

**Table 20FR20.E3.1A  
(Series 20FR20, 20FR20-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, 290psi	RTR-111F-665; CM-B4I
8" Flanges, 290psi	RTR-111F-666; CM-B4I
10" - 12" Flanges, 290psi	RTR-111F-667; CM-B4I
All materials are bi-axially laminated (closest definition to filament wound in D4024), epoxy vinyl ester resin, integrally molded flange.	
The D4024 codes are the closest codes to the 290psi ratings.	
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 D5685 Fittings Codes**

2" - 12" Fittings, 290psi	RTRF 54K4G
Contact molded fittings, epoxy vinyl ester resin, reinforced liner, butt & strap joint, 300psig rating (closest to 290psi)	

**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

Notes:

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

**Table 20FR20.E3M.1A (Metric)  
(Series 20FR20, 20FR20-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, 290psi	RTR-111F-665; CM-B4I
8" Flanges, 290psi	RTR-111F-666; CM-B4I
10" - 12" Flanges, 290psi	RTR-111F-667; CM-B4I
All materials are bi-axially laminated (closest definition to filament wound in D4024), epoxy vinyl ester resin, integrally molded flange.	
The D4024 codes are the closest codes to the 232psi ratings.	
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 D5685 Fittings Codes**

2" - 12" Fittings, 290psi	RTRF 54K4G
Contact molded fittings, epoxy vinyl ester resin, reinforced liner, butt & strap joint, 300psig rating (closest to 290psi)	

**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, $E_a/E_h * \nu_{ha} = \nu_{ah}$	0.35
Hazen Williams Coefficient	150
Specific Roughness (cm)	0.0005

Notes:

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

**Table 20FR20.E3.5A  
(Series 20FR20, 20FR20-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	0.25"	6.4mm	0.25"	6.4mm
1.5	40	0.25"	6.4mm	0.25"	6.4mm
2	50	0.28"	7.1mm	0.28"	7.1mm
3	80	0.25"	6.4mm	0.25"	6.4mm
4	100	0.25"	6.4mm	0.25"	6.4mm
6	150	0.30"	7.6mm	0.33"	8.4mm
8	200	0.39"	9.9mm	0.43"	10.9mm
10	250	0.48"	12.2mm	0.53"	13.5mm
12	300	0.58"	14.7mm	0.63"	16.0mm
14	350	0.61"	15.5mm	0.67"	17.0mm
16	400	0.69"	17.5mm	0.76"	19.3mm
18	450	0.78"	19.8mm	0.85"	21.6mm
20	500				
24	600				

Nominal Size	
(in.)	(mm)
1	25
1.5	40
2	50
3	80
4	100
6	150
8	200
10	250
12	300
14	350
16	400
18	450
20	500
24	600

Flange B.C.	
(in.)	(mm)
3.13"	79.4mm
3.88"	98.4mm
4.75"	120.7mm
6.00"	152.4mm
7.50"	190.5mm
9.50"	241.3mm
11.75"	298.5mm
14.25"	362.0mm
17.00"	431.8mm
18.75"	476.3mm
21.25"	539.8mm
22.75"	577.9mm

**Table 20FR20.E3.5B  
(Series 20FR20, 20FR20-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	

**ISO14692:2002 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*	9,570 psi	66.0 MPa
r-bends*	1.0	1.0
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	

\* Values account for hoop SIFs applied in stress analysis.

**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 20FR20.E3.5C**  
**(Series 20FR20, 20FR20-C)**  
**Stress Analysis Data (page 3 of 3)**

Caution should be used when selecting ISO14692 as a design code in some software. The Qs values for tees, if defaulted to an r value of 1.0, will incorrectly calculate a low allowable longitudinal stress for bi-axially reinforced tees.

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 20FR20.E3.4A  
(20FR20, 20FR20-C)**

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

Stress Intensification Factors (SIFs), Flexibility Factors (Kappa), Pressure Stress Multipliers (PSMs)  
(BS7159, Type 2 Laminate, 0.0015 design strain)

Size  (in.)	Series 20FR20, 20FR20-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	1.3	1.0
3	1.9	1.4	1.5	2.5	2.2	1.6	1.0
4	2.5	1.7	1.8	2.5	2.5	1.6	1.0
6	2.7	1.8	2.0	2.5	2.5	1.6	1.0
8	2.8	1.8	2.0	2.5	2.5	1.6	1.0
10	2.8	1.9	2.0	2.5	2.5	1.6	1.0
12	2.9	1.9	2.0	2.5	2.5	1.6	1.0
14	3.0	2.0	2.1	2.5	2.5	1.7	1.0
16	3.0	2.0	2.1	2.5	2.5	1.7	1.0
18	3.0	2.0	2.1	2.5	2.5	1.7	1.0
20	3.0	2.1	2.3	2.5	2.5	1.8	1.0
24	3.0	2.1	2.3	2.5	2.5	1.8	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 20FR20.E3.6A  
(Series 20FR20, 20FR20-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	0.58	0.8	1.4	1.16	2.2
2	0.71	1.1	2.3	1.42	3.4
3	0.86	1.9	3.2	1.72	5.2
4	1.13	3.5	6.7	2.26	10.1
6	1.32	5.3	10.4	2.64	15.7
8	1.50	8.4	14.0	3.00	22.4
10	1.87	13.7	26.8	3.74	40.6
12	2.16	22.1	36.7	4.32	58.8
14	2.13	23.9	43.7	4.26	67.6
16	2.46	33.4	61.7	4.92	95.1
18	2.44	33.6	70.5	4.88	104.0
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	14.7	0.3	0.7	29.5	1.0
50	18.0	0.5	1.1	36.1	1.5
80	21.8	0.9	1.5	43.7	2.3
100	28.7	1.6	3.0	57.4	4.6
150	33.5	2.4	4.7	67.1	7.1
200	38.1	3.8	6.4	76.2	10.1
250	47.5	6.2	12.2	95.0	18.4
300	54.9	10.0	16.7	109.7	26.7
350	54.1	10.8	19.8	108.2	30.7
400	62.5	15.2	28.0	125.0	43.2
450	62.0	15.2	32.0	124.0	47.2
500					
600					

**Table 20FR20.E3.7A  
(Series 20FR20, 20FR20-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 = 290 psig		P = 261 psig		P = 290 psig		P = 290 psig	
		Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)
1	4.00	725	2273	653	2260	725	2784	725	2976
1.5	6.00	1015	2326	914	2307	1015	2837	1015	3029
2	7.14	1181	2356	1063	2334	1181	2867	1181	3059
3	12.00	1885	2484	1697	2450	1885	2995	1885	3187
4	16.00	2465	2589	2219	2545	2465	3101	2465	3292
6	20.00	3045	2695	2741	2639	3045	3206	3045	3398
8	20.51	3119	2708	2807	2652	3119	3220	3119	3411
10	20.83	3166	2717	2849	2659	3166	3228	3166	3420
12	20.69	3145	2713	2831	2656	3145	3224	3145	3416
14	23.36	3532	2783	3179	2719	3532	3295	3532	3486
16	23.55	3560	2788	3204	2724	3560	3300	3560	3492
18	23.40	3538	2784	3184	2720	3538	3296	3538	3487
20									
24									

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

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

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