STAR™ Downhole Tubing/Casing *(Anhydride Cured Epoxy - Product Data)*

Product Description

- Pressure - Up to 2500 psi (17,2 MPa)
- Resin System - Anhydride Cured Epoxy
- Reinforcement - Premium Fiberglass
- Joining Systems - API 5B 8rd, Integral Joint
- Joint Length - 28 to 33 feet (8,5 to 10,1 meters)
- Temperature - Up to 150°F (65.6°C) Maximum
- Sizes - 1.9 through 8 $^{5}/_{8}$ inches
- Fittings - A variety of filament wound API 5B threaded Nipples and Couplings

Tubing Design

- Non API Design
- Design Temperature - 150° F (65.6°C)
- Design - Based on the Proportional Elastic Limit in both the Hoop and Axial direction
- 100% Factory Hydrotest - All sizes to 1.25 x Pressure Rating
- Tensile Test - The hydrotest is across the joint and unrestrained; therefore, tensile loads of a proportional amount are generated.

Flow Factors

- Hazen-Williams C=150
- Absolute Roughness = 0.00021 in. (0.00533 mm)

Nominal Moduli

- Modulus of Elasticity
  - Hoop - 3.5 x 10^6 psi (24,1 GPa)
  - Axial - 2.5 x 10^6 psi (17,2 GPa)
- Poisson's Ratio (Minor) = 0.35

Physical Properties

- Density = 127 lbs/cu ft (2033 kgs/cu m)
- Specific Gravity = 2.03

Thermal Properties

- Coefficient of Thermal Conductivity
  - 0.23 BTU/(ft•hr•°F) (0.4 W/(m•°C))
- Coefficient of Thermal Expansion
  - 8.0 x 10^{-6} in/in/°F (14,4 x 10^{-6} mm/mm/°C)

Benefits

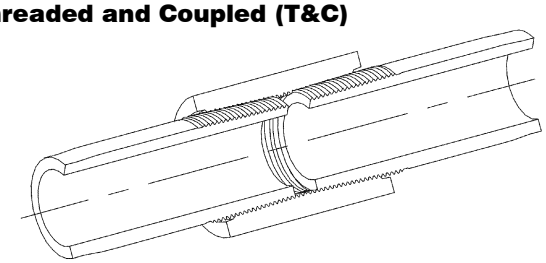
- Corrosion Control
- Improved Flow Efficiency
- Easily Drilled Up
- Excellent Logging Characteristics

Applications

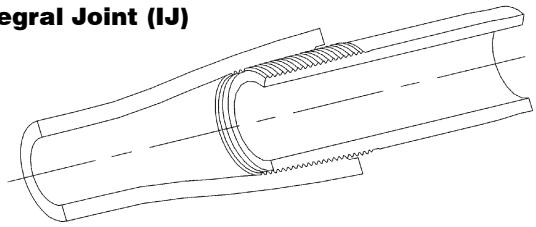
- Disposal or Injection Tubing
- Production Tubing - ESP, Gas Lift, Rod Pump, PCP
- Casing Liners
- Chemical Waste Disposal
- Geothermal
- Slotted Production Liners and Prepacked Screens
- Observation Well Casing
- Open Hole Casing, Zone or to Surface

Joining System

Threaded and Coupled (T&C)



Integral Joint (IJ)



API 5B THREADS (EUE 5B 10rd, EUE 8rd, OD 8rd)

- Advanced Composite Thread
- Precision molded with Epoxy, Graphite and Ceramic
- Tighter tolerances than steel
- Improved make and break properties
- Minimizes thread and wrench damage
- Provides higher thread shear than cut or ground threads
- Chemically resistant threads
- Compatible with steel API 5B threads

