SPE 54458

Coiled-Tubing Stretch and Stuck-Point Calculations

K. R. Newman

This paper was prepared for presentation at the 1999 SPE/ICoTA Coiled Tubing Roundtable held in Houston, Texas, 25–26 May 1999.

Abstract

The plastic bending that occurs at surface causes large residual stresses in coiled tubing (CT) as it is run in and out of a well. When an axial force is applied to the CT it stretches more than pipe which has never been bent. Thus the conventional stretch calculations often used are incorrect for CT applications.

This paper presents equations which model the elastic/plastic stretch of CT. The results from these equations are compared to a computer model which was developed based on CT elongation research.

This paper also proposes a method to be used for stuck point depth calculations which avoids the plastic stretch complication.

Introduction

There are four factors which change the depth of CT in a well compared to the measured length of CT run into the well at surface:

- Stretch due to axial force
- Thermal elongation
- Elongation due to pressure differential
- Shortening due to helical buckling

The stretch due to axial force is the primary discussion in this paper. Thermal elongation is significant, and is easy to calculate. The elongation due to pressure is usually included in the stretch due to axial force, when the axial force is adjusted for the pressure. The shortening due to helical buckling is usually trivial.

These changes in length need to be calculated in a tubing forces computer model which calculates the axial force and pressures along the length of the CT string.

The stuck point calculation presented in this paper is similar to stuck point calculations used for other oilfield tubulars. The procedure given ensures that the residual stresses from bending do not affect the stuck point calculation.

Stretch due to Axial Force

The depth measurement systems used at surface may or may not account for some of the stretch in the CT due to the axial force depending on the location of the friction wheel. The axial force in the CT varies as the pressure inside and outside the CT varies. The stretch included in the depth measurement depends upon the axial force in the CT under the friction wheel when the measurement is being made.

CT stretch is much more complicated than stretch of conventional tubulars because of the residual bending stresses in the CT. The following is an explanation of these residual stresses taken from reference 1.

Stress Profiles Caused by Bending and Straightening

Figure 1 shows the stress profiles across a section of CT when it is bent and straightened. The Y-axis is the outside radius of the 2” OD CT with zero at the neutral axis 1.0 at the top surface and –1.0 at the bottom surface. The X-axis shows the stress for a 70 ksi yield (σ_y) material. When the pipe is bent so that the middle bows upward, the material in the upper section of the pipe stretches elastically until it reaches the yield stress, then it continues to stretch plastically, with the stress remaining at the yield stress. The material in the lower section of the pipe behaves in exactly the opposite manner, resulting in most of the lower section being at the yield stress in compression ($-\sigma_y$), which in this case is -70 ksi.

When the CT is straightened after bending, the sections that were yielded in one direction must now be yielded in the other direction for the CT to be forced into the straight position. Figure 1 also shows the resulting stress profile after the CT is straightened. Note that a short section of the profile across the center of the CT, returns to almost zero stress because it has not been plastically deformed. The upper portion of Figure 3 shows the cross-section of CT that has been bent and straightened.

The radius from the neutral axis to the point where the CT material yields is:

$$r_y = \frac{R_b \sigma_y}{E}$$

Horizontal lines are shown on Figures 1 and 2 at the $\pm r_y$ and the $\pm 2r_y$ values. As can be seen in Figure 1, these values are at the points where the stress profiles change between elastic and plastic.

Stress Profiles and Stretch with Axial Force

The "Straightened" profile in Figure 2 is the same stress profile after straightening as in Figure 1. When a small axial tensile force is applied, the lower portion of the CT cross-section, (from Y= $-2r_y$ to –1.0) which is already at the yield stress in tension, continues to yield plastically but does not bear any of the additional force. Thus the force must be borne by the remaining cross-sectional area (from Y= 1.0 to –2ry). As the tensile force increases, more of the lower section of the CT cross-section becomes plastic. This radius changes from $-2r_y$ to $-r_y$. This is shown in the lower portion of Figure 3 as αr_y with α varying from 2 to 1.

Transition Load

As the axial force increases, a point (called the transition load in reference 1) is reached where the stress at the neutral axis reaches the yield stress. The transition load can be calculated with the following equation:

$$F_t = \frac{1}{2}F_y + 3\frac{{\sigma_y}^2}{E}R_b t$$

If the axial force increases beyond the transition load, the entire section of the CT from Y = -1.0 to r_y yields plastically and cannot support any additional force. Thus the force must be supported only by the section from Y = r_y to 1.0. This abrupt change in the area that supports additional force, which occurs at the transition load, changes the stretch characteristics of the CT.

After the transition load, the radius between elastic and plastic begins at r_y and moves to $2r_y$ just before the full body yield load is reached. In this case α varies from 1 to 2.

Comparison of results from the stretch equations which follow with results from the *Plastic* software model discussed in Reference 1, yielded the following equation for α for all values of F_a for the example used:

$$\alpha = 2 - \frac{F_a}{2F_t}$$

To calculate the stretch for the situation described above, it is necessary to calculate the area of the CT cross-section which is not already at the yield stress in tension. It is this area that must carry the axial force. In the top portion of Figure 3, this area includes the Elastic and the Plastic Compression portions of the cross section. The lower portion of Figure 3 shows a quarter section of the CT cross-section with αr_y shown from the neutral axis upwards. From geometry:

$$\theta_o = \arcsin\left(\frac{\alpha r_y}{r_o}\right) \qquad \theta_i = \arcsin\left(\frac{\alpha r_y}{r_i}\right)$$

The area of the CT wall in this section from the neutral axis to αr_y, including both the left and right sides of the tube is defined as Δ and from geometry is:

$$\Delta = r_o^2\theta_o - r_i^2\theta_i + r_o r_i \sin(\theta_i - \theta_o)$$

For axial forces less than the transition load, ($F_a < F_t$), the axial stretch is:

$$\delta_{fa<ft} = \frac{F_a L}{\left(\frac{A}{2} + \Delta\right)E}$$

For $F_a = F_t$ the stretch is:

$$\delta_{ft} = \frac{F_a L}{\left(\frac{A}{2} + \Delta\right)E}$$

For $F_a > F_t$ the stretch is:

$$\delta_{fa>ft} = \delta_{ft} + \frac{(F_a - F_t)L}{\left(\frac{A}{2} - \Delta\right)E}$$

The previous discussion was based entirely upon an increasing tensile axial force. Unloading is always elastic. Thus the contraction when unloading is the typical elastic equation usually used for pipe that has not been bent:

$$\delta_{af} = \frac{F_a L}{AE}$$

For this paper an Elastic Modulus (E) of 27 X 10^6 psi was used for all calculations. Using these equations, Figure 4 shows the stretch, which occurs as a piece of 2" OD, 0.156" wall CT with a 70,000psi yield strength which has been bent to a 72" radius of curvature and straightened, when it is loaded from zero to 80% of its yield load, and then the force is released. The three stretch equations given above were used to produce this curve. Note that the release curve is the linear elastic curve which would typically have been used in the past. After this sample is loaded and released there is a remaining elongation of 1.8 ft/1,000 ft. If the sample is then loaded again, it will simply follow up and down the linear elastic curve like conventional pipe. Thus the stretch in CT at any given point in time depends on its axial force history since the last bending and straightening event.

The above discussion applies to compressive forces as well as tensile forces. Note that the plastic stretch values depend upon the bending radius that the CT was last bent to on surface. Usually this is the radius of the guide arch.

Comparison of the results in Figure 4 with results from the *Plastic* software model yields differences of less than 1% when the equation given for α is used. These equations can be simplified by assuming that α is always 1.5. This allows tables of slopes to be produced for ease of use in the field. This assumption causes errors up to 6% in this particular example (when compared to *Plastic*) for low values of F_a and errors of less than 2% for higher F_a values (F_a > 40% of F_y).

Tables 1 through 4 give the stretch for typical CT sizes, assuming α is 1.5.

Example Elastic/Plastic Stretch Calculations Using Tables

A 1,000 ft section of 2.0" diameter, 0.156" wall, 70,000 psi yield CT has been bent around a 72" radius and straightened. From table 2 obtain the following values:

Transition load (F_t)	37,746 lb
Elastic Stretch	0.0410 ft/1,000 ft per 1,000 lb
Plastic Stretch <F_t	0.0685 ft/1,000 ft per 1,000 lb
Plastic Stretch >F_t	0.1020 ft/1,000 ft per 1,000 lb

Each of the following is a stretch calculation based upon these values. Note that this sequence of forces must be applied in this order, as some of the stretch calculations depend on previous load steps. Also note that this exact sequence can be done in compression, in which case all of the force and stretch numbers would be negative.

