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1 General Specification

1.1 Quality System

- CRP is an ISO 9001:2000 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. The company was one of the first in the UK to obtain approval to the upgraded version ISO 9001:2000. All of the company's manufacturing and test procedures fall within this regime.

1.2 Design and Test Standards

- 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 97/23/EC
- Qualification Testing: to EDSPIP 53.01C and ASTM F423/ASTM F1545. Rating: full vacuum to Class 150 at 200 °C for sizes up to and including 150NB.

1.3 Product Traceability

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

1.4 Product Origin

- All CRP manufactured products originate from a single manufacturing source at Littleborough near Manchester England. This both clearly establishes the origin and gives a commonality of manufacturing methods and materials – providing consistency of product standards through materials supplied.

1.5 Common Product Standards

- All PTFE pipe spools are manufactured using in-house produced PTFE paste extruded liner, whilst PFA lined fittings use virgin material. In both cases these materials are compliant with the requirements of FDA reference 21 CFR 177.1550. For spools and fittings lined in static dissipating liners, those lined in PTFE are compliant with the aforesaid FDA reference. However, PFA lined fittings are not compliant, since at present no such polymer exists.
- All products are painted with a corrosion resistant zinc phosphate primer in red-brown with a typical dry coating thickness of 25 µm.
- All products (except type 1 spacers) include suitable venting within the metal structure of the item. Typically one or more 3mm diameter holes in spools and PTFE lined fittings, and the injection boss of PFA moulded fittings.
- When Vent Extensions are required, a 10mm high BSPT or NPT internally threaded boss is welded to pipe spools. For moulded fittings the injection boss is drilled and tapped with an appropriate BSPT/NPT female thread. A 65mm long vent extension is then supplied to fit to this, to provide a standard 75mm vent extension.
- Special requirements – to be agreed between customer and CRP, but can include special paint finishes, stainless steel spools & fittings, BS, DIN or JIS flanges, the use of static dissipating polymers, special low temperature service requirements, non-standard face to face dimensions, rotating flanges and the creation of special components for the reduction of flanges or to assist in tight access areas.

1.6 Product Identification and Packaging

- All CE marked product is identified with a UV resistant high temperature nylon cable tie, providing manufacturers details, location and notified body CE registration number.
- Additionally all cast products are identified with the CRP logo and details of the product size, cast materials specification and cast reference – “heat number”. All products where relevant are identified with CRP’s traceability reference.
- Additionally, product is marked in indelible marker with details of the sales order and line item for easy cross-reference to the delivery documentation and for project activity; tape colour coding is used for identifying specific isometric drawing content.
- Pipe spools are finished with protective water resistant MDF end boards using BZP Roofing Bolts. PFA lined products are protected with a polyethylene end cap.

1.7 Product Certification

- Standard product certification comprises a certificate of compliance and test to EN10204 type 2.2, confirming that the products supplied meet the relevant specifications, that fluoropolymer meet the requirements of the FDA regulation reference 21 CFR 177.1550 and details of the product tests undergone.
- Project documentation – to customer specification. The following documentation can be supplied as evidence of quality control: Quality Plan, Product Drawings, Weld Procedures, Welder Qualifications, NDT Procedures, NDT Operator Qualification, Material Certification (2.2 or 3.1) and CRP Certificate of Conformance.

1.8 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.
- 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.

2 PTFE and PFA Specifications

Liner Type	Specification	Properties
Virgin PTFE Paste Extruded	ASTM D4895	Minimum Tensile Strength: 20.7 MPa Minimum Elongation at Break: 250% Specific Gravity: 2.14 – 2.18 (when tested to ASTM D792 or D1505)
Static Dissipating PTFE Paste Extruded	ASTM D4895	Minimum Tensile Strength: 20.7 MPa Minimum Elongation at Break: 250% Specific Gravity: 2.14 – 2.18 (when tested to ASTM D792 or D1505) Volume Resistivity: $<10^7 \Omega\cdot\text{cm}$
Virgin PFA	ASTM D3307	Minimum Tensile Strength: 26.2 MPa Minimum Elongation at Break: 300% Specific Gravity: 2.12 – 2.17 (when tested to ASTM D792 or D1505) Melt Flow Rate: 1-2.5g/10mins (when tested to ASTM D3307 at 372°C)
Static Dissipating PFA	ASTM D3307	Minimum Tensile Strength: 26.2 MPa Minimum Elongation at Break: 300% Specific Gravity: 2.12 – 2.17 (when tested to ASTM D792 or D1505) Melt Flow Rate: 1-2.5g/10mins (when tested to ASTM D3307 at 372°C) Volume Resistivity: $<10^7 \Omega\cdot\text{cm}$
Virgin PTFE Isostatically Moulded	ASTM D4894	Minimum Tensile Strength: 17.3 MPa Minimum Elongation at Break: 250% Specific Gravity: 2.14 – 2.18 (when tested to ASTM D792 or D1505)
Static Dissipating PTFE Isostatically Moulded	ASTM D4894	Minimum Tensile Strength: 17.3 MPa Minimum Elongation at Break: 250% Specific Gravity: 2.14 – 2.18 (when tested to ASTM D792 or D1505) Volume Resistivity: $<10^7 \Omega\cdot\text{cm}$

