✓
Fillet Weld	Carbon Steel	✗	✗	✓	✓ Not preferred
Fillet Weld	Stainless Steel	✗	✗	✗	✓

Training

CRP offer customers and their nominated contractor's comprehensive training in three specific areas:

Installation Training

Because of the niche position of PTFE and PFA lined equipment, it is not unusual for installation contractors to be unfamiliar with the installation of lined equipment. This can lead to installation mistakes, expensive rework and a delayed project implementation. Through the provision of some simple training CRP can assist in ensuring a good piping installation that does the equipment justice and gives the client confidence in its application.

Product Training

CRP is keen to help customers choose the correct lined equipment for the job and get the best out of it. With the health, safety and environmental duties that come to bear on many of our customers and the need to keep the general technical level of understanding up of an ever changing workforce, CRP has developed training to assist design, project and plant engineers to understand the world of lined equipment. The objective is to provide a comprehensive overview of PTFE lined piping systems, including an understanding of why such materials are selected and how they are used. This could be to meet training obligations - either for continuous professional development, or

to fulfil health and safety requirements.

Field Flare Training

Field Flare piping is a useful addition to the toolbox of any serious user of lined equipment. It provides a simple self-help system, enabling the local fabrication of spools for emergency use or for the odd small modification or maintenance task. Occasionally because of historic site development or convenience some customers manufacture all of their spool requirements locally and CRP can support such users. Through the provision of training CRP can "approve" nominated staff of the end user or their contractor in the use and installation of field flare spools.

Method

Usually this is provided via a classroom based training session, site based or at CRP's facility; making use of audio-visual presentations and classroom media. The training session would typically last two hours and a class size of around 10 is ideal. The training is provided by our technical, manufacturing and commercial staff as appropriate. Field flare training is usually provided via a practical training session at CRP's factory. This enables the candidates not only to undertake hands on training on the activity of field flaring, but also to understand all of the other issues that surround the use of fluoropolymer lined equipment.

A short multiple choice question paper is set

to both help fix and confirm understanding. As part of the presentation, CRP will put together a small exhibition of products to aid understanding and a question and answer session concludes the training.

Course Materials

We plan to provide course materials for each attendee, which will include notes relating to the presentation and other reference materials for subsequent reference. We will also provide immediately after the visit, certificates confirming the individual's attendance and understanding of the training.

Caveat and Costs

It is important to comment that we are not acting as paid consultants. We are not insured for such a role. However, we believe that we can bring a wealth of both theoretical and practical experience that is not available from other sources, which should give your team and others a good background in working with these materials.

We see the provision of such training as part of the added value that a supply chain relationship with CRP can bring. To this end we offer such training to our supply contract customers and their agents and sub-contractors. Costs are usually on the basis of meeting our expenses.