1. An axial force (F_a) of 20,000 lb is applied to this 1,000 ft section of CT. Since F_a is less than F_t, only the 0.0685 stretch factor is needed. The stretch is this value multiplied by 20 (for 20 thousand lbs) which gives a stretch of 1.37 ft
2. The above axial force is released, so F_a=0. When the force is released the CT shortens elastically. The elastic stretch factor multiplied by 20 is 0.82 ft. The remaining stretch (or elongation) once the force is released is 1.37-0.82 = 0.550 ft.
3. A force of 20,000 lb is applied again. The CT stretches elastically 0.82 ft to a total of 1.37 ft again.
4. The force is increased to 50,600 lbs (80% of yield). Until the transition load the stretch is 0.0685 multiplied by 37.746 (the transition load is 37.746 thousand lb) which gives a stretch at the transition load of 2.59 ft. The remaining force (50,600 – 37,746 = 12,854 lb) causes stretching to occur at the 0.1020 rate for an additional stretch of 1.31 ft. The total stretch is 2.59 + 1.31 = 3.90 ft.
5. The force is released. The elastic shortening is 0.041 * 50.6 = 2.08 ft. The remaining elongation once the force is released is 3.90 – 2.08 = 1.82 ft, which corresponds to the elongation shown in Figure 4.

Thermal Elongation

The elongation due to temperature is simply the change in temperature multiplied by an expansion coefficient. The expansion coefficients are:

6.5×10^{-6} for degrees Fahrenheit
3.61×10^{-6} for degrees Centigrade

Example Thermal Elongation Calculation

A 1,000 ft section of CT is 100 F at surface when it goes into the well, and 350 F when it gets downhole. The change in temperature is 250 F. The elongation is $250 \times 6.5 \times 10^{-6} \times 1{,}000 = 1.625$ ft.

Elongation due to Pressure Differential

Changes in internal and external pressure cause changes in the axial force in the CT. The axial force used to calculate the axial stretch of the CT must take these pressures into account. When they are accounted for correctly in the axial force calculation, the stretch due to the pressure differential is already included in the stretch calculation for axial force discussed previously.

There is another elongation effect caused by pressure, known as the Poisson effect. However, this effect is very small, and can be neglected.

Shortening due to Helical Buckling

Sometimes when CT is in compression it "buckles" into a helical shape in the hole. Though the CT itself does not change length, the length it occupies in the well is shorter when it is in a helical shape. This apparent shortening of the CT affects the depth of the end of the CT.

Helical buckling of the CT is quite complicated. A simplified explanation is given here to aid the user in comparing the apparent shortening due to helical buckling with the other stretch factors already discussed.

First the Helical Buckling Load (HBL) must be calculated. The HBL is the compressive "effective axial force" at which the CT will buckle into a helix. The HBL depends upon the buoyant weight of the CT, which in turn depends on the density of the fluids inside and outside the CT. The following equation can be used to calculate the HBL for CT in a horizontal hole ignoring friction affects.

$$HBL = -2\sqrt{\frac{2EIW_b}{F_e}}$$

The effective axial force is different from the real axial force in that it does not include the effects of pressure. Given the real axial force and the internal and external pressures, the effective axial force can be calculated using the following equation:

$$F_e = F_a - P_i A_i + P_o A_o$$

The length of the period formed by the helix is:

$$\lambda = 2\pi\sqrt{\frac{2EI}{F_e}}$$

The apparent shortening due to the helix is:

$$\delta_{hb} = -L\left\{\sqrt{\left(\frac{2\pi r_c}{\lambda}\right)^2 + 1} - 1\right\}$$

Example Helical Shortening Calculation

A 1,000 ft section of 1.5" diameter, .109" wall CT is inside a straight, horizontal 4" ID hole. There is no fluid inside or outside the CT. The CT weighs 1.6 lbs per foot. There is a compressive force on the CT of 5,000 lbs.

The HBL is –2,598 lbs. Since the 5,000 lb compressive force applied is more compressive than the HBL, the CT is buckled.

Using the equations above, the period is 18.5 ft and the apparent change in length is –0.624 ft.

Note that this example is highly unrealistic. The additional wall contact force and friction caused by the buckling will not allow a constant compressive force of 5,000 lbs

Stuck Point Calculations

To determine the point at which CT is stuck in a well, the following procedure should be used:

1. Pull on the CT to some maximum allowable force, usually 80% of the yield stress. If there is high pressure in the CT, be careful to include the internal pressure multiplied by the cross sectional area in the force calculation. This force is not included in the weight read on the weight indicator.
2. Release the CT to some lower force value, measuring accurately the length of CT which moves into the well, defined as ∂L. This lower force value should be greater than the value that allows the CT to go into compression (and thus helically buckle) at some point in the well. This lower value can be determined with a tubing forces model. The difference between the higher value in step 1 and this lower value is ∂F
3. Calculate the depth of the stuck point based on the change in axial force (∂F) and the change in length (∂L) using the elastic stretch factor. For vertical wells this calculation can be done by hand using the following equation:

$$SP = \frac{\partial L}{\partial F \delta_{elastic}}$$

For deviated wells with curvature in the wellbore, this calculation must be done with a tubing forces model.

Note that following the above procedure causes all of the plastic deformation to occur in the initial loading of the CT in step 1. The plastic stretch which happens in this step is ignored. The change in length which is recorded in step 2 is elastic, so the elastic stretch factor can be used.

Example Stuck Point Calculation

A 2.0" diameter, 0.156" wall, 70,000 psi yield CT string has become stuck in a vertical well. The CT is pulled until the weight indicator reads 50,600 lbs, then released until the weight indicator reads 30,000 lbs. As the weight is released the depth friction wheel shows that 5 ft of CT moved into the well. From any of the tables (note that the elastic stretch factor is independent of the yield stress and the radius of bending), the elastic stretch factor is 0.0410 ft/1,000 ft per 1,000 lb. The stuck point depth for ∂L = 5 feet and ∂F = 20.6 thousand pounds is 5.92 thousand ft.

Conclusions

The four factors which affect the depth measurement in a well have been analzyed. Of these four, the stretch and thermal elongation are the most important.

The stretch for CT is more complicated than the elastic stretch used for conventional well tubulars due to the plastic deformation which occurs when the CT is bent. Equations were presented to calculate the stretch for CT. Results from these equations have been validated with the *Plastic* software which calculates CT elongation.

A method and equation for calculating the stuck point of CT was presented.

References

1. Newman, K.R., Sathuvalli, U.B., Wolhart, S.: "Elongation of Coiled Tubing During its Life," SPE paper 38408 presented at the 2nd North American Coiled Tubing Roundtable, Montgomery Texas, April, 1997.
2. Newman, K.R., Sathuvalli, U.B, Stone, L.R., Wolhart, S.: "Defining Coiled Tubing Limits - A New Approach," paper OTC 8221 presented at Offshore Technology Conference, May 6-9,1996.
3. Tipton, S. M., "Coiled Tubing Deformation Mechanics: Diametral Growth and Elongation," paper SPE 36336 presented at the 1st North American SPE/ICoTA Coiled Tubing Roundtable, February 25-28, 1996

Nomenclature

A	Cross-sectional area of the CT, in^2
E	Modulus of elasticity, (27 X 10^6psi used)
F_a	Real axial force, lb
F_e	Effective axial force, lb
F_t	Transition force, lb
F_y	Full body yield force, lb
HBL	Helical Buckling Load, lb
L	Length, ft
r_i	Inner radius of CT, in
r_o	Outer radius of CT, in
r_y	Distance from neutral axis to beginning of yielded area, in
R_b	Bending radius, in
SP	Stuck point depth, ft
t	Wall thickness
α	Area variable
δ	Stretch, ft
Δ	Area shown in Figure 3, in^2
σ	Stress, psi
σ_y	Yield stress, psi
θ_i	Angle shown in Figure 3
θ_o	Angle shown in Figure 3