SIZE	NOMINAL DIMENSIONS						IJ		T&C		TENSILE		COLLAPSE		
Thread	Inside Diameter In	(mm)	Drift Diameter In	(mm)	Outside Diameter In	(mm)	Weight Lbs/ft	(kg/m)	Connection Diameter In	(mm)	Connection Diameter In	(mm)	Rating[1] Lbs	(kgs)	Rating[1] PSI	(MPa)	Mfg. Loc*
Series 1250 (8,6 MPa) - ACT															
2 3/8	2.00	(50,8)	1.91	(48,4)	2.24	(56,9)	0.93	(1,4)	2.97	(75,4)	3.25	(82.6)	8000	(3629)	1200	(8,3)	W,H,B
2 7/8	2.43	(61,7)	2.34	(59,3)	2.72	(69,2)	1.28	(1,9)	3.57	(90,6)	3.80	(96.5)	11000	(4990)	1000	(6,9)	H
2 7/8	2.38	(60,5)	2.28	(57,9)	2.66	(67,6)	1.28	(1,9)	3.57	(90,7)	---	---	11000	(4990)	1200	(8,3)	W
3 1/2	3.00	(76,2)	2.88	(73,0)	3.36	(85,4)	1.98	(2,9)	4.32	(109,8)	4.60	(116.8)	17000	(7711)	1100	(7,6)	W,H,B
4 1/2	3.91	(99,3)	3.79	(96,1)	4.38	(111,3)	3.25	(4,8)	5.50	(139,8)	5.80	(147.3)	29000	(13154)	1000	(6,9)	W,H
4 1/2	3.75	(95,3)	3.63	(92,2)	4.20	(106,7)	2.95	(4,4)	5.49	(139,4)	---	---	25000	(11340)	800	(5,5)	B
5 1/2	4.74	(120,4)	4.62	(117,3)	5.31	(134,9)	4.60	(6,8)	6.45	(163,8)	6.45	(163.8)	42000	(19051)	800	(5,5)	H
6 5/8	5.50	(139,7)	5.38	(136,5)	6.16	(156,6)	6.05	(9,0)	7.64	(194,0)	7.90	(200.7)	54000	(24494)	800	(5,5)	W,H,B
8 5/8	7.50	(190,5)	7.38	(187,3)	8.41	(213,5)	10.69	(15,9)	9.92	(252,0)	---	---	98000	(44453)	800	(5,5)	W,B
Series 1500 (10,3 MPa) - ACT															
1.90	1.50	(38,1)	1.41	(35,7)	1.72	(43,7)	0.72	(1,1)	2.48	(62,9)	2.80	(71.1)	6000	(2722)	2000	(13,8)	W,H
2 3/8	2.00	(50,8)	1.91	(48,4)	2.29	(58,3)	1.07	(1,6)	3.07	(78,0)	3.25	(82.6)	9000	(4082)	1900	(13,1)	W,H,B
2 7/8	2.43	(61,7)	2.34	(59,3)	2.79	(70,8)	1.55	(2,3)	3.65	(92,6)	3.80	(96.5)	14000	(6350)	1800	(12,4)	H
2 7/8	2.38	(60,5)	2.28	(57,9)	2.72	(69,1)	1.54	(2,3)	3.65	(92,7)	---	---	13000	(5897)	2000	(13,8)	W
3 1/2	3.00	(76,2)	2.88	(73,0)	3.44	(87,4)	2.21	(3,3)	4.43	(112,4)	4.60	(116.8)	19000	(8618)	1500	(10,3)	W,H,B
4 1/2	3.91	(99,3)	3.79	(96,1)	4.49	(113,9)	3.54	(5,3)	5.65	(143,6)	5.80	(147.3)	32000	(14515)	1300	(9,0)	W,H,B
4 1/2	3.75	(95,3)	3.63	(92,2)	4.30	(109,2)	3.65	(5,4)	5.63	(143,0)	---	---	32000	(14515)	1600	(11,0)	B
5 1/2	4.74	(120,4)	4.62	(117,2)	5.44	(138,1)	5.61	(8,3)	6.59	(167,5)	6.60	(167.6)	52000	(23587)	1700	(11,7)	W,H
6 5/8	5.50	(139,7)	5.38	(136,5)	6.31	(160,2)	7.60	(11,3)	7.83	(198,8)	7.90	(200.7)	70000	(31752)	1700	(11,7)	W,H,B
7	5.95	(151,1)	5.83	(148,1)	6.83	(173,5)	8.56	(12,7)	8.40	(213,4)	8.40	(213.4)	82000	(37195)	1400	(9,7)	H
*8 5/8	7.50	(190,5)	7.38	(187,3)	8.52	(216,5)	12.00	(17,9)	10.08	(256,1)	---	---	107000	(48535)	1100	(7,6)	W,B
* 8 5/8 is rated to 1400 psi																	
Series 1750 (12,1 MPa) - ACT															
2 7/8	2.43	(61,7)	2.34	(59,3)	2.85	(72,5)	1.72	(2,6)	3.80	(96,4)	4.00	(101.6)	15000	(6804)	2250	(15,5)	H
2 7/8	2.38	(60,5)	2.28	(57,9)	2.49	(63,2)	1.72	(2,6)	3.80	(96,5)	---	---	15000	(6804)	2250	(15,5)	W
3 1/2	3.00	(76,2)	2.88	(73,0)	3.52	(89,5)	2.55	(3,8)	4.56	(115,8)	4.80	(121.9)	23000	(10433)	2250	(15,5)	W,H,B
4 1/2	3.91	(99,3)	3.79	(96,1)	4.59	(116,6)	4.25	(6,3)	5.82	(147,7)	6.10	(154.9)	39000	(17690)	2250	(15,5)	W,H
4 1/2	3.75	(95,3)	3.63	(92,2)	4.40	(111,8)	4.13	(6,1)	5.80	(147,3)	---	---	36000	(16329)	2250	(15,5)	B
5 1/2	4.74	(120,4)	4.62	(117,3)	5.56	(141,2)	6.62	(9,9)	6.75	(171,5)	6.75	(171.5)	62000	(28123)	2250	(15,5)	H
6 5/8	5.50	(139,7)	5.38	(136,5)	6.46	(164,0)	8.61	(12,8)	8.03	(203,9)	8.25	(209.6)	70000	(31752)	2250	(15,5)	W,H,B
7	5.95	(151,1)	5.38	(148,1)	6.99	(177,5)	9.94	(14,8)	8.75	(222,3)	8.75	(222.3)	87000	(39463)	2200	(15,2)	H

