AutoCad Project: Bellows Assembly per 18001

Used on US Navy Pilot Oxygen Regulator System. At high altitudes there is not sufficient oxygen to sustain life in case a pilot needs to eject from the airplane. Therefore, a supplemental oxygen supply is required. An O_2 canister is attached to the parachute pack and the flow of oxygen is controlled by a regulating valve. Inside this valve is bellows assembly 18001. Note that the bellows assembly is evacuated and sealed so that at sea level it is fully compressed as the soldered in end pieces will be touching. At high altitudes the bellows assembly is compressed only a slight amount due to the minimal atmospheric pressure. At this condition, oxygen flow is at its maximum. As the pilot descends, the bellows assembly compresses due to the increase in atmospheric pressure. When it becomes fully compressed, that is, the soldered in end pieces are touching, the oxygen flow is at its minimum. *At what altitude is the oxygen flow first minimized?*

Use the following relationships to solve the problem:
F=KX and F=PA where F is the force acting on the bellows assembly due to its compression, like compressing a spring. The spring rate (K) is 22.5 #/in, meaning it takes 22.5 pounds to compress the bellows one inch. The compression (X) is the amount the bellows is compressed. However, F is also the force acting on the bellows assembly due to the atmospheric pressure (P) times the area of the bellows (A) which is .0723 in^2. The table below lists conversions from atmospheric pressure (psi) to altitude (ft). At any given altitude, the forces (both F's) will be equal, hence this system will be in equilibrium.

ALTITUDE—PRESSURE—TEMPERATURE

Based on U. S. Standard Atmosphere — From N. A. C. A. Report No. 538

ALTITUDE (Feet)	PRESSURE In. Hg.	PRESSURE Mm. Hg.	PRESSURE P. S. I.	TEMPERATURE °C	TEMPERATURE °F
−1,000	31.02	787.9	15.25	17.0	62.6
− 500	30.47	773.8	14.94	16.0	60.8
0	29.921	760.0	14.70	15.0	59.0
500	29.38	746.4	14.43	14.0	57.2
1,000	28.86	732.9	14.18	13.0	55.4
1,500	28.33	719.7	13.90	12.0	53.6
2,000	27.82	706.6	13.67	11.0	51.8
2,500	27.31	693.8	13.41	10.0	50.0
3,000	26.81	681.1	13.19	9.1	48.4
3,500	26.32	668.6	12.92	8.1	46.6
4,000	25.84	656.3	12.70	7.1	44.8
4,500	25.36	644.2	12.45	6.1	43.0
5,000	24.89	632.3	12.23	5.1	41.2
5,500	24.43	620.6	12.00	4.1	39.4
6,000	23.98	609.0	11.77	3.1	37.6
6,500	23.53	597.6	11.56	2.1	35.8
7,000	23.09	586.4	11.34	1.1	34.0
7,500	22.65	575.3	11.12	0.1	32.2
8,000	22.22	564.4	10.90	− 0.8	30.67
8,500	21.80	553.7	10.70	− 1.8	28.8
9,000	21.38	543.2	10.50	− 2.8	27.0
9,500	20.98	532.8	10.30	− 3.8	25.2
10,000	20.58	522.6	10.10	− 4.8	23.4
10,500	20.18	512.5	9.91	− 5.8	21.6
11,000	19.79	502.6	9.73	− 6.8	19.8
11,500	19.40	492.8	9.53	− 7.8	18.0
12,000	19.03	483.3	9.35	− 8.8	16.2
12,500	18.65	473.8	9.15	− 9.8	14.4
13,000	18.29	464.5	8.97	−10.8	12.6
13,500	17.93	455.4	8.81	−11.7	10.9
14,000	17.57	446.4	8.63	−12.7	9.1
14,500	17.22	437.5	8.46	−13.7	7.3
15,000	16.88	428.8	8.28	−14.7	5.5
15,500	16.54	420.2	8.13	−15.7	3.7
16,000	16.21	411.8	7.96	−16.7	1.9
16,500	15.89	403.5	7.81	−17.7	0.1
17,000	15.56	395.3	7.64	−18.7	− 1.7
17,500	15.25	387.3	7.49	−19.7	− 3.5
18,000	14.94	379.4	7.34	−20.7	− 5.3
18,500	14.63	371.7	7.19	−21.7	− 7.1
19,000	14.33	364.0	7.04	−22.6	− 8.7
19,500	14.04	356.5	6.90	−23.6	−10.5
20,000	13.75	349.1	6.75	−24.6	−12.3
20,500	13.46	341.9	6.61	−25.6	−14.1
21,000	13.18	334.7	6.48	−26.6	−15.9
21,500	12.90	327.7	6.34	−27.6	−17.7
22,000	12.63	320.8	6.21	−28.6	−19.5
22,500	12.36	314.1	6.08	−29.6	−21.3
23,000	12.10	307.4	5.94	−30.6	−23.1
23,500	11.84	300.9	5.82	−31.6	−24.9
24,000	11.59	294.4	5.70	−32.5	−26.5
24,500	11.34	288.1	5.58	−33.5	−28.3
25,000	11.10	281.9	5.45	−34.5	−30.1
25,500	10.86	275.8	5.33	−35.5	−31.9
26,000	10.62	269.8	5.22	−36.5	−33.7
26,500	10.39	263.9	5.11	−37.5	−35.5
27,000	10.16	258.1	4.99	−38.5	−37.3
27,500	9.94	252.5	4.88	−39.5	−39.1
28,000	9.72	246.9	4.78	−40.5	−40.9
28,500	9.50	241.4	4.67	−41.5	−42.7
29,000	9.29	236.0	4.56	−42.5	−44.5
29,500	9.08	230.7	4.46	−43.4	−46.1
30,000	8.88	225.6	4.36	−44.4	−47.9
30,500	8.68	220.5	4.27	−45.4	−49.7
31,000	8.48	215.5	4.17	−46.4	−51.5
31,500	8.29	210.6	4.07	−47.4	−53.3
32,000	8.10	205.8	3.98	−48.4	−55.1