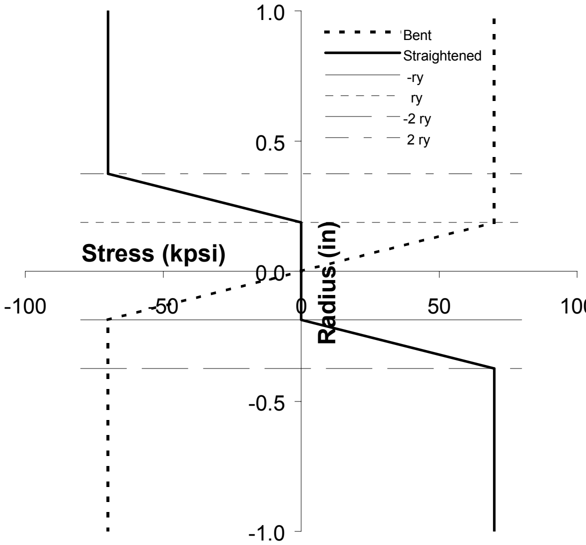

Figure 1 – Stress Profiles from Bending and Straightening

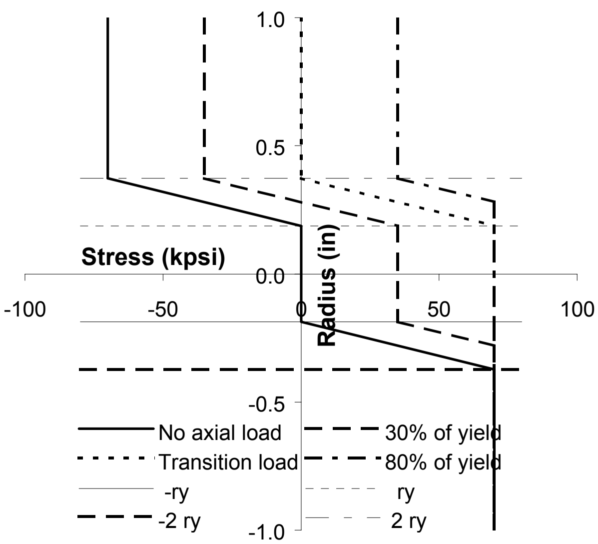

Figure 2 – Stress Profiles from Axial Force

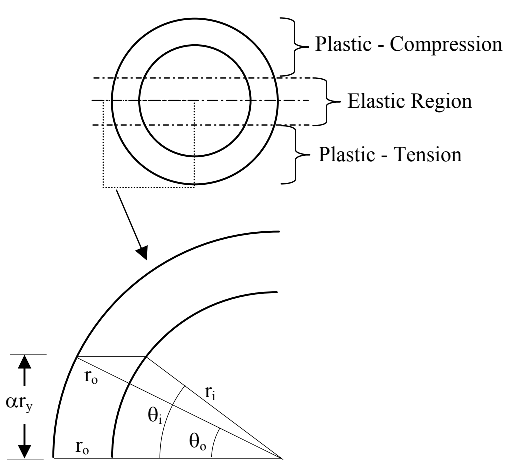

Figure 3 – Geometry of CT cross-section

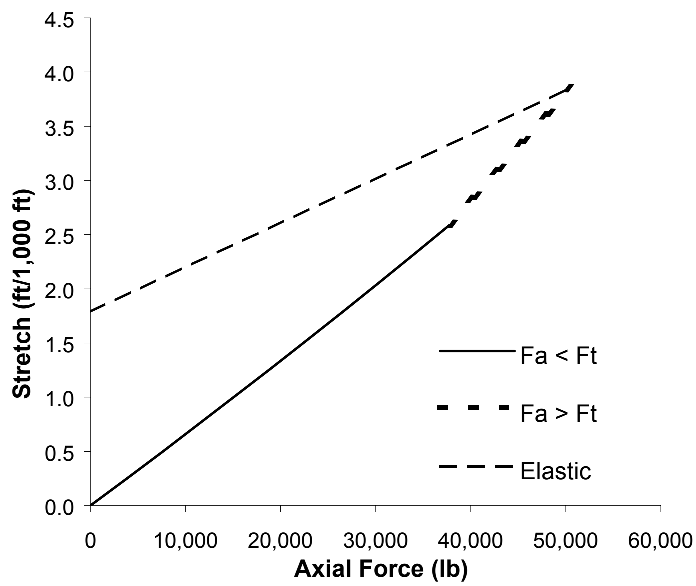

Figure 4 – Stretch of CT which has been bent

Table 1 - Stretch for 70,000 psi *(483 Mpa)* Yield CT in (ft/1,000 ft per 1,000 lbs) or *(m/1,000 m per 1,000 kg)*

CT OD		Wall		R_b		F_t		Elastic Stretch		Stretch $<F_t$		Stretch $>F_t$	
(in)	*(mm)*	(in)	*(mm)*	(in)	*(mm)*	(lb)	*(kg)*	(ft)	*(m)*	(ft)	*(m)*	(ft)	*(m)*
1.000	25.400	0.080	2.032	36	1.42	9,661	4,382	0.1602	0.0488	0.2677	0.0816	0.3989	0.1216
1.000	25.400	0.095	2.413	36	1.42	11,315	5,133	0.1371	0.0418	0.2285	0.0696	0.3429	0.1045
1.000	25.400	0.109	2.769	36	1.42	12,815	5,813	0.1214	0.0370	0.2017	0.0615	0.3048	0.0929
1.000	25.400	0.125	3.175	36	1.42	14,476	6,566	0.1078	0.0329	0.1785	0.0544	0.2720	0.0829
1.000	25.400	0.080	2.032	48	1.89	10,183	4,619	0.1602	0.0488	0.2530	0.0771	0.4365	0.1330
1.000	25.400	0.095	2.413	48	1.89	11,936	5,414	0.1371	0.0418	0.2158	0.0658	0.3761	0.1146
1.000	25.400	0.109	2.769	48	1.89	13,527	6,136	0.1214	0.0370	0.1904	0.0580	0.3351	0.1021
1.000	25.400	0.125	3.175	48	1.89	15,293	6,937	0.1078	0.0329	0.1683	0.0513	0.2998	0.0914
1.000	25.400	0.080	2.032	72	2.83	11,229	5,093	0.1602	0.0488	0.2261	0.0689	0.5495	0.1675
1.000	25.400	0.095	2.413	72	2.83	13,177	5,977	0.1371	0.0418	0.1924	0.0586	0.4772	0.1455
1.000	25.400	0.109	2.769	72	2.83	14,952	6,782	0.1214	0.0370	0.1694	0.0516	0.4286	0.1306
1.000	25.400	0.125	3.175	72	2.83	16,926	7,678	0.1078	0.0329	0.1493	0.0455	0.3873	0.1181
1.250	31.750	0.095	2.413	48	1.89	14,548	6,599	0.1074	0.0327	0.1777	0.0541	0.2719	0.0829
1.250	31.750	0.109	2.769	48	1.89	16,524	7,495	0.0948	0.0289	0.1564	0.0477	0.2407	0.0734
1.250	31.750	0.134	3.404	48	1.89	19,945	9,047	0.0788	0.0240	0.1295	0.0395	0.2014	0.0614
1.250	31.750	0.156	3.962	48	1.89	22,842	10,361	0.0691	0.0211	0.1131	0.0345	0.1775	0.0541
1.250	31.750	0.095	2.413	72	2.83	15,789	7,162	0.1074	0.0327	0.1625	0.0495	0.3171	0.0967
1.250	31.750	0.109	2.769	72	2.83	17,948	8,141	0.0948	0.0289	0.1429	0.0436	0.2816	0.0858
1.250	31.750	0.134	3.404	72	2.83	21,696	9,841	0.0788	0.0240	0.1181	0.0360	0.2371	0.0723
1.250	31.750	0.156	3.962	72	2.83	24,881	11,286	0.0691	0.0211	0.1029	0.0314	0.2101	0.0641
1.250	31.750	0.095	2.413	100	3.94	17,237	7,819	0.1074	0.0327	0.1461	0.0445	0.4061	0.1238
1.250	31.750	0.109	2.769	100	3.94	19,610	8,895	0.0948	0.0289	0.1282	0.0391	0.3634	0.1108
1.250	31.750	0.134	3.404	100	3.94	23,739	10,768	0.0788	0.0240	0.1056	0.0322	0.3106	0.0947