Note on Static Dissipating Liners

By the addition of a small amount of carbon to the PTFE/PFA, static dissipating versions of these polymers can be produced. While they have the same corrosion resistance as the virgin versions, their electrical resistance is dramatically reduced, making them ideal for handling non-conductive/statically charging liquids. For virgin PTFE/PFA, their volume resistivity is typically in the order of $>10^{18} \Omega\cdot\text{cm}$, whereas static dissipating PTFE/PFA have volume resistivity of $<10^7 \Omega\cdot\text{cm}$.

3 Pipe Spools

3.1 General

Feature	Specification
Nominal Bore:	½" – 12" inclusive
Minimum Length:	½" – 6": 100mm
	1" – 4" Van Stone: 250mm
	8" – 12": 180mm
Maximum Length:	½" – 6": 6000mm
	8" – 12": 3500mm
Flange Design:	ASME B16.5, Class 150 (others available on request)
Stub End Design:	ASME B16.5
Pipe Weight:	½" – 6": ASME B36.10 Schedule 40
	8" – 12": ASME B36.10 Schedule 30

3.2 Termination Options

- Van Stone flares at both ends with lapped flanges to provide rotating flanges at both ends. Only available 1" – 4" NB inclusive).
- Fixed slip on welding flanges at both ends, the flanges being oriented in any rotational position relative to each other.
- Welded on stub ends at both ends, retaining lapped flanges at both ends to give rotating flanges.
- A fixed flange at one end and a welded on stub end retaining a lapped flange to give a rotating flange at the other end.

The liner in all spools is an interference fit within the pipework, and is flared to the flange raised face diameter at both ends.

3.3 Materials of Construction

Feature	Specification
Liner:	Virgin PTFE (paste extruded). For 8" – 12" NB this can be supplied in either standard or heavy duty versions. Static dissipating PTFE (paste extruded) – 1" to 6" NB only.
Pipe:	API 5L Grade B or ASTM A106.
Stub End:	BS1501-161-430A.
Flange:	ASTM A105.

3.4 Operating Conditions

Attribute	Specification
Operating Temperature Range:	-29°C to +200°C
Minimum Operating Pressure:	½" – 6": Full vacuum
	8" – 12": See below

8" – 12" NB Minimum Operating Pressures

Spool NB	Liner	
	Standard Duty (bar(g))	Heavy Duty (bar(g))
8"	1	Full vacuum at all temperatures
10"	1	Full vacuum at temperatures up to 150 °C
12"	1	Full vacuum at temperatures up to 150 °C

Maximum Operating Pressures

These are limited by the pressure classification of the flanges used – for Class 150 flanges see table below.

Temperature (°C)	Pressure (bar(g))
-29 to +38	19.7
93	17.9
149	15.9
200	13.8

3.5 Dimensional Data

Spools are supplied in mm length increments. Pipe and liner thicknesses are as detailed below.

Spool NB	PTFE Thickness (mm)	Pipe Wall Thickness (mm)
1/2"	2.0	2.9
3/4"	2.0	2.9
1"	3.2	3.4
1.1/2"	3.2	3.7
2"	3.2	3.9
3"	3.3	5.5
4"	4.5	6.0
6"	5.5	7.1
8" Standard	5.0	7.0
8" Heavy	8.0	7.0
10" Standard	5.0	7.8
10" Heavy	9.0	7.8
12" Standard	6.0	8.4
12" Heavy	9.5	8.4

3.6 Stainless Steel

All spools of all nominal bores, lengths and termination variants, as detailed above, can be offered in 304/304L stainless steel as standard, with 316/316L as a further option. As standard, schedule 10 pipe is used, although heavier weights are available. In all cases the wall weight of PTFE is the same as for carbon steel spools.

