

**Table 110FW.E3.1A
(Series 110FW)
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.
Ambient	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
150	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
175	8,190	25,740	16,380	N/A	17,550	1,365,000	2,145,000	1,365,000	2,145,000	1,462,500
200	7,980	25,080	15,960	N/A	17,100	1,330,000	2,090,000	1,330,000	2,090,000	1,425,000
225	7,770	24,420	15,540	N/A	16,650	1,295,000	2,035,000	1,295,000	2,035,000	1,387,500
250	7,560	23,760	15,120	N/A	16,200	1,260,000	1,980,000	1,260,000	1,980,000	1,350,000

ASTM D4024 / D5421 Flange Codes

2" - 6" Flanges, 150psi	RTR-111C-334; CM-B4IF-66
8" Flanges, 150psi	RTR-111C-335; CM-B4IF-66
10" - 12" Flanges, 150psi	RTR-111C-336; CM-B4IF-66
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 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

ASTM D5685 Fittings Codes

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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 ² -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

ASTM D5685 Fittings Codes

2" - 24" Fittings, 150psi	RTRF 54K4D
Contact molded fittings, epoxy vinyl ester resin, reinforced liner, 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 110FW.E3M.1A (Metric)
(Series 110FW)
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.
Ambient	57.9	182.0	115.8	N/A	124.1	9.7	15.2	9.7	15.2	10.3
65.6	57.9	182.0	115.8	N/A	124.1	9.7	15.2	9.7	15.2	10.3
79.4	56.5	177.5	112.9	N/A	121.0	9.4	14.8	9.4	14.8	10.1
93.3	55.0	172.9	110.0	N/A	117.9	9.2	14.4	9.2	14.4	9.8
107.2	53.6	168.4	107.1	N/A	114.8	8.9	14.0	8.9	14.0	9.6
121.1	52.1	163.8	104.3	N/A	111.7	8.7	13.7	8.7	13.7	9.3

ASTM D4024 / D5421 Flange Codes

2" - 6" Flanges, 150psi	RTR-111C-334; CM-B4IF-66
8" Flanges, 150psi	RTR-111C-335; CM-B4IF-66
10" - 12" Flanges, 150psi	RTR-111C-336; CM-B4IF-66
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 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

ASTM D5685 Fittings Codes

2" - 24" Fittings, 150psi	RTRF 54K4D
Contact molded fittings, epoxy vinyl ester resin, reinforced liner, butt & strap joint, 150psig rating	

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, ν_{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

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

**Table 110FW.E3.5A
(Series 110FW)
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
ρ	0.060 lb/in. ³	1.7 g/cm ³
$E_a/E_h * \nu_{ha} = \nu_{ah}$	0.35	0.35
Shear-Axial Modulus Ratio	0.714	0.714

BS7159 Data

SH, $\epsilon_d * E_a$	2,520 psi (based on 0.0018 design strain)	17.4 MPa
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	

B31.3 Data

SC	5,000 psi	34.5 MPa
SH (up to 250F, 121c)	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

D	Pipe		Bends / tees	Flg. B.C.
	tr,min	tr,min		
1	0.24"	0.25"		3.13"
1.5	0.24"	0.25"		3.88"
2	0.24"	0.25"		4.75"
3	0.24"	0.25"		6.00"
4	0.24"	0.31"		7.50"
6	0.30"	0.38"		9.50"
8	0.36"	0.44"		11.75"
10	0.42"	0.50"		14.25"
12	0.48"	0.56"		17.00"
14	0.53"	0.63"		18.75"
16	0.59"	0.69"		21.25"
18	0.65"	0.75"		22.75"
20	0.71"	0.88"		25.00"
24	0.83"	1.00"		29.50"

D	Pipe		Bends / tees	Flg. B.C.
	tr,min	tr,min		
25	6.1mm	6.4mm		79mm
40	6.1mm	6.4mm		98mm
50	6.1mm	6.4mm		121mm
80	6.1mm	6.4mm		152mm
100	6.1mm	7.9mm		191mm
150	7.6mm	9.7mm		241mm
200	9.1mm	11.2mm		298mm
250	10.7mm	12.7mm		362mm
300	12.2mm	14.2mm		432mm
350	13.5mm	16.0mm		476mm
400	15.0mm	17.5mm		540mm
450	16.5mm	19.1mm		578mm
500	18.0mm	22.4mm		635mm
600	21.1mm	25.4mm		749mm

**Table 110FW.E3.4A
(110FW)**

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 110FW, 110FW-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	2.0	1.5	1.6	2.5	2.3	1.5	1.0
6	2.5	1.7	1.8	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	3.0	2.0	2.2	2.5	2.5	1.7	1.0
14	3.0	2.1	2.2	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	2.2	2.3	2.5	2.5	2.0	1.0
20	3.0	2.1	2.3	2.5	2.5	2.1	1.0
24	3.0	2.2	2.3	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 110FW.E3.6A
(110FW)
Flange Thickness and Weight**

Nominal Size	Flange			Flange Pair	
	thk (in.)	Weight		thk (in.)	Weight (lbs)
		w/out bolts	w/ bolts		
		(lbs)	(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	1.62	4.9
4	0.94	2.9	5.7	1.88	8.6
6	1.19	4.8	9.6	2.38	14.4
8	1.25	7.0	12.1	2.50	19.1
10	1.44	10.6	22.1	2.88	32.7
12	1.75	17.9	31.0	3.50	48.9
14	1.75	19.6	37.4	3.50	57.0
16	1.94	26.3	50.9	3.88	77.3
18	2.00	27.5	61.0	4.00	88.5
20	2.13	34.7	78.0	4.26	112.7
24	2.38	48.9	107.6	4.76	156.5

DN	Flange			Flange Pair	
	thk (mm)	Mass		thk (mm)	Mass (kg)
		w/out bolts	w/ bolts		
		(kg)	(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	35.1	1.5
80	20.6	0.8	1.4	41.1	2.2
100	23.9	1.3	2.6	47.8	3.9
150	30.2	2.2	4.4	60.5	6.5
200	31.8	3.2	5.5	63.5	8.7
250	36.6	4.8	10.0	73.2	14.8
300	44.5	8.1	14.1	88.9	22.2
350	44.5	8.9	17.0	88.9	25.9
400	49.3	12.0	23.1	98.6	35.1
450	50.8	12.5	27.7	101.6	40.2
500	54.1	15.8	35.4	108.2	51.2
600	60.5	22.2	48.9	120.9	71.1

**Table 110FW.E3.7A
(110FW)
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 = 150 psig		P = 200 psig		P = 200 psig		P = 200 psig	
		Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)
1	4.17	388	1894	517	1918	517	2353	517	2517
1.5	6.25	544	1923	725	1956	725	2391	725	2554
2	8.33	700	1951	933	1993	933	2429	933	2592
3	12.50	1013	2008	1350	2069	1350	2505	1350	2668
4	16.67	1325	2065	1767	2145	1767	2581	1767	2744
6	20.00	1575	2110	2100	2206	2100	2641	2100	2804
8	22.22	1742	2140	2322	2246	2322	2682	2322	2845
10	23.81	1861	2162	2481	2275	2481	2710	2481	2874
12	25.00	1950	2178	2600	2297	2600	2732	2600	2895
14	26.89	2092	2204	2789	2331	2789	2766	2789	2930
16	27.54	2141	2213	2854	2343	2854	2778	2854	2942
18	28.08	2181	2220	2908	2353	2908	2788	2908	2951
20	28.52	2214	2226	2952	2361	2952	2796	2952	2959
24	29.22	2266	2236	3022	2373	3022	2809	3022	2972

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

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

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