1.250	31.750	0.156	3.962	100	3.94	27,259	12,365	0.0691	0.0211	0.0917	0.0280	0.2796	0.0852
1.500	38.100	0.095	2.413	48	1.89	17,159	7,783	0.0883	0.0269	0.1508	0.0460	0.2131	0.0650
1.500	38.100	0.109	2.769	48	1.89	19,520	8,854	0.0778	0.0237	0.1326	0.0404	0.1880	0.0573
1.500	38.100	0.134	3.404	48	1.89	23,629	10,718	0.0644	0.0196	0.1095	0.0334	0.1564	0.0477
1.500	38.100	0.156	3.962	48	1.89	27,131	12,306	0.0562	0.0171	0.0954	0.0291	0.1370	0.0418
1.500	38.100	0.095	2.413	72	2.83	18,400	8,346	0.0883	0.0269	0.1401	0.0427	0.2391	0.0729
1.500	38.100	0.109	2.769	72	2.83	20,944	9,500	0.0778	0.0237	0.1230	0.0375	0.2112	0.0644
1.500	38.100	0.134	3.404	72	2.83	25,380	11,512	0.0644	0.0196	0.1015	0.0309	0.1762	0.0537
1.500	38.100	0.156	3.962	72	2.83	29,169	13,231	0.0562	0.0171	0.0883	0.0269	0.1548	0.0472
1.750	44.450	0.134	3.404	100	3.94	31,106	14,110	0.0544	0.0166	0.0825	0.0251	0.1601	0.0488
1.750	44.450	0.156	3.962	100	3.94	35,835	16,255	0.0474	0.0144	0.0716	0.0218	0.1404	0.0428
1.750	44.450	0.175	4.445	100	3.94	39,834	18,069	0.0428	0.0130	0.0644	0.0196	0.1275	0.0389
1.750	44.450	0.134	3.404	120	4.72	32,565	14,771	0.0544	0.0166	0.0782	0.0238	0.1792	0.0546
1.750	44.450	0.156	3.962	120	4.72	37,534	17,025	0.0474	0.0144	0.0678	0.0207	0.1577	0.0481
1.750	44.450	0.175	4.445	120	4.72	41,740	18,933	0.0428	0.0130	0.0609	0.0186	0.1436	0.0438
2.000	50.800	0.134	3.404	72	2.83	32,747	14,854	0.0471	0.0144	0.0790	0.0241	0.1170	0.0357
2.000	50.800	0.156	3.962	72	2.83	37,746	17,121	0.0410	0.0125	0.0685	0.0209	0.1020	0.0311
2.000	50.800	0.175	4.445	72	2.83	41,977	19,041	0.0369	0.0113	0.0616	0.0188	0.0921	0.0281
2.000	50.800	0.203	5.156	72	2.83	48,068	21,804	0.0323	0.0098	0.0538	0.0164	0.0810	0.0247
2.000	50.800	0.134	3.404	100	3.94	34,789	15,780	0.0471	0.0144	0.0740	0.0226	0.1298	0.0396
2.000	50.800	0.156	3.962	100	3.94	40,124	18,200	0.0410	0.0125	0.0642	0.0196	0.1134	0.0346
2.000	50.800	0.175	4.445	100	3.94	44,645	20,251	0.0369	0.0113	0.0577	0.0176	0.1026	0.0313
2.000	50.800	0.203	5.156	100	3.94	51,163	23,207	0.0323	0.0098	0.0503	0.0153	0.0904	0.0276
2.375	60.325	0.134	3.404	100	3.94	40,315	18,287	0.0393	0.0120	0.0641	0.0195	0.1014	0.0309
2.375	60.325	0.156	3.962	100	3.94	46,556	21,118	0.0341	0.0104	0.0555	0.0169	0.0882	0.0269
2.375	60.325	0.175	4.445	100	3.94	51,861	23,524	0.0306	0.0093	0.0498	0.0152	0.0795	0.0242
2.375	60.325	0.134	3.404	120	4.72	41,774	18,948	0.0393	0.0120	0.0617	0.0188	0.1081	0.0329
2.375	60.325	0.156	3.962	120	4.72	48,255	21,888	0.0341	0.0104	0.0534	0.0163	0.0941	0.0287
2.375	60.325	0.175	4.445	120	4.72	53,766	24,388	0.0306	0.0093	0.0479	0.0146	0.0849	0.0259

