

**Table 20JF.E3.1A  
(Series 20JF, 20JF-C)  
Mechanical Specifications**

Temp (F)	Pipe Strengths (psi)					Pipe Moduli (psi)				
	Axial Tensile	Hoop Tensile	Axial Flex.	Hoop Flex.	Axial Comp.	Axial Tensile	Hoop Tensile	Axial Flex.	Hoop Flex.	Axial Comp.
<b>Ambient</b>	8,400	26,400	16,800	N/A	18,000	1,400,000	2,200,000	1,400,000	2,200,000	1,500,000
<b>150</b>	8,400	26,400	16,800	N/A	18,000	1,400,000	2,200,000	1,400,000	2,200,000	1,500,000
<b>175</b>	7,980	25,080	15,540	N/A	17,100	1,330,000	2,090,000	1,295,000	2,035,000	1,425,000
<b>200</b>	7,560	23,760	14,280	N/A	16,200	1,260,000	1,980,000	1,190,000	1,870,000	1,350,000
<b>225</b>										
<b>250</b>										

**ASTM D4024 / D5421 Flange Codes**

2" - 6" Flanges, 200psi	RTR-111D-445; CM-B4I
8" Flanges, 200psi	RTR-111D-446; CM-B4I
10" - 12" Flanges, 200psi	RTR-111D-447; CM-B4I
14" - 24" Flanges, 150psi	RTR-111C-337; CM-B4IF-66

All materials are contact molded (closest definition to filament wound in D4024), epoxy vinyl ester resin, integrally molded flange.  
The grade epoxy is interpreted to include epoxy vinyl esters.  
ASTM D5421 does not have ratings above 150psi.

**ASTM D2310 / D2996 Pipe Codes**

2" - 3" Pipe	RTRP-11FT1-1112
4" Pipe	RTRP-11FT1-1113
6" Pipe	RTRP-11FT1-1114
8" and larger Pipe	RTRP-11FT1-1116

All materials are filament wound, epoxy vinyl ester resin, reinforced liner, HDB of > 5,000psi for joints, > 10,000psi for pipe (axial loads included).  
Short term hoop strength > 10,000psi; long. tensile strength > 8,000psi;  
Long. tensile modulus > 1,000,000psi; stiffness factor varies with pipe size.  
The grade epoxy is interpreted to include epoxy vinyl esters.  
Replace 'T' with 'Q' for the HDB rating of joints.

**ASTM F1173 / ISO15840 Codes**

Type I, Resin 2, Class B, Rating Method 1 and 4  
Fire Endurance: Fluid S, Fire Type IF, Integrity B, Duration 30

**ASTM F1173 / ISO15840 Codes (continued)**

Fire Endurance: Fluid EF, Fire Type JF, Integrity C, Duration 25  
Fire Endurance: Fluid EF, Fire Type IF, Integrity B, Duration 30

**Other Properties**

Density (lb/cu in.)	0.06
Shear Modulus (psi)	1,000,000
Thermal Expansion Coefficient (in./in./F)	0.00001
Thermal Conductivity (BTU-in./ft <sup>2</sup> -hr-F)	1.3
Minor Poisson's Ratio, $\nu_{min} = \nu_{ha}$	0.55
Major Poisson's Ratio, $E_a/E_h \cdot \nu_{ha} = \nu_{ah}$	0.35
Hazen Williams Coefficient	150
Specific Roughness (in.)	0.0002

**ASTM D5685 Fittings Codes**

2" - 12" Fittings, 200psi	RTRF 54K4E
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Contact molded fittings, epoxy vinyl ester resin, reinforced liner,  
butt & strap joint, 200psig rating

14" - 24" Fittings, 150psi	RTRF 54K4D
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butt & strap joint, 150psig rating

Notes:  
1. Axial flexural is also termed bending; hoop flexural is also termed circumferential.  
2. Blank areas are Not Recommended.

**Table 20JF.E3M.1A (Metric)  
(Series 20JF, 20JF-C)  
Mechanical Specifications**

Temp (C)	Pipe Strengths (MPa)					Pipe Moduli (GPa)				
	Axial Tensile	Hoop Tensile	Axial Flex.	Hoop Flex.	Axial Comp.	Axial Tensile	Hoop Tensile	Axial Flex.	Hoop Flex.	Axial Comp.
<b>Ambient</b>	57.9	182.0	115.8	N/A	124.1	9.7	15.2	9.7	15.2	10.3
<b>65.6</b>	57.9	182.0	115.8	N/A	124.1	9.7	15.2	9.7	15.2	10.3
<b>79.4</b>	55.0	172.9	107.1	N/A	117.9	9.2	14.4	8.9	14.0	9.8
<b>93.3</b>	52.1	163.8	98.5	N/A	111.7	8.7	13.7	8.2	12.9	9.3
<b>107.2</b>										
<b>121.1</b>										

**ASTM D4024 / D5421 Flange Codes**

2" - 6" Flanges, 200psi	RTR-111D-445; CM-B4I
8" Flanges, 200psi	RTR-111D-446; CM-B4I
10" - 12" Flanges, 200psi	RTR-111D-447; CM-B4I
14" - 24" Flanges, 150psi	RTR-111C-337; CM-B4IF-66

All materials are contact molded (closest definition to filament wound in D4024), epoxy vinyl ester resin, integrally molded flange.  
The grade epoxy is interpreted to include epoxy vinyl esters.  
ASTM D5421 does not have ratings above 150psi.