3.6.1 Materials of Construction

Feature	Specification
Liner:	Virgin PTFE (paste extruded). For 8" – 12" NB this can be supplied in either standard or heavy duty versions. Static dissipating PTFE (paste extruded): 1" to 6" NB only.
Pipe:	ASTM A312 Grades: 304, 304L, 316, 316L
Stub End:	ASTM A240 Grades 304L, 316L
Flange:	ASTM A182 Grades: F304, F304L, F316, F316L

3.6.2 Operating Conditions

The temperature range and the minimum operating pressures are all identical to carbon steel lined spools.

Maximum Operating Pressures

These are limited by the pressure classification of the flanges used – for Class 150 flanges see table below.

Temperature (°C)	Pressure (bar(g))*
-29 to +38	19.0
93	15.9
149	14.1
200	13.1

* The pressures shown are for flanges made from ASTM A182 Grade F304. Apply to factory for allowable pressures for alternate grades of stainless steel, and alternate flange types.

4 Cast Fittings

4.1 Product Range

Product	Body Size →	1/2"	3/4"	1"	1.1/2"	2"	3"	4"	6"
Branch Size ↓									
90 Degree Elbow				✓	✓	✓	✓	✓	✓
90 Degree Elbow Rotating				✓	✓	✓	✓	✓	
90 Degree Elbow 5D				✓	✓	✓			
45 Degree Elbow				✓	✓	✓	✓	✓	✓
Equal Tee				✓	✓	✓	✓	✓	✓
Equal Tee Rotating Flanges				✓	✓	✓	✓	✓	
Reducing Tee	1"				✓	✓	✓	✓	✓
	1.1/2"					✓	✓	✓	✓
	2"						✓	✓	✓
	3"							✓	✓
	4"								✓
Reducing Tee Rotating Flanges	1"				✓	✓			
	1.1/2"					✓			
	2"						✓		
Short Stack Equal Tee				✓	✓	✓	✓		
Instrument Tee	1"			✓	✓	✓	✓	✓	✓
	1.1/2"				✓	✓	✓	✓	✓
	2"					✓	✓	✓	✓
Lateral Tee				✓	✓	✓			
Reducing Lateral Tee	1"					✓			
	1.1/2"						✓		
Concentric Reducer	1/2"			✓					
	1"				✓	✓	✓	✓	
	1.1/2"					✓	✓	✓	
	2"						✓	✓	✓
	3"							✓	✓
	4"								✓
	6"								
Eccentric Reducer	1"				✓	✓	✓		
	1.1/2"					✓	✓		
	2"						✓	✓	
	3"							✓	
Equal Cross				✓	✓	✓	✓		

4.2 General

- Design: ASME B16.5 Class 150 (except instrument tees, since not covered by standard).
- Instrument tees – in-house design, approved under Pressure Equipment Directive, and in line with relevant ASME standards.
- Terminations: All flanges are fixed, with off centre bolt holes, unless specified as rotating flanges, in which case all flanges are rotating (see table for details).

4.3 Materials of Construction

Feature	Specification
Liner:	Virgin PTFE (paste extruded). Virgin PFA. Static dissipating PTFE (paste extruded). Static dissipating PFA.
Housing Materials:	Cast Steel ASTM A216 Grade WCB

4.4 Operating Conditions

Attribute	Specification
Operating Temperature Range:	-29°C to +200°C
Operating Pressure Range:	See table below

Temperature (°C)	Pressure (bar(g))	
	Minimum	Maximum
-29 to +38	-1	19.7
93	-1	17.9
149	-1	15.9
200	-1	13.8

4.5 Dimensional Data

Fitting centreline to face and face to face dimensions are in accordance with those laid down in ASME B16.5 where relevant.

4.6 Stainless Steel

A range of cast 304 stainless steel fittings are available.

4.6.1 Product Range

Product	Body Size →	1/2"	3/4"	1"	1.1/2"	2"	3"	4"	6"
Branch Size ↓									
90 Degree Elbow		✓	✓	✓	✓	✓	✓	✓	
45 Degree Elbow				✓	✓	✓			
Equal Tee				✓	✓	✓	✓		
Reducing Tee	1"				✓	✓			
Instrument Tee	1"					✓			
Concentric Reducer	1"				✓	✓			
	1.1/2"					✓			

4.6.2 General

- Design: ASME B16.5 Class 150 (except instrument tees, since not covered by standard).
- Instrument tees – in-house design, approved under Pressure Equipment Directive, and in line with relevant ASME standards.
- Terminations: Fixed flanges fitted off centres.