Table 2 - Stretch for 80,000 psi *(552 Mpa)*Yield CT in (ft/1,000 ft per 1,000 lbs) or *(m/1,000 m per 1,000 kg)*

CT OD		Wall		R_b		F_t		Elastic Stretch		Stretch <F_t		Stretch >F_t	
(in)	*(mm)*	(in)	*(mm)*	(in)	*(mm)*	(lb)	*(kg)*	(ft)	*(m)*	(ft)	*(m)*	(ft)	*(m)*
1.000	*25.400*	0.080	*2.032*	36	*1.42*	11,297	*5,124*	0.1602	*0.0488*	0.2613	*0.0796*	0.4140	*0.1262*
1.000	*25.400*	0.095	*2.413*	36	*1.42*	13,236	*6,004*	0.1371	*0.0418*	0.2229	*0.0679*	0.3562	*0.1086*
1.000	*25.400*	0.109	*2.769*	36	*1.42*	14,995	*6,802*	0.1214	*0.0370*	0.1967	*0.0600*	0.3169	*0.0966*
1.000	*25.400*	0.125	*3.175*	36	*1.42*	16,944	*7,686*	0.1078	*0.0329*	0.1741	*0.0531*	0.2831	*0.0863*
1.000	*25.400*	0.080	*2.032*	48	*1.89*	11,980	*5,434*	0.1602	*0.0488*	0.2451	*0.0747*	0.4624	*0.1409*
1.000	*25.400*	0.095	*2.413*	48	*1.89*	14,047	*6,371*	0.1371	*0.0418*	0.2089	*0.0637*	0.3990	*0.1216*
1.000	*25.400*	0.109	*2.769*	48	*1.89*	15,925	*7,223*	0.1214	*0.0370*	0.1842	*0.0561*	0.3561	*0.1085*
1.000	*25.400*	0.125	*3.175*	48	*1.89*	18,011	*8,170*	0.1078	*0.0329*	0.1627	*0.0496*	0.3192	*0.0973*
1.000	*25.400*	0.080	*2.032*	72	*2.83*	13,345	*6,053*	0.1602	*0.0488*	0.2149	*0.0655*	0.6288	*0.1916*
1.000	*25.400*	0.095	*2.413*	72	*2.83*	15,668	*7,107*	0.1371	*0.0418*	0.1827	*0.0557*	0.5499	*0.1676*
1.000	*25.400*	0.109	*2.769*	72	*2.83*	17,785	*8,067*	0.1214	*0.0370*	0.1606	*0.0489*	0.4975	*0.1516*
1.000	*25.400*	0.125	*3.175*	72	*2.83*	20,144	*9,137*	0.1078	*0.0329*	0.1413	*0.0431*	0.4540	*0.1384*
1.250	*31.750*	0.095	*2.413*	48	*1.89*	17,031	*7,725*	0.1074	*0.0327*	0.1732	*0.0528*	0.2831	*0.0863*
1.250	*31.750*	0.109	*2.769*	48	*1.89*	19,349	*8,777*	0.0948	*0.0289*	0.1524	*0.0464*	0.2508	*0.0764*
1.250	*31.750*	0.134	*3.404*	48	*1.89*	23,366	*10,599*	0.0788	*0.0240*	0.1261	*0.0384*	0.2102	*0.0641*
1.250	*31.750*	0.156	*3.962*	48	*1.89*	26,771	*12,143*	0.0691	*0.0211*	0.1101	*0.0335*	0.1855	*0.0565*
1.250	*31.750*	0.095	*2.413*	72	*2.83*	18,652	*8,461*	0.1074	*0.0327*	0.1564	*0.0477*	0.3433	*0.1046*
1.250	*31.750*	0.109	*2.769*	72	*2.83*	21,209	*9,621*	0.0948	*0.0289*	0.1374	*0.0419*	0.3055	*0.0931*
1.250	*31.750*	0.134	*3.404*	72	*2.83*	25,653	*11,636*	0.0788	*0.0240*	0.1135	*0.0346*	0.2582	*0.0787*
1.250	*31.750*	0.156	*3.962*	72	*2.83*	29,433	*13,351*	0.0691	*0.0211*	0.0988	*0.0301*	0.2298	*0.0700*
1.250	*31.750*	0.095	*2.413*	100	*3.94*	20,544	*9,319*	0.1074	*0.0327*	0.1377	*0.0420*	0.4888	*0.1490*
1.250	*31.750*	0.109	*2.769*	100	*3.94*	23,380	*10,605*	0.0948	*0.0289*	0.1207	*0.0368*	0.4415	*0.1345*
1.250	*31.750*	0.134	*3.404*	100	*3.94*	28,321	*12,846*	0.0788	*0.0240*	0.0991	*0.0302*	0.3850	*0.1173*
1.250	*31.750*	0.156	*3.962*	100	*3.94*	32,540	*14,760*	0.0691	*0.0211*	0.0858	*0.0261*	0.3549	*0.1082*
1.500	*38.100*	0.095	*2.413*	48	*1.89*	20,016	*9,079*	0.0883	*0.0269*	0.1476	*0.0450*	0.2198	*0.0670*
1.500	*38.100*	0.109	*2.769*	48	*1.89*	22,774	*10,330*	0.0778	*0.0237*	0.1298	*0.0395*	0.1940	*0.0591*
1.500	*38.100*	0.134	*3.404*	48	*1.89*	27,576	*12,508*	0.0644	*0.0196*	0.1071	*0.0327*	0.1615	*0.0492*
1.500	*38.100*	0.156	*3.962*	48	*1.89*	31,672	*14,366*	0.0562	*0.0171*	0.0933	*0.0284*	0.1416	*0.0432*
1.500	*38.100*	0.095	*2.413*	72	*2.83*	21,637	*9,814*	0.0883	*0.0269*	0.1358	*0.0414*	0.2528	*0.0770*
1.500	*38.100*	0.109	*2.769*	72	*2.83*	24,634	*11,174*	0.0778	*0.0237*	0.1192	*0.0363*	0.2236	*0.0681*
1.500	*38.100*	0.134	*3.404*	72	*2.83*	29,863	*13,546*	0.0644	*0.0196*	0.0983	*0.0300*	0.1868	*0.0569*
1.500	*38.100*	0.156	*3.962*	72	*2.83*	34,334	*15,574*	0.0562	*0.0171*	0.0854	*0.0260*	0.1645	*0.0501*
1.750	*44.450*	0.134	*3.404*	100	*3.94*	36,741	*16,665*	0.0544	*0.0166*	0.0794	*0.0242*	0.1731	*0.0528*
1.750	*44.450*	0.156	*3.962*	100	*3.94*	42,341	*19,206*	0.0474	*0.0144*	0.0689	*0.0210*	0.1522	*0.0464*
1.750	*44.450*	0.175	*4.445*	100	*3.94*	47,081	*21,356*	0.0428	*0.0130*	0.0619	*0.0189*	0.1385	*0.0422*
1.750	*44.450*	0.134	*3.404*	120	*4.72*	38,646	*17,530*	0.0544	*0.0166*	0.0746	*0.0227*	0.2014	*0.0614*
1.750	*44.450*	0.156	*3.962*	120	*4.72*	44,560	*20,212*	0.0474	*0.0144*	0.0646	*0.0197*	0.1781	*0.0543*
1.750	*44.450*	0.175	*4.445*	120	*4.72*	49,569	*22,485*	0.0428	*0.0130*	0.0580	*0.0177*	0.1629	*0.0496*
2.000	*50.800*	0.134	*3.404*	72	*2.83*	38,282	*17,365*	0.0471	*0.0144*	0.0771	*0.0235*	0.1213	*0.0370*
2.000	*50.800*	0.156	*3.962*	72	*2.83*	44,136	*20,020*	0.0410	*0.0125*	0.0669	*0.0204*	0.1059	*0.0323*
2.000	*50.800*	0.175	*4.445*	72	*2.83*	49,094	*22,269*	0.0369	*0.0113*	0.0601	*0.0183*	0.0956	*0.0292*
2.000	*50.800*	0.203	*5.156*	72	*2.83*	56,235	*25,508*	0.0323	*0.0098*	0.0525	*0.0160*	0.0841	*0.0256*
2.000	*50.800*	0.134	*3.404*	100	*3.94*	40,950	*18,575*	0.0471	*0.0144*	0.0716	*0.0218*	0.1379	*0.0420*
2.000	*50.800*	0.156	*3.962*	100	*3.94*	47,242	*21,429*	0.0410	*0.0125*	0.0621	*0.0189*	0.1206	*0.0368*
2.000	*50.800*	0.175	*4.445*	100	*3.94*	52,578	*23,849*	0.0369	*0.0113*	0.0558	*0.0170*	0.1092	*0.0333*
2.000	*50.800*	0.203	*5.156*	100	*3.94*	60,277	*27,341*	0.0323	*0.0098*	0.0486	*0.0148*	0.0964	*0.0294*
2.375	*60.325*	0.134	*3.404*	100	*3.94*	47,265	*21,439*	0.0393	*0.0120*	0.0623	*0.0190*	0.1061	*0.0323*
2.375	*60.325*	0.156	*3.962*	100	*3.94*	54,594	*24,763*	0.0341	*0.0104*	0.0540	*0.0164*	0.0923	*0.0281*
2.375	*60.325*	0.175	*4.445*	100	*3.94*	60,825	*27,590*	0.0306	*0.0093*	0.0484	*0.0148*	0.0833	*0.0254*
2.375	*60.325*	0.134	*3.404*	120	*4.72*	49,171	*22,304*	0.0393	*0.0120*	0.0597	*0.0182*	0.1148	*0.0350*
2.375	*60.325*	0.156	*3.962*	120	*4.72*	56,812	*25,770*	0.0341	*0.0104*	0.0516	*0.0157*	0.1001	*0.0305*
2.375	*60.325*	0.175	*4.445*	120	*4.72*	63,314	*28,719*	0.0306	*0.0093*	0.0463	*0.0141*	0.0904	*0.0275*