**ASTM D2310 / D2996 Pipe Codes**

2" - 3" Pipe	RTRP-11FT1-1112
4" Pipe	RTRP-11FT1-1113
6" Pipe	RTRP-11FT1-1114
8" and larger Pipe	RTRP-11FT1-1116

All materials are filament wound, epoxy vinyl ester resin, reinforced liner, HDB of > 5,000psi for joints, > 10,000psi for pipe (axial loads included).  
Short term hoop strength > 10,000psi; long. tensile strength > 8,000psi;  
Long. tensile modulus > 1,000,000psi; stiffness factor varies with pipe size.  
The grade epoxy is interpreted to include epoxy vinyl esters.  
Replace 'T' with 'Q' for the HDB rating of joints.

**ASTM F1173 / ISO15840 Codes**

Type I, Resin 2, Class B, Rating Method 1 and 4  
Fire Endurance: Fluid S, Fire Type IF, Integrity B, Duration 30

**ASTM F1173 / ISO15840 Codes (continued)**

Fire Endurance: Fluid EF, Fire Type JF, Integrity C, Duration 25  
Fire Endurance: Fluid EF, Fire Type IF, Integrity B, Duration 30

**Other Properties**

Density (g/cu cm)	1.7
Shear Modulus (GPa)	6.9
Thermal Expansion Coefficient (mm/mm/C)	0.000018
Thermal Conductivity (W-cm/cm^2-C)	0.0019
Minor Poisson's Ratio, $\nu_{min} = \nu_{ha}$	0.55
Major Poisson's Ratio, $E_a/E_h \cdot \nu_{ha} = \nu_{ah}$	0.35
Hazen Williams Coefficient	150
Specific Roughness (cm)	0.0005

**ASTM D5685 Fittings Codes**

2" - 12" Fittings, 200psi	RTRF 54K4E
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Contact molded fittings, epoxy vinyl ester resin, reinforced liner, butt & strap joint, 200psig rating

14" - 24" Fittings, 150psi	RTRF 54K4D
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butt & strap joint, 150psig rating

Notes:  
1. Axial flexural is also termed bending; hoop flexural is also termed circumferential.  
2. Blank areas are Not Recommended.

**Table 20JF.E3.5A  
(Series 20JF, 20JF-C)  
Stress Analysis Data (page 1 of 3)**

**Material Properties**

$C_t$	0.000010 in./in./F	0.000018 mm/mm/C
$E_a = E_x$	1,400,000 psi	9.7 GPa
$\nu_{min} = \nu_{ha}$	0.55	0.55
$E_h$	2,200,000 psi	15.2 GPa
rho	0.060 lb/in. <sup>3</sup>	1.7 g/cm <sup>3</sup>
$E_a/E_h * \nu_{ha} = \nu_{ah}$	0.35	0.35
Shear-Axial Modulus Ratio	0.71	0.71

**Pipe Dimensions**

Nominal Size		Pipe - tr		Bends - tnom	
(in.)	(mm)	(in.)	(mm)	(in.)	(mm)
1	25	0.53"	13.5mm	0.56"	14.3mm
1.5	40	0.53"	13.5mm	0.56"	14.3mm
2	50	0.53"	13.5mm	0.56"	14.3mm
3	80	0.53"	13.5mm	0.56"	14.3mm
4	100	0.53"	13.5mm	0.56"	14.3mm
6	150	0.53"	13.5mm	0.56"	14.3mm
8	200	0.53"	13.5mm	0.63"	16.0mm
10	250	0.59"	15.0mm	0.69"	17.5mm
12	300	0.65"	16.5mm	0.81"	20.6mm
14	350	0.77"	19.6mm	0.88"	22.4mm
16	400	0.83"	21.1mm	1.00"	25.4mm
18	450				
20	500				
24	600				