4.6.3 Materials of Construction

Feature	Specification
Liner:	Static Dissipating PTFE (paste extruded) Virgin PFA. Static dissipating PFA.
Housing Materials:	Cast 304 Stainless Steel ASTM A351 Grade CF8

4.6.4 Operating Conditions

Attribute	Specification
Operating Temperature Range:	-29°C to +200°C
Operating Pressure Range:	See table below

Temperature (°C)	Pressure (bar(g))	
	Minimum	Maximum
-29 to +38	-1	19.0
93	-1	15.9
149	-1	14.1
200	-1	13.1

4.6.5 Dimensional Data

Fitting centreline to face and face to face dimensions are in accordance with those laid down in ASME B16.5 where relevant.

5 Fabricated Fittings

5.1 Product Range

Family	Sizes
Elbows – all angles up to 180°	½” – 12”
Tees – Equal and Reducing	½” – 12”
Lateral tees – Equal and Reducing	½” – 6”
Instrument Tees	½” – 12”
Short Stack Tees	1” – 6”
Reducing Flanges	½” – 12”
Reducers – Concentric and Eccentric	¾” – 12”
Crosses – Equal and Reducing	½” – 12”
Blank Flanges	½” – 12”

5.2 General

- Design: ASME B16.5 Class 150 (except instrument tees, since not covered by standard).
- Instrument tees – in-house design, approved under Pressure Equipment Directive, and in line with relevant ASME standards.

Feature	Specification
Flange Design:	ASME B16.5, Class 150 (others available on request)
Stub End Design:	ASME B16.5
Pipe Weight:	ASME B36.10 Schedule 40 up to and including 6”
	ASME B36.10 Schedule 30 - 8” to 12”
Wrought Fitting Design:	ASME B16.9

5.3 Termination Options

- Fixed slip on welding flanges in any rotational position (the standard is off centres).
- Welded on stub ends retaining lapped flanges to give rotating flanges, at one or more positions.

5.4 Materials of Construction

Feature	Specification
Liner:	Virgin PTFE (paste extruded and isostatically moulded) Virgin PFA Static dissipating PTFE (paste extruded and isostatically moulded) Static dissipating PFA
Pipe:	API 5L Grade B or ASTM A106.
Wrought Fittings:	ASTM A234 WPB.
Stub Ends:	BS1501-161-430A.
Flanges:	ASTM A105.
Carbon Steel Plate:	BS 1501-161-430A.

5.5 Operating Conditions

Attribute	Specification
Operating Temperature Range:	-29°C to +200°C
Minimum Operating Pressure:	1/2" – 6": Full vacuum
	8" – 12": See below

8" – 12" NB Minimum Operating Pressures

Spool NB	Temperature (°C)	Liner	
		Standard Duty (bar(g))	Heavy Duty (bar(g))
8"	20	-0.75	Full vacuum
	50	-0.65	Full vacuum
	100	-0.40	Full vacuum
	200	-0.15	-0.80
10"	20	-0.70	Full vacuum
	50	-0.50	Full vacuum
	100	-0.30	Full vacuum
	200	-0.20	-0.80
12"	20	-0.50	Full vacuum
	50	-0.25	Full vacuum
	100	-0.15	Full vacuum
	200	-0.05	-0.55

Maximum Operating Pressures

These are limited by the pressure classification of the flanges used – see table below.

Flange Class	Temperature (°C)	Flange Material	
		ASTM A105	BS1501-161-430A
ASME B16.5, Class 150	-29 to +38	19.7	18.3
	93	17.9	17.2
	149	15.9	15.9
	200	13.8	13.8

5.6 Dimensional Data

Fitting centreline to face and face to face dimensions are in accordance with those laid down in ASME B16.5 where relevant.

5.7 Stainless Steel

All fabricated fittings of all nominal bores, design, dimensions and termination variants, as detailed above, can be offered in 304/304L stainless steel as standard, with 316/316L as a further option. All metalwork and liner dimensions will be the same as for a carbon steel fitting of the same design.

5.7.1 Materials of Construction

Feature	Specification
Liner:	Virgin PTFE (paste extruded and isostatically moulded) Static dissipating PTFE (paste extruded and isostatically moulded) Virgin PFA Static dissipating PFA
Pipe:	ASTM A312 Grades: 304, 304L, 316, 316L
Wrought Fittings:	ASTM A403 Grades: 304L, 316L
Stub Ends:	ASTM A240 Grades 304L, 316L
Flanges:	ASTM A182 Grades: F304, F304L, F316, F316L
Stainless Plate:	ASTM A240 Grades 304L, 316L

5.7.2 Operating Conditions

The temperature range and the minimum operating pressures are all identical to carbon steel lined fittings.