SIZE	NOMINAL DIMENSIONS						IJ		T&C		TENSILE		COLLAPSE		
Thread	Inside Diameter In	(mm)	Drift Diameter In	(mm)	Outside Diameter In	(mm)	Weight Lbs/ft	(kg/m)	Connection Diameter In	(mm)	Connection Diameter In	(mm)	Rating[1] Lbs	(kgs)	Rating[1] PSI	(MPa)	Mfg. Loc*
Series 2000 (13,8 MPa) - ACT															
1.90	1.50	(38,1)	1.41	(35,7)	1.80	(45,8)	0.83	(1,2)	2.63	(66,7)	2.80	(71.1)	7000	(3175)	2500 (17,2)	W,H
2 3/8	2.00	(50,8)	1.91	(48,4)	2.40	(61,1)	1.44	(2,1)	3.25	(82,5)	3.40	(86.4)	13000	(5897)	2500 (17,2)	W,H,B
2 7/8	2.43	(61,7)	2.34	(59,3)	2.92	(74,2)	2.00	(3,0)	3.87	(98,4)	4.00	(101.6)	18000	(8165)	2500 (17,2)	H
2 7/8	2.38	(60,5)	2.28	(57,9)	2.85	(72,4)	1.99	(3,0)	3.88	(98,6)	---	---	18000	(8165)	2500 (17,2)	W
3 1/2	3.00	(76,2)	2.88	(73,0)	3.61	(91,6)	3.11	(4,6)	4.73	(120,2)	4.80	(121.9)	28000	(12701)	2500 (17,2)	W,H,B
4 1/2	3.75	(95,3)	3.63	(92,1)	4.51	(114,5)	4.62	(6,9)	5.97	(151,7)	6.10	(154.9)	41000	(18598)	2500 (17,2)	W,H,B
7	5.50	(139,7)	5.38	(136,7)	6.61	(167,9)	10.77	(16,0)	8.75	(222,3)	8.75	(222.3)	87000	(39463)	2500 (17,2)	H
Series 2500 (17,2 MPa) - ACT															
1.90	1.50	(38,1)	1.41	(35,7)	1.89	(48,0)	1.02	(1,5)	2.81	(71,3)	2.90	(73.7)	9000	(4082)	3000 (20,7)	W,H
2 3/8	1.88	(47,8)	1.79	(45,5)	2.37	(60,2)	1.72	(2,6)	3.60	(91,4)	3.60	(91.4)	15000	(6804)	3000 (20,7)	H
2 7/8	2.23	(56,6)	2.14	(54,4)	2.81	(71,4)	2.48	(3,7)	4.20	(106,7)	4.20	(106.7)	21000	(9526)	3000 (20,7)	H
2 7/8	2.38	(60,5)	2.28	(57,9)	2.99	(75,9)	2.54	(3,8)	4.14	(105,2)	---	---	22000	(9979)	3000 (20,7)	W
3 1/2	2.72	(69,1)	2.60	(66,0)	3.43	(87,1)	3.36	(5,0)	5.10	(129,5)	5.10	(129.5)	30000	(13608)	3000 (20,7)	H
4 1/2	3.35	(85,1)	3.23	(82,0)	4.22	(107,2)	5.52	(8,2)	6.40	(162,6)	6.40	(162.6)	45000	(20412)	3000 (20,7)	H
Series 3000 (20,7 MPa) - ACT															
1.90	1.50	(38,1)	1.41	(35,8)	1.98	(50,3)	1.32	(2,0)	3.05	(77,5)	3.05	(77.5)	10000	(4536)	3500 (24,1)	H
2 3/8	1.88	(47,8)	1.79	(45,5)	2.49	(63,2)	2.07	(3,1)	3.70	(94,0)	3.70	(94.0)	17000	(7711)	3500 (24,1)	H