Nominal Size		Flange B.C.	
(in.)	(mm)	(in.)	(mm)
1	25	3.13"	79.4mm
1.5	40	3.88"	98.4mm
2	50	4.75"	120.7mm
3	80	6.00"	152.4mm
4	100	7.50"	190.5mm
6	150	9.50"	241.3mm
8	200	11.75"	298.5mm
10	250	14.25"	362.0mm
12	300	17.00"	431.8mm
14	350	18.75"	476.3mm
16	400	21.25"	539.8mm
18	450	22.75"	577.9mm
20	500	25.00"	635.0mm
24	600	29.50"	749.3mm

**Table 20JF.E3.5B  
(Series 20JF, 20JF-C)  
Stress Analysis Data (page 2 of 3)**

**UKOOA Data**

SH, $f_1$ *LTHS	10,000 psi	69.0 MPa
R, Sa(0:1) / Sa(2:1)	0.64	0.64
$f_2$ - sustained	0.67	0.67
$f_2$ - thermal	0.83	0.83
$f_2$ - occasional	0.89	0.89
Elbows	Type 2 (CSM & Woven Roving)	
K	Mean temperature change multiplier, 0.85 for liquids, 0.8 for gases, 1.0 for amb. temp changes.	

**BS7159 Data**

SH, $\epsilon_d$ * $E_a$	2,520 psi	17.4 MPa
	(based on 0.0018 design strain)	
$E_h/E_a$	1.57	1.57
K	Mean temperature change multiplier, 0.85 for liquids, 0.8 for gases, 1.0 for amb. temp changes.	
Kn	Fatigue factor, 1.0 for static applications	

**ISO14692 Data**

al(0:1)	3,196 psi	22.0 MPa
al(2:1)	5,022 psi	34.6 MPa
hl(2:1)	10,043 psi	69.2 MPa
Qs-bends	5,037 psi	34.7 MPa
r-bends	1.9	1.9
Eh/Ea-bends	1.0	1.0
Qs-joints	4,478 psi	30.9 MPa
r-joints	2.0	2.0
$A_1$	1.0 up to 185F	1.0 up to 85c
20yr design life	1.0	1.0
System design factor	0.67-sustained, 0.83-thermal, 0.89-occasional	
Thermal factor, k	Same as UKOOA	

**B31.3 Data**

SC	5,000 psi	34.5 MPa
SH (up to 185F, 85c)	5,000 psi	34.5 MPa
Fn (up to 7000 cycles)	1.00	1.00
Eff	1.00	1.00
Sy	5,000 psi	34.5 MPa

**Table 20JF.E3.5C**  
**(Series 20JF, 20JF-C)**  
**Stress Analysis Data (page 3 of 3)**

Caution should be used when selecting ISO14692 as a design code in some software. The inability to adjust the biaxial stress ratio for tees and the inability to select Type 2 laminate construction for elbows may have an effect on the results. UKOOA as a design code is a better selection even though this code does not offer the ability to adjust  $f_2$  for the various loading cases.

Caution should be used when selecting ASME B31.3 as a design code. While A302.3.2(c) specifies an HDBS per ASTM D2992, using the HDBS as an allowable stress (with a service factor of 0.5) will generally be too high (5,000 psi) for most applications. For sustained conditions, an allowable stress of 2,750 psi is recommended. For secondary stresses (e.g. thermal loads), an allowable stress of 3,000 psi is recommended. For hydrotest and other occasional loads, an allowable stress of 3,400 psi is recommended.

Note: the above recommendations are based on loading cases at or near the design pressure of the product. The "design envelope" of FRP is a trapezoidal shape (whereas alloys and other isotropic materials are rectangular in shape). This trapezoidal shape means that the allowable longitudinal stress will increase as the pressure (and consequently the hoop stress) is increased. As an example, the recommended allowable stress for occasional loads is 3,400 psi. This would be a suitable stress for the hydrotest loading case. However, if one were to evaluate an occasional load case without any internal pressure (e.g. an offshore platform being transported), the recommended allowable would drop to about 2,900 psi. Of course, while the allowable has dropped from 3,400 to 2,900 psi, there is no longitudinal stress due to internal pressure in the latter case.

Allowable stresses are based on a 20 year design life. For 25 years, multiply the allowables by 0.986. For 30 years, 0.974. For 50 years, 0.942.

**Table 20JF.E3.4A  
(20JF, 20JF-C)**

**ISO 14692 Part 3 - Annex D Calculations**

Stress Intensification Factors (SIFs), Flexibility Factors (Kappa), Pressure Stress Multipliers (PSMs)  
(BS7159, Type 2 Laminate, 0.0012 design strain)

