

**Table 20FR16.E3.1A  
(Series 20FR16, 20FR16-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, 232psi	RTR-111D-445; CM-B4I
8" Flanges, 232psi	RTR-111D-446; CM-B4I
10" - 12" Flanges, 232psi	RTR-111D-447; 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, 232psi	RTRF 52E4E
Contact molded fittings, epoxy vinyl ester resin, reinforced liner, butt & strap joint, 200psig rating (closest to 232psi)	

**Other Properties**

Density (lb/cu in.)	0.06
Shear Modulus (psi)	1,400,000
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, $E_a/E_h * \nu_{ha} = \nu_{ah}$	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 20FR16.E3M.1A (Metric)  
(Series 20FR16, 20FR16-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, 232psi	RTR-111D-445; CM-B4I
8" Flanges, 232psi	RTR-111D-446; CM-B4I
10" - 12" Flanges, 232psi	RTR-111D-447; 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
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**Other Properties**

Density (g/cu cm)	1.7
Shear Modulus (GPa)	9.7
Thermal Expansion Coefficient (mm/mm/C)	0.000018
Thermal Conductivity (W-cm/cm^2-C)	0.0019
Minor Poisson's Ratio, $\nu_{ha}$	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, 232psi	RTRF 52E4E
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Contact molded fittings, epoxy vinyl ester resin, reinforced liner, butt & strap joint, 200psig rating (closest to 232psi)

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

**Table 20FR16.E3.5A  
(Series 20FR16, 20FR16-C)  
Stress Analysis Data**

**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

**UKOOA Data**

SH, $f_1 * LTHS$	10,000 psi	68.95 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
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	17.38 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)	2,722 psi	18.8 MPa
al(2:1)	4,278 psi	29.5 MPa
hl(2:1)	8,556 psi	59.0 MPa
Qs-bends	4,850 psi	33.4 MPa
r-bends	1.9	1.9
Eh/Ea-bends	1.0	1.0
Qs-joints	4,104 psi	28.3 MPa
r-joints	2.0	2.0
A1	1.0 up to 150F	1.0 up to 65c
System design factor	0.67-sustained, 0.83-thermal, 0.89-occasional	
Thermal factor, k	Same as UKOOA	

D	tr,min
1	0.25"
1.5	0.25"
2	0.25"
3	0.25"
4	0.25"
6	0.25"
8	0.32"
10	0.39"
12	0.46"
14	0.54"
16	0.62"
18	0.69"
20	0.76"
24	0.91"

D	tr,min
25	6.4mm
40	6.4mm
50	6.4mm
80	6.4mm
100	6.4mm
150	6.4mm
200	8.1mm
250	9.9mm
300	11.7mm
350	13.7mm
400	15.7mm
450	17.5mm
500	19.3mm
600	23.1mm

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 may be a better selection even though this code does not offer the ability to adjust  $f_2$  for the various loading cases.

**Table 20FR16.E3.4A  
(20FR16, 20FR16-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 20FR16, 20FR16-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	1.8	1.0
6	3.0	2.0	2.2	2.5	2.5	1.8	1.0
8	3.0	2.1	2.2	2.5	2.5	1.8	1.0
10	3.0	2.1	2.2	2.5	2.5	1.8	1.0
12	3.0	2.1	2.2	2.5	2.5	1.8	1.0
14	3.0	2.1	2.2	2.5	2.5	1.8	1.0
16	3.0	2.1	2.2	2.5	2.5	1.8	1.0
18	3.0	2.1	2.3	2.5	2.5	1.8	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 outlet would have the same SIF as a 6" tee.