

Series Specifications 20FRE.E3 (Series 20FRE, 20FRE-C)  
 Rev 3.0C, Feb-19-2009

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

Series		20FRE, 20FRE-C								
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	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
200	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
225										
250										
ASTM D4024 / D5421 Flange Codes						ASTM D2310 / D2996 Pipe 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.						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										
Other Properties						ASTM D5685 Fittings Codes				
Density (lb/cu in.)	0.06					2" - 12" Fittings, 200psi	RTRF 52E4E			
Shear Modulus (psi)	1,400,000					Contact molded fittings, epoxy vinyl ester resin, reinforced liner, butt & strap joint, 200psig rating				
Thermal Expansion Coefficient (in./in./F)	0.00001					14" - 24" Fittings, 150psi	RTRF 52E4D			
Thermal Conductivity (BTU-in./ft^2-hr-F)	1.3					butt & strap joint, 150psig rating				
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.										

Series Specifications 20FRE.E3 (Series 20FRE, 20FRE-C)  
 Rev 3.0C, Feb-19-2009

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

Series	20FRE, 20FRE-C
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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	55.0	172.9	107.1	N/A	117.9	9.2	14.4	8.9	14.0	9.8
93.3	52.1	163.8	98.5	N/A	111.7	8.7	13.7	8.2	12.9	9.3
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-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

**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, $\nu_{min} = \nu_{ha}$	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

**ASTM D5685 Fittings Codes**

2" - 12" Fittings, 200psi	RTRF 52E4E
Contact molded fittings, epoxy vinyl ester resin, reinforced liner, butt & strap joint, 200psig rating	
14" - 24" Fittings, 150psi	RTRF 52E4D
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.

**Design Envelope Data**  
 Rev 3.0B, May-01-2007

**Table 20FRE.E3.2A**  
**(Series 20FRE, 20FRE-C)**  
**Design Envelope Data**

<b>Series</b>	20FRE, 20FRE-C
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**ASTM D2992-96 Data**

<b>Identification</b>	Pipe
<b>Procedure</b>	B (Static)
<b>End Closure</b>	Free (2:1 Loading)
<b>Test Environment</b>	Water (inside and outside), 150F (65c)
<b>LTHS (psi)</b>	10,342
<b>r</b>	0.96
<b>Slope of Regression Line</b>	-0.064
<b>HDB (psi)</b>	10,000

**ASME B31.3 Data**

<b>HDB (psi)</b>	10,000
<b>HDS (psi)</b>	5,000

**ISO14692 Data**

	<b>Pipe</b>	<b>Fittings</b>	<b>Joints</b>
<b>NPRman (psi) (f2=0.67)</b>	(f3=0.7)	(f3=1.0)	(f3=1.0)
2"	738	598	451
6"	358	285	215
12"	298	297	224
<b>Pq = LCL = f1*LTHP (psi)</b>			
2"	1,574	893	673
6"	763	425	320
12"	636	443	334

**Recommended Design Data**

	<b>Sustained</b>	<b>Sust+Temp</b>	<b>Occasional</b>
	(f2=0.67)	(f2=0.83)	(f2=0.89)
<b>Allowable Hoop Stress (psi)</b>	5,732	7,101	7,614
<b>Allowable Axial Stress (psi)</b>	1,824	2,259	2,423
<b>Allowable Bending Stress (psi)</b>	3,283	4,067	4,361
<b>Allowable Shear Stress (Cross-laminar) (psi)</b>	2,606	3,228	3,461
<b>Allowable "Secondary Bond" Shear Stress (psi)</b>	100		

**Notes:**

1. For recommended design data, axial and bending stresses may have to be considered simultaneously. In this case, the combined axial and bending stresses must not exceed the allowable bending stress, which is the larger of these values.

**Design Envelope Data**  
 Rev 3.0B, May-01-2007

**Table 20FRE.E3M.2A**  
**(Series 20FRE, 20FRE-C)**  
**Design Envelope Data (SI)**

Series	20FRE, 20FRE-C
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**ASTM D2992-96 Data**

<b>Identification</b>	Pipe and Joint
<b>Procedure</b>	B (Static)
<b>End Closure</b>	Free (2:1 Loading)
<b>Test Environment</b>	Water (inside and outside), 150F (65c)
<b>LTHS (MPa)</b>	71.3
<b>r</b>	0.96
<b>Slope of Regression Line</b>	-0.064
<b>HDB (MPa)</b>	69.0

**ASME B31.3 Data**

<b>HDB (MPa)</b>	69.0
<b>HDS (MPa)</b>	34.5

**ISO14692 Data**

	Pipe	Fittings	Joints
<b>NPRman (MPa) (f2=0.67)</b>	(f3=0.7)	(f3=1.0)	(f3=1.0)
2"	5.1	4.1	3.1
6"	2.5	2.0	1.5
12"	2.1	2.0	1.5
<b>Pq = LCL = f1*LTHP (MPa)</b>			
2"	10.9	6.2	4.6
6"	5.3	2.9	2.2
12"	4.4	3.1	2.3

**Recommended Design Data**

	Sustained (f2=0.67)	Sust+Temp (f2=0.83)	Occasional (f2=0.89)
<b>Allowable Hoop Stress (MPa)</b>	39.5	49.0	52.5
<b>Allowable Axial Stress (MPa)</b>	12.6	15.6	16.7
<b>Allowable Bending Stress (MPa)</b>	22.6	28.0	30.1
<b>Allowable Shear Stress (Cross-laminar) (MPa)</b>	18.0	22.3	23.9
<b>Allowable "Secondary Bond" Shear Stress (MPa)</b>	0.7		

**Notes:**

1. For recommended design data, axial and bending stresses may have to be considered simultaneously. In this case, the combined axial and bending stresses must not exceed the allowable bending stress, which is the larger of these values.

