Lai and my PVC pipe PhL 4.14.12

This relates to Lai p 267 concerning pipes.

PVC pipe Example: how much $T_{\theta\theta}$ can it take? We will set $T_{\theta\theta} = p_i \, 2 / [(b/a)^2 - 1]$

Conclusion : theory agrees with practice, ball park.

Property	Rigid PVC	Flexible PVC
Density [g/cm^3][10]	1.3–1.45	1.1–1.35
Thermal conductivity [W/(m·K)][11]	0.14–0.28	0.14–0.17
Yield strength [MPa][10]	31–60	10–25
Young's modulus [psi]	490,000[12]	
Flexural strength (yield) [psi]	10,500[12]	
Compression strength [psi]	9500[12]	
Coefficient of thermal expansion (linear) [mm/(mm °C)]	5×10^{-5}[12]	
Vicat B [°C][11]	65–100	Not recommended
Resistivity [Ω m][13][14]	10^{16}	10^{12}–10^{15}
Surface resistivity [Ω][13][14]	10^{13}–10^{14}	10^{11}–10^{12}

I guess the PVC pipe would be "rigid".

The **yield strength** or **yield point** of a material is defined in engineering and materials science as the stress at which a material begins to deform plastically.

So let's do some measurements right now, or look it up

PVC Pipe

Superior Quality Piping for a Wide Range of Applications

SCHEDULE 40 & 80 - DIMENSIONS

Schedule 40 Dimensions

Nom. Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI**
1/8"	0.405	0.249	0.068	0.051	810
1/4"	0.540	0.344	0.088	0.086	780
3/8"	0.675	0.473	0.091	0.115	620
1/2"	0.840	0.602	0.109	0.170	600
3/4"	1.050	0.804	0.113	0.226	480
1"	1.315	1.029	0.133	0.333	450

The stuff we use for sprinklers has ID ≈ OD ≈ 1", so it is the 3/4" nominal. Then

a = 0.804" b = 1.050: $(b/a)^2 = 1.71$

My condition will be at the outer surface so

$$T_{\theta\theta} = YS = T_{\theta\theta} = p_i\, 2 / [\, (b/a)^2 - 1\,] = p_i 2/.71 = 2.8\, p_i$$

So the pipe starts stretching when

$$p_i = T_{\theta\theta}/2.8 = 31 \text{ MPa}/2.8 = 11 \text{ MPa} \approx 10 \text{ atmos} \approx 150 \text{ psi}$$

That is not really very much! I used the low end of the yield strength range, the high end would give 300 psi, and my pipe has 200 psi printed on it! This is for the weaker "Schedule 40" type pipe. Here is a table suggesting 480 psi.

Rigid & Flexible PVC Pipe Size Chart with ID/OD Dimensions & Pressure Ratings, including Clear PVC Pipe												
Buy this size, ie, "nominal"	Pipe Outside Diameter, OD Tolerance +/- .01"/.25mm (Inches, millimeters)	Schedule 40 ASTM D1785					Schedule 80 ASTM D1785			Class 200 ASTM D2241		
		ID* Inches	Wall Thickness* Inches	Rigid Pipe P.S.I.**	CLEAR Rigid Pipe P.S.I.**	FlexPVC Pipe Working/Burst P.S.I.**@68F (MORE DATA)	ID* Inches	Wall Thickness* Inches	P.S.I.**	ID* Inches	Wall Thickness* Inches	P.S.I.**
1/8"	.405 (~13/32", 10.31mm)	.249	.068	810	--	--/--	.195	.095	1230	--	--	--
1/4"	.540 (~1/2", 13.75mm)	.344	.088	780	390	--/--	.282	.119	1130	--	--	--
3/8"	.675 (~5/8", 17.14mm)	.473	.091	620	310	--/--	.403	.126	920	--	--	--
1/2"	.840 (~7/8", 21.336mm)	.622	.109	600	300	100/400 [BUY]	.546	.147	850	0.716	0.062	200
3/4"	1.050 (~1", 26.670mm)	.824	.113	480	240	100/400 [BUY]	.742	.154	690	0.930	0.060	200

But here is a different quote on yield strength

Mechanical			
Tensile Modulus	D 638	psi	411,000
Yield Strength	D 638	psi	7,500
Flexural Modulus	D 790	psi	481,000
Yield Strength	D 790	psi	12,800
Izod Impact	D 256	ft-lb/in	1.0

I think "tensile modulus" means Young's modulus at 411,000 psi here and 490,000 psi in the previous table, so ball park. Here yield strength is 7500 psi and 1 MPa is 145 psi so this is 7500/145 = 51.72 MPa, again in our range!

Here from a PDF

Table 9
Water Pressure Ratings of
Schedule 40 PVC Plastic Pipe
ASTM D 1785

Nominal Pipe Size (in.)	Pressure Ratings (in psi) at 23°C*			
	PVC 1120 PVC 1220	PVC 2116 CPVC 4110	PVC 2110	PVC 2112
1/8	810	650	400	500
1/4	780	620	390	490
3/8	620	500	310	390
1/2	600	480	300	370
3/4	480	390	240	300
1	450	360	220	280

which shows a range of 240-480 psi depending on the **kind of PVC** ! They note that Sch 40 is too thin to allow threaded connections, whereas Sch 80 does allow that, though you get much lower psi rating.