Pipe Capacity

Size Thread	Inside Diameter in	(mm)	Capacity Bbls/1,000 ft.	(m^3/km)
1.90	1.50	(38,1)	2.20	(1,1)
2 3/8	2.00	(50,8)	3.90	(2,0)
2 7/8	2.38	(60,5)	5.50	(2,9)
2 7/8	2.43	(61,7)	5.70	(3,0)
3 1/2	3.00	(76,2)	8.70	(4,5)
4 1/2	3.75	(95,3)	13.70	(7,1)
4 1/2	3.91	(99,3)	14.80	(7,7)
5 1/2	4.74	(120,4)	21.80	(11,4)
6 5/8	5.50	(139,7)	29.40	(15,3)
8 5/8	7.50	(190,5)	54.60	(28,5)

*Manufacturing Location

W = Wichita H = Harbin

B = Brazil

Joining System Information

API THREADED SIZE - Inches			1 1/2		2 3/8		2 7/8		3 1/2	
Thread Type[3]			EUE 10rd		EUE 8rd		EUE 8rd		EUE 8rd	
Thread Length - In (mm)			2.36	(59,9)	2.94	(74,7)	3.25	(82,6)	3.50	(88,9)
Make-Up Length Loss - In/Jt (mm/Jt)			2.06	(52,4)	2.56	(65,1)	2.88	(73,0)	3.13	(79,4)
Make-Up Torque - Ft. Lbs. (mm)		• Optimum	125	(170)	150	(204)	185	(252)	225	(306)
		• Minimum	100	(136)	125	(170)	150	(204)	175	(238)
		• Maximum	175	(238)	225	(306)	250	(340)	300	(408)
Recommended Make-Up Tool			**No. 5 Strap Wrench**							
Pin Upset O.D. - In (mm)			2.15	(54,6)	2.60	(66,0)	3.10	(78,7)	3.75	(95,3)
Handling Tools										
Elevators T&C (Shoulder Type) - In.[4]			2 3/8		2 7/8		3 1/2		4 1/2	
Elevators IJ (Slip Type)[5]			MYT		MYT		MYT		YT	
Floor Slips (Standard Type) - In.[6]			1 1/2		2 3/8		2 7/8		3 1/2	
Thread Compatibility										
FRP Long vs. Steel Short Form[3] (Extra Threads, Front of FRP Pin)			6		5		6		6	
Lubricant Usage (Joints/Gallon)			100		100		100		68	
Stretch Factor (in./per 100 ft)	**Series**	1250	---	---	4.57	(116,2)	3.32	(84,3)	2.16	(54,8)
(mm/per 30.5 m)		1500	5.93	(150,7)	3.93	(99,7)	2.69	(68,4)	1.94	(49,2)
		1750	---	---	---	---	2.41	(61,2)	1.65	(42,0)
		2000	5.12	(130,0)	2.84	(72,1)	2.06	(52,3)	1.33	(33,8)
		2500	4.14	(105,1)	---	---	---	---	---	---
Ultimate Stress[2] psi (MPa)			20,000	(137,8)	35,000	(241,3)	45,000	(310,2)	60,000	(413,6)