Table 3 - Stretch for 90,000 psi *(621 Mpa)*Yield CT in (ft/1,000 ft per 1,000 lbs) or *(m/1,000 m per 1,000 kg)*

CT OD		Wall		R_b		F_t		Elastic Stretch		Stretch $<F_t$		Stretch $>F_t$	
(in)	*(mm)*	(in)	*(mm)*	(in)	*(mm)*	(lb)	*(kg)*	(ft)	*(m)*	(ft)	*(m)*	(ft)	*(m)*
1.000	*25.400*	0.080	*2.032*	36	*1.42*	12,997	*5,895*	0.1602	*0.0488*	0.2551	*0.0777*	0.4306	*0.1312*
1.000	*25.400*	0.095	*2.413*	36	*1.42*	15,232	*6,909*	0.1371	*0.0418*	0.2176	*0.0663*	0.3709	*0.1130*
1.000	*25.400*	0.109	*2.769*	36	*1.42*	17,261	*7,830*	0.1214	*0.0370*	0.1919	*0.0585*	0.3303	*0.1007*
1.000	*25.400*	0.125	*3.175*	36	*1.42*	19,513	*8,851*	0.1078	*0.0329*	0.1697	*0.0517*	0.2954	*0.0900*
1.000	*25.400*	0.080	*2.032*	48	*1.89*	13,861	*6,287*	0.1602	*0.0488*	0.2374	*0.0723*	0.4926	*0.1501*
1.000	*25.400*	0.095	*2.413*	48	*1.89*	16,258	*7,375*	0.1371	*0.0418*	0.2022	*0.0616*	0.4260	*0.1298*
1.000	*25.400*	0.109	*2.769*	48	*1.89*	18,439	*8,364*	0.1214	*0.0370*	0.1782	*0.0543*	0.3809	*0.1161*
1.000	*25.400*	0.125	*3.175*	48	*1.89*	20,863	*9,463*	0.1078	*0.0329*	0.1573	*0.0479*	0.3423	*0.1043*
1.000	*25.400*	0.080	*2.032*	72	*2.83*	15,589	*7,071*	0.1602	*0.0488*	0.2035	*0.0620*	0.7518	*0.2291*
1.000	*25.400*	0.095	*2.413*	72	*2.83*	18,310	*8,306*	0.1371	*0.0418*	0.1726	*0.0526*	0.6665	*0.2031*
1.000	*25.400*	0.109	*2.769*	72	*2.83*	20,793	*9,432*	0.1214	*0.0370*	0.1514	*0.0461*	0.6124	*0.1867*
1.000	*25.400*	0.125	*3.175*	72	*2.83*	23,563	*10,688*	0.1078	*0.0329*	0.1328	*0.0405*	0.5722	*0.1744*
1.250	*31.750*	0.095	*2.413*	48	*1.89*	19,616	*8,898*	0.1074	*0.0327*	0.1688	*0.0515*	0.2955	*0.0901*
1.250	*31.750*	0.109	*2.769*	48	*1.89*	22,291	*10,111*	0.0948	*0.0289*	0.1485	*0.0453*	0.2620	*0.0799*
1.250	*31.750*	0.134	*3.404*	48	*1.89*	26,930	*12,215*	0.0788	*0.0240*	0.1229	*0.0374*	0.2200	*0.0670*
1.250	*31.750*	0.156	*3.962*	48	*1.89*	30,866	*14,001*	0.0691	*0.0211*	0.1071	*0.0327*	0.1944	*0.0593*
1.250	*31.750*	0.095	*2.413*	72	*2.83*	21,668	*9,829*	0.1074	*0.0327*	0.1504	*0.0458*	0.3762	*0.1147*
1.250	*31.750*	0.109	*2.769*	72	*2.83*	24,645	*11,179*	0.0948	*0.0289*	0.1321	*0.0403*	0.3357	*0.1023*
1.250	*31.750*	0.134	*3.404*	72	*2.83*	29,824	*13,528*	0.0788	*0.0240*	0.1089	*0.0332*	0.2853	*0.0870*
1.250	*31.750*	0.156	*3.962*	72	*2.83*	34,236	*15,529*	0.0691	*0.0211*	0.0947	*0.0289*	0.2553	*0.0778*
1.250	*31.750*	0.095	*2.413*	100	*3.94*	24,062	*10,914*	0.1074	*0.0327*	0.1286	*0.0392*	0.6521	*0.1988*
1.250	*31.750*	0.109	*2.769*	100	*3.94*	27,392	*12,425*	0.0948	*0.0289*	0.1124	*0.0343*	0.6058	*0.1846*
1.250	*31.750*	0.134	*3.404*	100	*3.94*	33,201	*15,060*	0.0788	*0.0240*	0.0920	*0.0280*	0.5508	*0.1679*
1.250	*31.750*	0.156	*3.962*	100	*3.94*	38,167	*17,312*	0.0691	*0.0211*	0.0804	*0.0245*	0.4906	*0.1495*
1.500	*38.100*	0.095	*2.413*	48	*1.89*	22,974	*10,421*	0.0883	*0.0269*	0.1446	*0.0441*	0.2271	*0.0692*
1.500	*38.100*	0.109	*2.769*	48	*1.89*	26,143	*11,859*	0.0778	*0.0237*	0.1270	*0.0387*	0.2005	*0.0611*
1.500	*38.100*	0.134	*3.404*	48	*1.89*	31,666	*14,364*	0.0644	*0.0196*	0.1048	*0.0320*	0.1670	*0.0509*
1.500	*38.100*	0.156	*3.962*	48	*1.89*	36,380	*16,502*	0.0562	*0.0171*	0.0912	*0.0278*	0.1465	*0.0447*
1.500	*38.100*	0.095	*2.413*	72	*2.83*	25,026	*11,352*	0.0883	*0.0269*	0.1316	*0.0401*	0.2687	*0.0819*
1.500	*38.100*	0.109	*2.769*	72	*2.83*	28,498	*12,927*	0.0778	*0.0237*	0.1155	*0.0352*	0.2380	*0.0725*
1.500	*38.100*	0.134	*3.404*	72	*2.83*	34,560	*15,677*	0.0644	*0.0196*	0.0952	*0.0290*	0.1993	*0.0607*
1.500	*38.100*	0.156	*3.962*	72	*2.83*	39,749	*18,030*	0.0562	*0.0171*	0.0827	*0.0252*	0.1758	*0.0536*
1.750	*44.450*	0.134	*3.404*	100	*3.94*	42,673	*19,356*	0.0544	*0.0166*	0.0764	*0.0233*	0.1894	*0.0577*
1.750	*44.450*	0.156	*3.962*	100	*3.94*	49,194	*22,314*	0.0474	*0.0144*	0.0662	*0.0202*	0.1670	*0.0509*
1.750	*44.450*	0.175	*4.445*	100	*3.94*	54,716	*24,819*	0.0428	*0.0130*	0.0595	*0.0181*	0.1524	*0.0464*
1.750	*44.450*	0.134	*3.404*	120	*4.72*	45,085	*20,451*	0.0544	*0.0166*	0.0710	*0.0216*	0.2336	*0.0712*
1.750	*44.450*	0.156	*3.962*	120	*4.72*	52,002	*23,588*	0.0474	*0.0144*	0.0614	*0.0187*	0.2080	*0.0634*
1.750	*44.450*	0.175	*4.445*	120	*4.72*	57,866	*26,248*	0.0428	*0.0130*	0.0551	*0.0168*	0.1917	*0.0584*
2.000	*50.800*	0.134	*3.404*	72	*2.83*	44,032	*19,973*	0.0471	*0.0144*	0.0753	*0.0230*	0.1261	*0.0384*
2.000	*50.800*	0.156	*3.962*	72	*2.83*	50,776	*23,032*	0.0410	*0.0125*	0.0653	*0.0199*	0.1101	*0.0336*
2.000	*50.800*	0.175	*4.445*	72	*2.83*	56,491	*25,624*	0.0369	*0.0113*	0.0587	*0.0179*	0.0995	*0.0303*
2.000	*50.800*	0.203	*5.156*	72	*2.83*	64,726	*29,359*	0.0323	*0.0098*	0.0512	*0.0156*	0.0876	*0.0267*
2.000	*50.800*	0.134	*3.404*	100	*3.94*	47,409	*21,505*	0.0471	*0.0144*	0.0693	*0.0211*	0.1474	*0.0449*
2.000	*50.800*	0.156	*3.962*	100	*3.94*	54,708	*24,815*	0.0410	*0.0125*	0.0600	*0.0183*	0.1291	*0.0393*
2.000	*50.800*	0.175	*4.445*	100	*3.94*	60,901	*27,624*	0.0369	*0.0113*	0.0539	*0.0164*	0.1171	*0.0357*
2.000	*50.800*	0.203	*5.156*	100	*3.94*	69,841	*31,680*	0.0323	*0.0098*	0.0470	*0.0143*	0.1036	*0.0316*
2.375	*60.325*	0.134	*3.404*	100	*3.94*	54,513	*24,727*	0.0393	*0.0120*	0.0607	*0.0185*	0.1113	*0.0339*
2.375	*60.325*	0.156	*3.962*	100	*3.94*	62,978	*28,567*	0.0341	*0.0104*	0.0525	*0.0160*	0.0970	*0.0296*
2.375	*60.325*	0.175	*4.445*	100	*3.94*	70,178	*31,833*	0.0306	*0.0093*	0.0471	*0.0144*	0.0876	*0.0267*
2.375	*60.325*	0.134	*3.404*	120	*4.72*	56,925	*25,821*	0.0393	*0.0120*	0.0577	*0.0176*	0.1227	*0.0374*
2.375	*60.325*	0.156	*3.962*	120	*4.72*	65,786	*29,840*	0.0341	*0.0104*	0.0499	*0.0152*	0.1071	*0.0326*
2.375	*60.325*	0.175	*4.445*	120	*4.72*	73,328	*33,261*	0.0306	*0.0093*	0.0448	*0.0136*	0.0968	*0.0295*

Table 4 - Stretch for 100,000 psi *(689 Mpa)*Yield CT in (ft/1,000 ft per 1,000 lbs) or *(m/1,000 m per 1,000 kg)*