Maximum Operating Pressures

These are limited by the pressure classification of the flanges used – for Class 150 flanges see table below.

Temperature (°C)	Pressure (bar(g))*
-29 to +38	19.0
93	15.9
149	14.1
200	13.1

* The pressures shown are for flanges made from ASTM A182 Grade F304. Apply to factory for allowable pressures for alternate grades of stainless steel, and alternate flange types.

6 Spacers

6.1 General

Feature	Specification
Nominal Bore:	1/2" – 12" inclusive
Outside Diameter	To suit ASME Class 150 Inside Bolt Circles
Minimum Length (Type 1):	1mm
Maximum Length (Type 1):	29mm
Minimum Length (Type 2):	30mm
Maximum Length (Type 2):	1/2" – 1 1/2" NB 69mm
	2" – 5" NB 79mm
	6" – 12" NB 89mm
Minimum Length (Type 3):	1/2" – 1 1/2" NB 70mm
	2" – 5" NB 80mm
	6" – 12" NB 90mm
Maximum Length (Type 3):	1/2" – 2" NB 109mm
	3" – 6" NB 159mm
	8" – 12" NB 249mm
To Suit Flange Type:	ASME B16.5, Class 150 (others available on request)
Type 3 Pipe Weight:	ASME B36.10 Schedule 40

N.B. Type 1 spacers can be offered in a tapered form to allow for minor changes in direction of pipework.

6.2 Materials of Construction

Feature	Specification
Type 1:	Virgin PTFE (isostatically moulded) Static dissipating PTFE (isostatically moulded)
Type 2 and 3 Liner:	Virgin PTFE (paste extruded) Static Dissipating PTFE (paste extruded and isostatically moulded)
Type 2 Body:	BS1501-161-430A.
Type 3 Pipe:	API 5L Grade B or ASTM A106.
Type 3 Stub End:	BS1501-161-430A.

6.3 Operating Conditions

Attribute	Specification
Operating Temperature Range:	-29°C to +200°C (N.B. Type 1 spacers will require specific review)
Minimum Operating Pressure:	Full vacuum
Maximum Operating Pressure:	See below for details

General Specification for CRP Lined Pipe & Fittings

Maximum Operating Pressures

These are limited by the pressure classification of the flanges of the adjoining components.

Flange Class	Temperature (°C)	Maximum Pressure (Bar (g))
ASME B16.5, Class 150	-29 to+38	19.7
	93	17.9
	149	15.9
	200	13.8

6.4 Dimensional Data

NB	Type 1	Type 2		Type 3	
	PTFE Thickness (mm)	PTFE Thickness (mm)	Steel Thickness (mm)	PTFE Thickness (mm)	Steel Thickness (mm)
1/2"	12.0	2.0	14.3	2.0	2.9
3/4"	17.0	2.0	16.5	2.0	2.9
1"	19.5	3.2	18.5	3.2	3.4
1.1/2"	22.5	3.2	20.5	3.2	3.7
2"	25.5	3.2	24.5	3.2	3.9
3"	28.5	3.3	28.0	3.3	5.5
4"	34.5	4.5	35.0	4.5	6.0
6"	33.5	5.5	32.5	5.5	7.1
8"	36.0	5.0	35.5	5.0	7.0
10"	41.0	5.0	39.5	5.0	7.8
12"	50.5	6.0	50.0	6.0	8.4

6.5 Stainless Steel – Type 2 and Type 3 Spacers

All type 2 and type 3 spacers of all nominal bores, and lengths, as detailed above, can be offered in 304/304L stainless steel as standard, with 316/316L as a further option. As standard, schedule 10 pipe is used for type 3 spacers, although heavier weights are available. In all cases the wall weight of PTFE is the same as for carbon steel spacers.

6.5.1 Materials of Construction

Feature	Specification
Liner:	Virgin PTFE (paste extruded). For 8" – 12" NB this can be supplied in either standard or heavy duty versions. Static dissipating PTFE (paste extruded and isostatically moulded)
Pipe:	ASTM A312 Grades: 304, 304L, 316, 316L
Stub End & Type 2 Body:	ASTM A240 Grades 304L, 316L

6.5.2 Operating Conditions

The temperature range and the minimum operating pressures are all identical to carbon steel lined spacers.

Maximum Operating Pressures

These are limited by the pressure classification of the flanges used – for Class 150 flanges see table below.

Temperature (°C)	Pressure (bar(g))*
-29 to +38	19.0
93	15.9
149	14.1
200	13.1

* The pressures shown are for spacers made from ASTM A182 Grade F304. Apply to factory for allowable pressures for alternate grades of stainless steel.