API THREADED SIZE - Inches			4 1/2		5 1/2		6 5/8		8 5/8	
Thread Type[3]			EUE 8rd		OD 8rd		OD 8rd		OD 8rd	
Thread Length - In (mm)			3.88	(98,6)	4.74	(120,7)	4.25	(108,0)	4.85	(123,2)
Make-Up Length Loss - In/Jt (mm/Jt)			3.50	(88,9)	4.38	(98,4)	3.88	(98,4)	4.50	(114,3)
Make-Up Torque - Ft. Lbs. (mm)		• Optimum	300	(408)	400	(544)	500	(680)	700	(952)
		• Minimum	250	(340)	320	(436)	400	(544)	475	(646)
		• Maximum	450	(612)	560	(762)	650	(884)	825	(1122)
Recommended Make-Up Tool			**No. 11 Strap Wrench**		**Approved Power Tongs**					
Pin Upset O.D. - In (mm)			4.75	(120,7)	5.55	(141,0)	6.65	(168,9)	9.65	(245,1)
Handling Tools										
Elevators T&C (Shoulder Type) - In.[4]			5 1/2		6 7/8		7		9 5/8	
Elevators IJ (Slip Type)[5]			YC		YC		MYT		YT	
Floor Slips (Standard Type) - In.[6]			4 1/2		5 1/2		6 5/8		8 5/8	
Thread Compatibility										
FRP Long vs. Steel Short Form[3] (Extra Threads, Front of FRP Pin)			7		5		6		9	
Lubricant Usage (Joints/Gallon)			50		34		34		26	
Stretch Factor (in/per 100 ft)	**Series**	1250	1.27	(32,3)	---	---	0.70	(17,7)	0.38	(9,7)
(mm/per 30.5 m)		1500	1.17	(29,8)	0.72	(18,3)	0.54	(13,7)	0.34	(8,6)
		1750	0.96	(24,4)	---	---	0.47	(12,0)	---	---
		2000	0.90	(22,9)	---	---	---	---	---	---
		2500	---	---	---	---	---	---	---	---
Ultimate Stress[2] psi (MPa)			90,000	(620,5)	130,000	(896,3)	140,000	(965,2)	215,000	(1482,3)

Setting Tension - Refer to NOV Fiber Glass Systems Downhole Tubing Installation and Application Practices - Considerations for Setting Tubing Tension (Anhydride & Aromatic Amine Tubing). A **STAR Well** will provide more accurate setting tension/stretch.

Corresponding Numbered Notes:

1. **Ratings** - All ratings are maximum operating limits. Exceeding these limits will void the warranty on all STAR pipe.
2. **Ultimates** - The typical mode of failure for pressure is weep and for tensile it is an across the joint pipe body shear.
3. **Threads** - All 1 1/2" EUE 10rd and 2 3/8" - 4 1/2" EUE 8rd API threads conform to API 5B Table 14, 14th Edition (L4 is minimum) and all 5 1/2" - 9 5/8" O.D. 8rd casing threads conform to API 5B, Table 7, 14th Edition (L4 is minimum).
4. **Elevators T&C** - The 1250 & 1500 PSI products have smaller OD's which may work with the same size elevators as the thread size.
5. **Elevators IJ** - The setting plate must be removed so that the slips will properly set on the fiberglass pipe. Sizing slip type elevators requires use of the tubing O.D. instead of the upset O.D. on the male end. Rubber setting plates are available to minimize marking and to improve the fit. Shorter bolts are required to hold in place.
6. **Floor Slips** - When running lighter weight (1250-1500 PSI) products, it is good practice to replace the slip dies to make sure they will latch on the pipe body.

Packer Selection

(More information listed in "Downhole Tubing and Casing Installation and Application Practices" Manual)

- STAR tubing is designed to be set in tension (see stretch chart).
- Double Grip Packers are preferred with an on/off tool seal assembly, 1/4 turn release.
- Direct Tension Set Packers should be avoided due to the movement of fiberglass.
- Direct Set Packers are set <3500 feet deep (1,067 m).
- When packer setting is >3500 feet (1,067 m) deep, use steel work string to set packer.
- Hydraulic Set Packers are not recommended due to uncontrollable forces.
- Polished Bore Receptacles are set with proper precautions to avoid compression. A complete STAR Well Evaluation must be performed to determine the proper set-ups.

Perforation

- Use a Jet Perforating Gun. Shoot a maximum of two shots at a time at 0° Phase or 180° Phase.
- Thread lock all steel to FRP connections.
- When installing mixed strings, have one joint of FRP casing supplied without a coupling (pin x pin) for cross-overs.

Cementing

- Cementing in two stages may help avoid exceeding collapse rating.
- Keep differential below external and internal ratings at all times.
- Care must be given to avoid shock collapse pressure when setting cement plug.
- Fiberglass centralizers are available, metal centralizers must be qualified to fit to FRP.
- Cement residue can be cleaned up with proper care using a rock bit.
- Landing joints are available, but must be sized for the well-head selected.
- Drilling-Up fiberglass tubing or casing is easy with a rock bit (not a mill).

Rod Pump Wells

- Rod Guides must be used.

Electric Submersible Pumps

- Care must be given to direction and amount of start-up torque.

Fishing

- Normal Procedures, Spear or Overshot.

Cutting

- Mechanical Jet Cutter.

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