CT OD		Wall		R_b		F_t		Elastic Stretch		Stretch $<F_t$		Stretch $>F_t$	
(in)	*(mm)*	(in)	*(mm)*	(in)	*(mm)*	(lb)	*(kg)*	(ft)	*(m)*	(ft)	*(m)*	(ft)	*(m)*
1.000	*25.400*	0.080	*2.032*	36	*1.42*	14,761	*6,696*	0.1602	*0.0488*	0.2490	*0.0759*	0.4490	*0.1368*
1.000	*25.400*	0.095	*2.413*	36	*1.42*	17,305	*7,849*	0.1371	*0.0418*	0.2123	*0.0647*	0.3871	*0.1180*
1.000	*25.400*	0.109	*2.769*	36	*1.42*	19,615	*8,897*	0.1214	*0.0370*	0.1872	*0.0571*	0.3452	*0.1052*
1.000	*25.400*	0.125	*3.175*	36	*1.42*	22,181	*10,061*	0.1078	*0.0329*	0.1655	*0.0504*	0.3091	*0.0942*
1.000	*25.400*	0.080	*2.032*	48	*1.89*	15,828	*7,179*	0.1602	*0.0488*	0.2298	*0.0700*	0.5286	*0.1611*
1.000	*25.400*	0.095	*2.413*	48	*1.89*	18,572	*8,424*	0.1371	*0.0418*	0.1957	*0.0596*	0.4584	*0.1397*
1.000	*25.400*	0.109	*2.769*	48	*1.89*	21,069	*9,557*	0.1214	*0.0370*	0.1723	*0.0525*	0.4109	*0.1253*
1.000	*25.400*	0.125	*3.175*	48	*1.89*	23,847	*10,817*	0.1078	*0.0329*	0.1520	*0.0463*	0.3706	*0.1130*
1.000	*25.400*	0.080	*2.032*	72	*2.83*	17,961	*8,147*	0.1602	*0.0488*	0.1911	*0.0583*	0.9891	*0.3015*
1.000	*25.400*	0.095	*2.413*	72	*2.83*	21,105	*9,573*	0.1371	*0.0418*	0.1613	*0.0492*	0.9156	*0.2791*
1.000	*25.400*	0.109	*2.769*	72	*2.83*	23,975	*10,875*	0.1214	*0.0370*	0.1416	*0.0432*	0.8500	*0.2591*
1.000	*25.400*	0.125	*3.175*	72	*2.83*	27,181	*12,329*	0.1078	*0.0329*	0.1254	*0.0382*	0.7656	*0.2333*
1.250	*31.750*	0.095	*2.413*	48	*1.89*	22,302	*10,116*	0.1074	*0.0327*	0.1646	*0.0502*	0.3095	*0.0943*
1.250	*31.750*	0.109	*2.769*	48	*1.89*	25,349	*11,498*	0.0948	*0.0289*	0.1447	*0.0441*	0.2747	*0.0837*
1.250	*31.750*	0.134	*3.404*	48	*1.89*	30,637	*13,897*	0.0788	*0.0240*	0.1197	*0.0365*	0.2310	*0.0704*
1.250	*31.750*	0.156	*3.962*	48	*1.89*	35,128	*15,934*	0.0691	*0.0211*	0.1043	*0.0318*	0.2045	*0.0623*
1.250	*31.750*	0.095	*2.413*	72	*2.83*	24,836	*11,265*	0.1074	*0.0327*	0.1444	*0.0440*	0.4195	*0.1279*
1.250	*31.750*	0.109	*2.769*	72	*2.83*	28,256	*12,817*	0.0948	*0.0289*	0.1268	*0.0386*	0.3759	*0.1146*
1.250	*31.750*	0.134	*3.404*	72	*2.83*	34,210	*15,518*	0.0788	*0.0240*	0.1044	*0.0318*	0.3222	*0.0982*
1.250	*31.750*	0.156	*3.962*	72	*2.83*	39,288	*17,821*	0.0691	*0.0211*	0.0906	*0.0276*	0.2909	*0.0887*
1.250	*31.750*	0.095	*2.413*	100	*3.94*	27,791	*12,606*	0.1074	*0.0327*	0.1193	*0.0363*	1.0849	*0.3307*
1.250	*31.750*	0.109	*2.769*	100	*3.94*	31,647	*14,355*	0.0948	*0.0289*	0.1050	*0.0320*	0.9709	*0.2959*
1.250	*31.750*	0.134	*3.404*	100	*3.94*	38,379	*17,409*	0.0788	*0.0240*	0.0872	*0.0266*	0.8175	*0.2492*
1.250	*31.750*	0.156	*3.962*	100	*3.94*	44,141	*20,022*	0.0691	*0.0211*	0.0764	*0.0233*	0.7177	*0.2187*
1.500	*38.100*	0.095	*2.413*	48	*1.89*	26,033	*11,808*	0.0883	*0.0269*	0.1416	*0.0431*	0.2349	*0.0716*
1.500	*38.100*	0.109	*2.769*	48	*1.89*	29,630	*13,440*	0.0778	*0.0237*	0.1244	*0.0379*	0.2075	*0.0632*
1.500	*38.100*	0.134	*3.404*	48	*1.89*	35,899	*16,284*	0.0644	*0.0196*	0.1026	*0.0313*	0.1730	*0.0527*
1.500	*38.100*	0.156	*3.962*	48	*1.89*	41,254	*18,713*	0.0562	*0.0171*	0.0893	*0.0272*	0.1519	*0.0463*
1.500	*38.100*	0.095	*2.413*	72	*2.83*	28,566	*12,958*	0.0883	*0.0269*	0.1275	*0.0389*	0.2876	*0.0877*
1.500	*38.100*	0.109	*2.769*	72	*2.83*	32,536	*14,758*	0.0778	*0.0237*	0.1119	*0.0341*	0.2551	*0.0777*
1.500	*38.100*	0.134	*3.404*	72	*2.83*	39,472	*17,905*	0.0644	*0.0196*	0.0921	*0.0281*	0.2142	*0.0653*
1.500	*38.100*	0.156	*3.962*	72	*2.83*	45,414	*20,600*	0.0562	*0.0171*	0.0800	*0.0244*	0.1895	*0.0578*
1.750	*44.450*	0.134	*3.404*	100	*3.94*	48,904	*22,183*	0.0544	*0.0166*	0.0734	*0.0224*	0.2107	*0.0642*
1.750	*44.450*	0.156	*3.962*	100	*3.94*	56,393	*25,580*	0.0474	*0.0144*	0.0636	*0.0194*	0.1866	*0.0569*
1.750	*44.450*	0.175	*4.445*	100	*3.94*	62,740	*28,458*	0.0428	*0.0130*	0.0570	*0.0174*	0.1710	*0.0521*
1.750	*44.450*	0.134	*3.404*	120	*4.72*	51,881	*23,533*	0.0544	*0.0166*	0.0672	*0.0205*	0.2867	*0.0874*
1.750	*44.450*	0.156	*3.962*	120	*4.72*	59,860	*27,152*	0.0474	*0.0144*	0.0580	*0.0177*	0.2596	*0.0791*
1.750	*44.450*	0.175	*4.445*	120	*4.72*	66,628	*30,222*	0.0428	*0.0130*	0.0519	*0.0158*	0.2436	*0.0742*
2.000	*50.800*	0.134	*3.404*	72	*2.83*	49,997	*22,678*	0.0471	*0.0144*	0.0735	*0.0224*	0.1314	*0.0400*
2.000	*50.800*	0.156	*3.962*	72	*2.83*	57,666	*26,157*	0.0410	*0.0125*	0.0637	*0.0194*	0.1148	*0.0350*
2.000	*50.800*	0.175	*4.445*	72	*2.83*	64,167	*29,106*	0.0369	*0.0113*	0.0573	*0.0175*	0.1038	*0.0316*
2.000	*50.800*	0.203	*5.156*	72	*2.83*	73,541	*33,358*	0.0323	*0.0098*	0.0500	*0.0152*	0.0915	*0.0279*
2.000	*50.800*	0.134	*3.404*	100	*3.94*	54,166	*24,569*	0.0471	*0.0144*	0.0671	*0.0204*	0.1588	*0.0484*
2.000	*50.800*	0.156	*3.962*	100	*3.94*	62,519	*28,359*	0.0410	*0.0125*	0.0580	*0.0177*	0.1394	*0.0425*
2.000	*50.800*	0.175	*4.445*	100	*3.94*	69,612	*31,576*	0.0369	*0.0113*	0.0521	*0.0159*	0.1267	*0.0386*
2.000	*50.800*	0.203	*5.156*	100	*3.94*	79,857	*36,223*	0.0323	*0.0098*	0.0454	*0.0138*	0.1124	*0.0343*
2.375	*60.325*	0.134	*3.404*	100	*3.94*	62,059	*28,150*	0.0393	*0.0120*	0.0590	*0.0180*	0.1172	*0.0357*
2.375	*60.325*	0.156	*3.962*	100	*3.94*	71,709	*32,527*	0.0341	*0.0104*	0.0511	*0.0156*	0.1023	*0.0312*
2.375	*60.325*	0.175	*4.445*	100	*3.94*	79,920	*36,252*	0.0306	*0.0093*	0.0458	*0.0140*	0.0924	*0.0282*
2.375	*60.325*	0.134	*3.404*	120	*4.72*	65,037	*29,500*	0.0393	*0.0120*	0.0559	*0.0170*	0.1321	*0.0403*
2.375	*60.325*	0.156	*3.962*	120	*4.72*	75,175	*34,099*	0.0341	*0.0104*	0.0483	*0.0147*	0.1156	*0.0352*
2.375	*60.325*	0.175	*4.445*	120	*4.72*	83,809	*38,016*	0.0306	*0.0093*	0.0433	*0.0132*	0.1047	*0.0319*

Table 5 - Stretch for 110,000 psi *(758 Mpa)*Yield CT in (ft/1,000 ft per 1,000 lbs) or *(m/1,000 m per 1,000 kg)*