**Design Envelope Data**  
 Rev 3.0C, Apr-24-2008

**Table 20FRE.E3.4A**  
**(20FR-E, 20FRE-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 20FRE, 20FRE-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.

**Stress Analysis Data**  
 Rev 3.0C, Feb-19-2009

**Table 20FRE.E3.5A**  
**(Series 20FRE, 20FR-EC)**  
**Stress Analysis Data**

<b>Series</b>	20FR-E, 20FR-EC
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**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, $f_1 * LT_{HS}$	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	

Figure 20FRE.E3.C1 Rev 3.0A, Feb-15-2005  
ISO 14692 Design Envelope - FIBERBOND® Pipe  
f1\*LTHP=763psi; f1\*LTHS=8556psi; STHP=2356psi; STHS=26400psi  
Short Term Axial Strength=8400psi; Est'd Long Term Axial Strength=2722psi; r=0.64

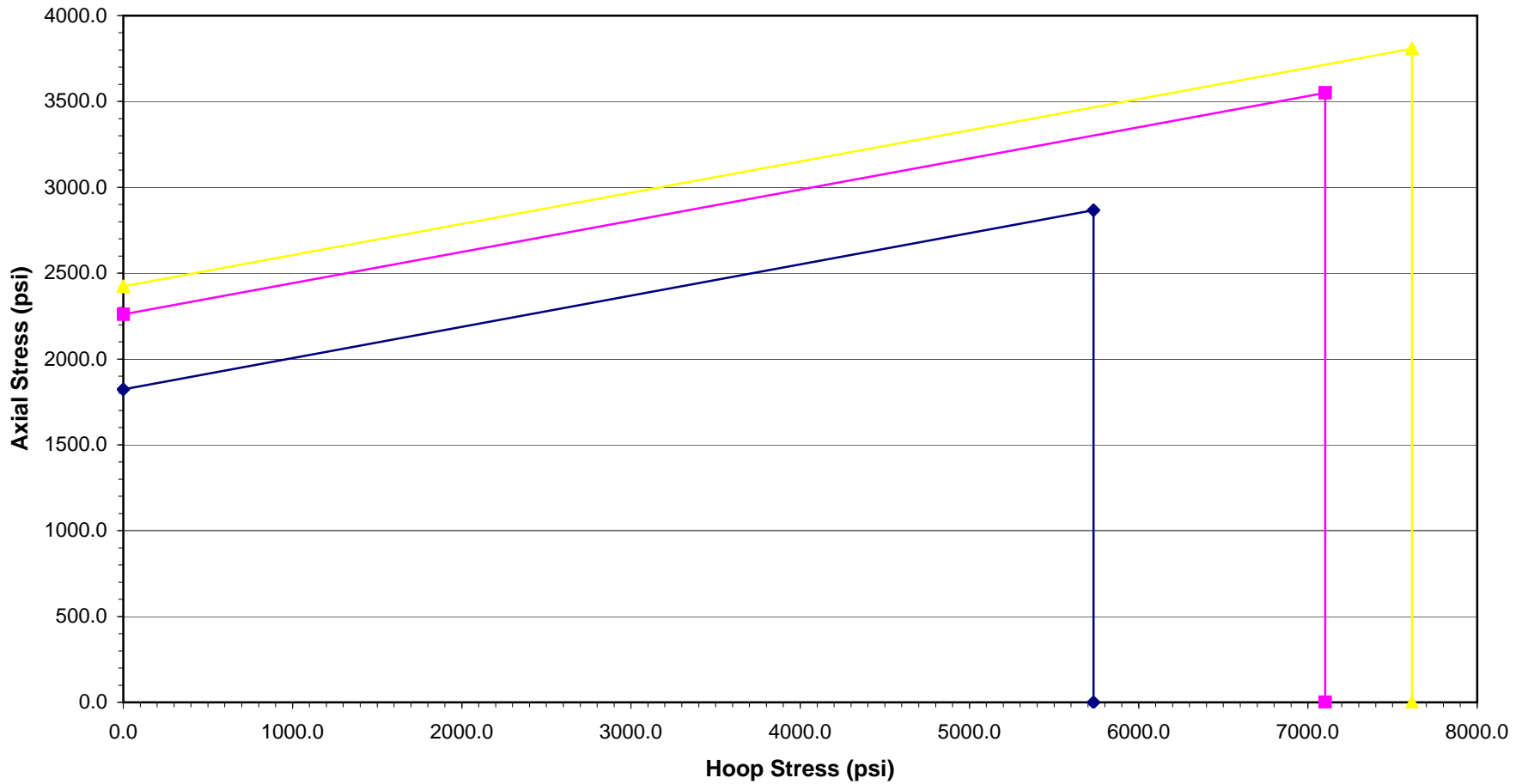


Figure 20FRE.E3.C2 Rev 3.0A, Feb-15-2005  
ISO 14692 Design Envelope - FIBERBOND(R) Fittings  
f1\*LTHP=425psi; f1\*LTHS=4851psi; STHP=1139psi; STHS=13000psi  
Short Term Axial Strength = 12200psi; Est'd Long Term Axial Strength = 4552psi; r=1.9

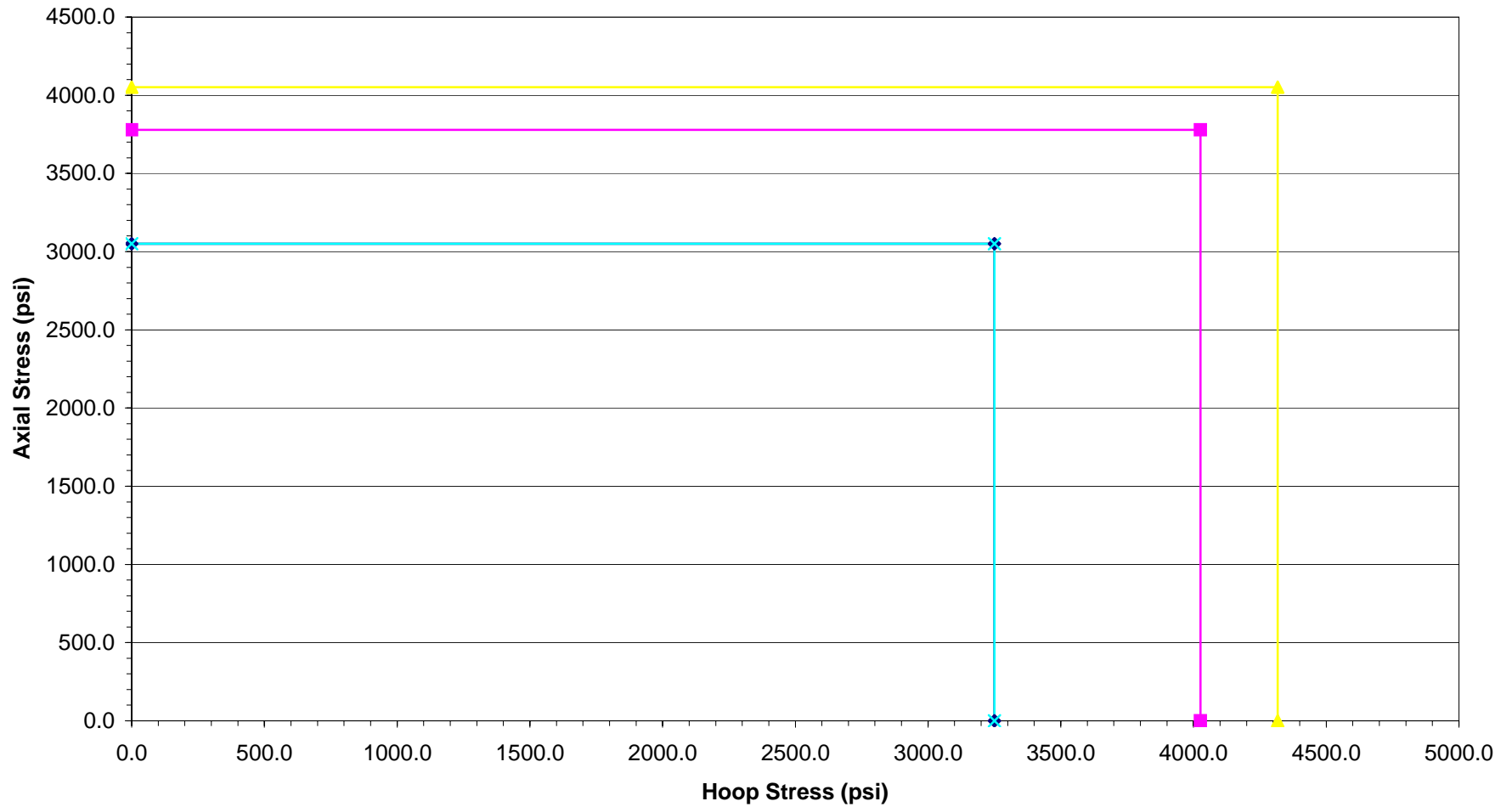


Figure 20FRE.E3.C3 Rev 3.0A, Feb-15-2005  
ISO 14692 Design Envelope - FIBERBOND® Butt Weld Joints  
f1\*LTHP=320psi; f1\*LTHS=3657psi; STHP=859psi; STHS=9800psi  
Short Term Axial Strength = 11000psi; Est'd Long Term Axial Strength = 4104psi; r=2.2