ALTITUDE (Feet)	PRESSURE In. Hg.	PRESSURE Mm. Hg.	PRESSURE P. S. I.	TEMPERATURE °C	TEMPERATURE °F
32,500	7.91	201.0	3.89	−49.4	−56.9
33,000	7.73	196.4	3.80	−50.4	−58.7
33,500	7.55	191.8	3.71	−51.4	−60.5
34,000	7.38	187.4	3.63	−52.4	−62.3
34,500	7.20	183.0	3.54	−53.4	−64.1
35,000	7.04	178.7	3.46	−54.3	−65.8
35,332	6.93	175.9	3.40	−55.0	−66.0
35,500	6.87	174.5	3.375	−55.0	−66.0
36,000	6.71	170.4	3.296	−55.0	−66.0
36,500	6.55	166.4	3.22	−55.0	−66.0
37,000	6.39	162.4	3.14	−55.0	−66.0
37,500	6.24	158.6	3.067	−55.0	−66.0
38,000	6.10	154.9	2.994	−55.0	−66.0
38,500	5.95	151.2	2.925	−55.0	−66.0
39,000	5.81	147.6	2.852	−55.0	−66.0
39,500	5.68	144.1	2.798	−55.0	−66.0
40,000	5.54	140.7	2.72	−55.0	−66.0
40,500	5.41	137.4	2.66	−55.0	−66.0
41,000	5.28	134.2	2.595	−55.0	−66.0
41,500	5.16	131.0	2.535	−55.0	−66.0
42,000	5.04	127.9	2.47	−55.0	−66.0
42,500	4.92	124.9	2.415	−55.0	−66.0
43,000	4.80	122.0	2.36	−55.0	−66.0
43,500	4.69	119.1	2.304	−55.0	−66.0
44,000	4.58	116.3	2.25	−55.0	−66.0
44,500	4.47	113.5	2.195	−55.0	−66.0
45,000	4.36	110.8	2.14	−55.0	−66.0
45,500	4.26	108.2	2.094	−55.0	−66.0
46,000	4.16	105.7	2.042	−55.0	−66.0
46,500	4.06	103.2	1.997	−55.0	−66.0
47,000	3.97	100.7	1.948	−55.0	−66.0
47,500	3.873	98.38	1.90	−55.0	−66.0
48,000	3.781	96.05	1.858	−55.0	−66.0
48,500	3.693	93.79	1.813	−55.0	−66.0
49,000	3.605	91.57	1.772	−55.0	−66.0
49,500	3.52	89.41	1.729	−55.0	−66.0
50,000	3.436	87.30	1.689	−55.0	−66.0
51,000	3.276	83.22	1.610	−55.0	−66.0
52,000	3.124	79.34	1.533	−55.0	−66.0
53,000	2.978	75.64	1.463	−55.0	−66.0
54,000	2.839	72.12	1.395	−55.0	−66.0
55,000	2.707	68.76	1.33	−55.0	−66.0
56,000	2.581	65.55	1.269	−55.0	−66.0
57,000	2.460	62.49	1.208	−55.0	−66.0
58,000	2.346	59.58	1.152	−55.0	−66.0
59,000	2.236	56.80	1.098	−55.0	−66.0
60,000	2.132	54.15	1.048	−55.0	−66.0
61,000	2.033	51.63	1.000	−55.0	−66.0
62,000	1.938	49.22	0.952	−55.0	−66.0
63,000	1.847	46.92	0.906	−55.0	−66.0
64,000	1.761	44.73	0.865	−55.0	−66.0
65,000	1.679	42.65	0.825	−55.0	−66.0
66,000	1.601	40.66	0.786	−55.0	−66.0
67,000	1.526	38.76	0.748	−55.0	−66.0
68,000	1.455	36.95	0.714	−55.0	−66.0
69,000	1.387	35.23	0.681	−55.0	−66.0
70,000	1.322	33.59	0.649	−55.0	−66.0
71,000	1.261	32.02	0.619	−55.0	−66.0
72,000	1.202	30.53	0.590	−55.0	−66.0
73,000	1.146	29.10	0.562	−55.0	−66.0
74,000	1.093	27.75	0.536	−55.0	−66.0
75,000	1.041	26.45	0.512	−55.0	−66.0
76,000	0.993	25.22	0.488	−55.0	−66.0
77,000	0.946	24.04	0.465	−55.0	−66.0
78,000	0.902	22.92	0.443	−55.0	−66.0
79,000	0.860	21.85	0.423	−55.0	−66.0
80,000	0.820	20.83	0.403	−55.0	−66.0