CT OD		Wall		R_b		F_t		Elastic Stretch		Stretch $<F_t$		Stretch $>F_t$	
(in)	*(mm)*	(in)	*(mm)*	(in)	*(mm)*	(lb)	*(kg)*	(ft)	*(m)*	(ft)	*(m)*	(ft)	*(m)*
1.000	*25.400*	0.080	*2.032*	36	*1.42*	16,589	*7,525*	0.1602	*0.0488*	0.2431	*0.0741*	0.4695	*0.1431*
1.000	*25.400*	0.095	*2.413*	36	*1.42*	19,453	*8,824*	0.1371	*0.0418*	0.2072	*0.0632*	0.4054	*0.1235*
1.000	*25.400*	0.109	*2.769*	36	*1.42*	22,057	*10,005*	0.1214	*0.0370*	0.1827	*0.0557*	0.3619	*0.1103*
1.000	*25.400*	0.125	*3.175*	36	*1.42*	24,949	*11,317*	0.1078	*0.0329*	0.1614	*0.0492*	0.3246	*0.0989*
1.000	*25.400*	0.080	*2.032*	48	*1.89*	17,880	*8,110*	0.1602	*0.0488*	0.2224	*0.0678*	0.5728	*0.1746*
1.000	*25.400*	0.095	*2.413*	48	*1.89*	20,986	*9,519*	0.1371	*0.0418*	0.1892	*0.0577*	0.4984	*0.1519*
1.000	*25.400*	0.109	*2.769*	48	*1.89*	23,815	*10,802*	0.1214	*0.0370*	0.1664	*0.0507*	0.4485	*0.1367*
1.000	*25.400*	0.125	*3.175*	48	*1.89*	26,965	*12,231*	0.1078	*0.0329*	0.1467	*0.0447*	0.4064	*0.1239*
1.000	*25.400*	0.080	*2.032*	72	*2.83*	20,461	*9,281*	0.1602	*0.0488*	0.1787	*0.0545*	1.5439	*0.4706*
1.000	*25.400*	0.095	*2.413*	72	*2.83*	24,051	*10,910*	0.1371	*0.0418*	0.1527	*0.0465*	1.3443	*0.4097*
1.000	*25.400*	0.109	*2.769*	72	*2.83*	27,332	*12,398*	0.1214	*0.0370*	0.1351	*0.0412*	1.1995	*0.3656*
1.000	*25.400*	0.125	*3.175*	72	*2.83*	30,999	*14,061*	0.1078	*0.0329*	0.1199	*0.0365*	1.0681	*0.3255*
1.250	*31.750*	0.095	*2.413*	48	*1.89*	25,090	*11,381*	0.1074	*0.0327*	0.1604	*0.0489*	0.3253	*0.0991*
1.250	*31.750*	0.109	*2.769*	48	*1.89*	28,524	*12,938*	0.0948	*0.0289*	0.1411	*0.0430*	0.2890	*0.0881*
1.250	*31.750*	0.134	*3.404*	48	*1.89*	34,487	*15,643*	0.0788	*0.0240*	0.1166	*0.0355*	0.2436	*0.0742*
1.250	*31.750*	0.156	*3.962*	48	*1.89*	39,556	*17,942*	0.0691	*0.0211*	0.1015	*0.0309*	0.2162	*0.0659*
1.250	*31.750*	0.095	*2.413*	72	*2.83*	28,155	*12,771*	0.1074	*0.0327*	0.1384	*0.0422*	0.4804	*0.1464*
1.250	*31.750*	0.109	*2.769*	72	*2.83*	32,041	*14,534*	0.0948	*0.0289*	0.1213	*0.0370*	0.4334	*0.1321*
1.250	*31.750*	0.134	*3.404*	72	*2.83*	38,811	*17,604*	0.0788	*0.0240*	0.0997	*0.0304*	0.3771	*0.1149*
1.250	*31.750*	0.156	*3.962*	72	*2.83*	44,589	*20,226*	0.0691	*0.0211*	0.0863	*0.0263*	0.3465	*0.1056*
1.250	*31.750*	0.095	*2.413*	100	*3.94*	31,731	*14,393*	0.1074	*0.0327*	0.1117	*0.0340*	2.8360	*0.8644*
1.250	*31.750*	0.109	*2.769*	100	*3.94*	36,144	*16,395*	0.0948	*0.0289*	0.0985	*0.0300*	2.4867	*0.7579*
1.250	*31.750*	0.134	*3.404*	100	*3.94*	43,855	*19,892*	0.0788	*0.0240*	0.0820	*0.0250*	2.0384	*0.6213*
1.250	*31.750*	0.156	*3.962*	100	*3.94*	50,462	*22,889*	0.0691	*0.0211*	0.0719	*0.0219*	1.7593	*0.5362*
1.500	*38.100*	0.095	*2.413*	48	*1.89*	29,193	*13,242*	0.0883	*0.0269*	0.1386	*0.0423*	0.2434	*0.0742*
1.500	*38.100*	0.109	*2.769*	48	*1.89*	33,232	*15,074*	0.0778	*0.0237*	0.1218	*0.0371*	0.2152	*0.0656*
1.500	*38.100*	0.134	*3.404*	48	*1.89*	40,275	*18,269*	0.0644	*0.0196*	0.1004	*0.0306*	0.1796	*0.0547*
1.500	*38.100*	0.156	*3.962*	48	*1.89*	46,295	*20,999*	0.0562	*0.0171*	0.0873	*0.0266*	0.1579	*0.0481*
1.500	*38.100*	0.095	*2.413*	72	*2.83*	32,259	*14,633*	0.0883	*0.0269*	0.1234	*0.0376*	0.3105	*0.0946*
1.500	*38.100*	0.109	*2.769*	72	*2.83*	36,749	*16,669*	0.0778	*0.0237*	0.1083	*0.0330*	0.2759	*0.0841*
1.500	*38.100*	0.134	*3.404*	72	*2.83*	44,599	*20,230*	0.0644	*0.0196*	0.0891	*0.0271*	0.2326	*0.0709*
1.500	*38.100*	0.156	*3.962*	72	*2.83*	51,328	*23,282*	0.0562	*0.0171*	0.0773	*0.0236*	0.2065	*0.0629*
1.750	*44.450*	0.134	*3.404*	100	*3.94*	55,432	*25,144*	0.0544	*0.0166*	0.0704	*0.0214*	0.2405	*0.0733*
1.750	*44.450*	0.156	*3.962*	100	*3.94*	63,939	*29,003*	0.0474	*0.0144*	0.0609	*0.0185*	0.2146	*0.0654*
1.750	*44.450*	0.175	*4.445*	100	*3.94*	71,152	*32,274*	0.0428	*0.0130*	0.0546	*0.0166*	0.1981	*0.0604*
1.750	*44.450*	0.134	*3.404*	120	*4.72*	59,035	*26,778*	0.0544	*0.0166*	0.0628	*0.0191*	0.4086	*0.1245*
1.750	*44.450*	0.156	*3.962*	120	*4.72*	68,134	*30,905*	0.0474	*0.0144*	0.0543	*0.0165*	0.3757	*0.1145*
1.750	*44.450*	0.175	*4.445*	120	*4.72*	75,858	*34,409*	0.0428	*0.0130*	0.0488	*0.0149*	0.3441	*0.1049*
2.000	*50.800*	0.134	*3.404*	72	*2.83*	56,176	*25,481*	0.0471	*0.0144*	0.0718	*0.0219*	0.1372	*0.0418*
2.000	*50.800*	0.156	*3.962*	72	*2.83*	64,806	*29,396*	0.0410	*0.0125*	0.0622	*0.0190*	0.1200	*0.0366*
2.000	*50.800*	0.175	*4.445*	72	*2.83*	72,124	*32,715*	0.0369	*0.0113*	0.0559	*0.0170*	0.1086	*0.0331*
2.000	*50.800*	0.203	*5.156*	72	*2.83*	82,682	*37,504*	0.0323	*0.0098*	0.0487	*0.0149*	0.0959	*0.0292*
2.000	*50.800*	0.134	*3.404*	100	*3.94*	61,220	*27,769*	0.0471	*0.0144*	0.0648	*0.0198*	0.1730	*0.0527*
2.000	*50.800*	0.156	*3.962*	100	*3.94*	70,678	*32,059*	0.0410	*0.0125*	0.0561	*0.0171*	0.1523	*0.0464*
2.000	*50.800*	0.175	*4.445*	100	*3.94*	78,712	*35,703*	0.0369	*0.0113*	0.0503	*0.0153*	0.1387	*0.0423*
2.000	*50.800*	0.203	*5.156*	100	*3.94*	90,324	*40,971*	0.0323	*0.0098*	0.0438	*0.0133*	0.1237	*0.0377*
2.375	*60.325*	0.134	*3.404*	100	*3.94*	69,903	*31,708*	0.0393	*0.0120*	0.0574	*0.0175*	0.1241	*0.0378*
2.375	*60.325*	0.156	*3.962*	100	*3.94*	80,786	*36,644*	0.0341	*0.0104*	0.0497	*0.0151*	0.1084	*0.0330*
2.375	*60.325*	0.175	*4.445*	100	*3.94*	90,051	*40,847*	0.0306	*0.0093*	0.0445	*0.0136*	0.0980	*0.0299*
2.375	*60.325*	0.134	*3.404*	120	*4.72*	73,506	*33,342*	0.0393	*0.0120*	0.0540	*0.0165*	0.1439	*0.0439*
2.375	*60.325*	0.156	*3.962*	120	*4.72*	84,981	*38,547*	0.0341	*0.0104*	0.0467	*0.0142*	0.1262	*0.0384*
2.375	*60.325*	0.175	*4.445*	120	*4.72*	94,757	*42,981*	0.0306	*0.0093*	0.0418	*0.0127*	0.1145	*0.0349*