Rev F, Jun-12-2015

Table 20HV.E3.1A
(Series 20HV, 20HV-C, 20HV(FDA), 20HV(FDA)-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.
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	6,300	19,800	12,600	N/A	13,500	1,050,000	1,650,000	1,050,000	1,650,000	1,125,000
200										
225										
250										

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-12ET1-1112
4" Pipe	RTRP-12ET1-1113
6" Pipe	RTRP-12ET1-1114
8" and larger Pipe	RTRP-12ET1-1116

All materials are filament wound, polyester 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.

Replace 'T' with 'Q' for the HDB rating of joints.

ASTM F1173 / ISO15840 Codes

Type I, Resin 3, Class B, Rating Method 1

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, υmin = υha	0.55
Major Poisson's Ratio, Ea/Eh*υha = υah	0.35
Hazen Williams Coefficient	150
Specific Roughness (in.)	0.0002

ASTM D5685 Fittings Codes

2" - 12" Fittings, 200psi	RTRF 54K4E

Contact molded fittings, epoxy vinyl ester resin, reinforced liner,
butt & strap joint, 200psig rating

14" - 24" Fittings, 150psi	RTRF 54K4D

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.

Rev F, Jun-12-2015

Table 20HV.E3M.1A (Metric)
(Series 20HV, 20HV-C, 20HV(FDA), 20HV(FDA)-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.
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	43.4	136.5	86.9	N/A	93.1	7.2	11.4	7.2	11.4	7.8
93.3										
107.2										
121.1										

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-12ET1-1112
4" Pipe	RTRP-12ET1-1113
6" Pipe	RTRP-12ET1-1114
8" and larger Pipe	RTRP-12ET1-1116

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.

Replace 'T' with 'Q' for the HDB rating of joints.

ASTM F1173 / ISO15840 Codes

Type I, Resin 3, Class B, Rating Method 1

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, υmin = υha	0.55
Major Poisson's Ratio, Ea/Eh*υha = υah	0.35
Hazen Williams Coefficient	150
Specific Roughness (cm)	0.0005

ASTM D5685 Fittings Codes

2" - 12" Fittings, 200psi	RTRF 54K4E

Contact molded fittings, epoxy vinyl ester resin, reinforced liner, butt & strap joint, 200psig rating

14" - 24" Fittings, 150psi	RTRF 54K4D

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.

Rev F - Jan-21-2013

Table 20HV.E3.5A
(Series 20HV, 20HV-C, 20HV(FDA), 20HV(FDA)-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
$\upsilon_{min} = \upsilon_{ha}$	0.55		0.55	
E_h	2,200,000	psi	15.2	GPa
rho	0.060	lb/in.^{3}	1.7	g/cm^3
$E_a/E_h * \nu_{ha} = \upsilon_{ah}$	0.35		0.35	
Shear-Axial Modulus Ratio	0.71		0.71	

Pipe Dimensions

Nominal Size (in.)	Nominal Size (mm)	Pipe - tr (in.)	Pipe - tr (mm)	Bends - tnom (in.)	Bends - tnom (mm)
1	25	0.24"	6.1mm	0.25"	6.4mm
1.5	40	0.24"	6.1mm	0.25"	6.4mm
2	50	0.24"	6.1mm	0.25"	6.4mm
3	80	0.24"	6.1mm	0.25"	6.4mm
4	100	0.24"	6.1mm	0.25"	6.4mm
6	150	0.30"	7.6mm	0.31"	7.9mm
8	200	0.36"	9.1mm	0.44"	11.2mm
10	250	0.42"	10.7mm	0.50"	12.7mm
12	300	0.48"	12.2mm	0.63"	16.0mm
14	350	0.42"	10.7mm	0.56"	14.2mm
16	400	0.48"	12.2mm	0.63"	16.0mm
18	450	0.53"	13.5mm	0.69"	17.5mm
20	500	0.59"	15.0mm	0.75"	19.1mm
24	600	0.71"	18.0mm	0.88"	22.4mm

Nominal Size (in.)	Nominal Size (mm)	Flange B.C. (in.)	Flange B.C. (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

Rev G - Jun-04-2018

Table 20HV.E3.5B
(Series 20HV, 20HV-C, 20HV(FDA), 20HV(FDA)-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, ε_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 150F, 65c)	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 20HV.E3.5C
(Series 20HV, 20HV-C, 20HV(FDA), 20HV(FDA)-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.

Rev 3.0C, Apr-24-2008

Table 20HV.E3.4A
(20HV, 20HV-C, 20HV(FDA), 20HV(FDA)-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	Series 20HV, 20HV-C, 20HV(FDA)						
	Elbows					Tees	
	Flexibility	Axial bending SIF		Hoop bending SIF			
(in.)	Factor	In-plane	Out-of-plane	In-plane	Out-of-plane	SIF	PSM
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.

Rev: Oct-15-2012

Table 20HV.E3.6A
(20HV, 20HV-C)
Flange Thickness and Weight

Nominal	Flange			Flange Pair	
Size	thk	Weight		thk	Weight
		w/out bolts	w/ 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	1.62	4.9
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	13.1	2.76	20.8
10	1.63	12.0	24.5	3.26	36.5
12	1.88	19.2	32.8	3.76	52.1
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	Mass		thk	Mass
		w/out bolts	w/ 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	35.1	1.5
80	20.6	0.8	1.4	41.1	2.2
100	25.4	1.4	2.8	50.8	4.2
150	30.2	2.2	4.4	60.5	6.5
200	35.1	3.5	5.9	70.1	9.4
250	41.4	5.4	11.1	82.8	16.6
300	47.8	8.7	14.9	95.5	23.6
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

Rev: Jan-21-2013

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

Nominal Size	D / t	Sustained (f2 = 0.67) P = 150 psig		Sustained (f2 = 0.67) P = 200 psig		Sustained+Thermal (f2 = 0.83) P = 200 psig		Occasional (f2 = 0.89) P = 200 psig	
		Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)	Hoop (calc.)	Long. (allow.)
1	4.17	388	2212	517	2235	517	2747	517	2938
1.5	6.25	544	2240	725	2273	725	2784	725	2976
2	8.33	700	2269	933	2311	933	2822	933	3014
3	12.50	1013	2325	1350	2387	1350	2898	1350	3090
4	16.67	1325	2382	1767	2462	1767	2974	1767	3166
6	20.00	1575	2428	2100	2523	2100	3034	2100	3226
8	22.22	1742	2458	2322	2563	2322	3075	2322	3267
10	23.81	1861	2480	2481	2592	2481	3104	2481	3295
12	25.00	1950	2496	2600	2614	2600	3125	2600	3317
14	33.93	2620	2617	3493	2776	3493	3288	3493	3479
16	33.85	2614	2616	3485	2775	3485	3286	3485	3478
18	34.43	2658	2624	3543	2785	3543	3297	3543	3489
20	34.32	2649	2623	3532	2783	3532	3295	3532	3486
24	34.15	2637	2621	3515	2780	3515	3292	3515	3483

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

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

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