Size  (in.)	Series 20JF, 20JF-C						
	Flexibility Factor	Elbows			Tees		
		Axial bending SIF		Hoop bending SIF		SIF	PSM
	In-plane	Out-of-plane	In-plane	Out-of-plane			
2	1.3	1.1	1.2	1.9	1.7	1.1	1.0
3	1.9	1.5	1.6	2.5	2.2	1.3	1.0
4	2.5	1.7	1.8	2.5	2.5	1.5	1.0
6	2.9	1.9	2.1	2.5	2.5	1.7	1.0
8	2.8	1.9	2.0	2.5	2.5	1.7	1.0
10	3.0	2.0	2.1	2.5	2.5	1.8	1.0
12	2.9	1.9	2.1	2.5	2.5	1.7	1.0
14	3.0	2.2	2.4	2.5	2.5	2.0	1.0
16	3.0	2.1	2.3	2.5	2.5	1.9	1.0
18	3.0	2.3	2.4	2.5	2.5	2.0	1.0
20	3.0	2.3	2.4	2.5	2.5	2.1	1.0
24	3.0	2.3	2.5	2.5	2.5	2.1	1.0
30	3.0	2.5	2.5	2.5	2.5	2.3	1.0
36	3.0	2.5	2.5	2.5	2.5	2.3	1.0
42	3.0	2.5	2.5	2.5	2.5	2.3	1.0
48	3.0	2.5	2.5	2.5	2.5	2.3	1.0

Note: Tees that are qualified according to ISO14692 have a PSM of 1.0. Tees that are not qualified will typically have PSMs ranging from 1.8 to 3.0. Reducing tees will have slightly different SIFs than tees; however, it is acceptable to use the same values as the same-size tees. e.g., a 6"x2" reducing tee or olet would have the same SIF as a 6" tee.

**Table 20JF.E3.6A  
(Series 20JF, 20JF-C)  
Flange Thickness and Weight**

Nominal Size	Flange			Flange Pair	
	thk	Weight		thk	Weight
		w/out bolts	w/ bolts		
	(in.)	(lbs)	(lbs)	(in.)	(lbs)
1	0.50	0.6	1.2	1.00	1.8
1.5	0.50	0.7	1.3	1.00	2.0
2	0.69	1.0	2.3	1.38	3.3
3	0.81	1.8	3.1	1.63	5.0
4	1.00	3.1	6.1	2.00	9.2
6	1.19	4.8	9.6	2.38	14.4
8	1.38	7.7	13.0	2.75	20.7
10	1.63	11.9	24.5	3.25	36.4
12	1.88	19.2	32.8	3.75	51.9
14	1.94	21.7	40.2	3.88	61.9
16	2.13	28.9	55.3	4.25	84.1
18					
20					
24					

DN	Flange			Flange Pair	
	thk	Mass		thk	Mass
		w/out bolts	w/ bolts		
	(mm)	(kg)	(kg)	(mm)	(kg)
25	12.7	0.3	0.6	25.4	0.8
40	12.7	0.3	0.6	25.4	0.9
50	17.5	0.5	1.0	34.9	1.5
80	20.6	0.8	1.4	41.3	2.2
100	25.4	1.4	2.8	50.8	4.2
150	30.2	2.2	4.4	60.3	6.5
200	34.9	3.5	5.9	69.9	9.4
250	41.3	5.4	11.1	82.6	16.5
300	47.6	8.7	14.9	95.3	23.6
350	49.2	9.9	18.2	98.4	28.1
400	54.0	13.1	25.1	108.0	38.2
450					
500					
600					

**Table 20JF.E3.7A  
(20JF, 20JF-C)  
Recommended Allowables (in psi)**

Nominal Size	D / t	Sustained (f2 = 0.67)		Sustained (f2 = 0.67)		Sustained+Thermal (f2 = 0.83)		Occasional (f2 = 0.89)	
		P = 200 psig		P = 150 psig		P = 200 psig		P = 200 psig	
		Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)
1	1.89	289	2194	217	2181	289	2705	289	2897
1.5	2.83	383	2211	287	2194	383	2722	383	2914
2	3.77	477	2228	358	2206	477	2739	477	2931
3	5.66	666	2262	500	2232	666	2774	666	2966
4	7.55	855	2297	641	2258	855	2808	855	3000
6	11.32	1232	2365	924	2309	1232	2877	1232	3068
8	15.09	1609	2434	1207	2361	1609	2945	1609	3137
10	16.95	1795	2468	1346	2386	1795	2979	1795	3171
12	18.46	1946	2495	1460	2407	1946	3006	1946	3198
14	18.51	1951	2496	1463	2407	1951	3007	1951	3199
16	19.58	2058	2515	1543	2422	2058	3027	2058	3218

$$\sigma_{a,sum} \leq f_2 * \sigma_{al(0:1)} + \frac{\sigma_{h,sum}}{\sigma_{qs}} * \left( \frac{\sigma_{qs}}{2} - \sigma_{al(0:1)} \right)$$

$$\sigma_{al(0:1)} = r * \frac{\sigma_{qs}}{2}$$

$$\sigma_{h,sum} = \frac{PD}{2t}$$