ANNEX E TO THE CASE FOR HIGHER THAN ADVERTISED MARTIAN AIR PRESSURE
(Based on data from http://www-k12.atmos.washington.edu/k12/resources/mars_data-information/data.html)
Measured vs. Predicted Pressure Percent Differences for Viking-1 Time-bins 0.3 and 0.34

This Annex focuses on two specific time-bins (0.3 and 0.34) for Viking 1 pressures between its sols 200 and 350. As with Appendix 2 to Annex D, it compares pressures recorded by Viking 1 to pressures predicted by what is often called Gay-Lussac's Law (also known as Amonton's law (http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch4/gaslaws3.html#amonton). It can be summed up as follows:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

The two time-bins correspond roughly to 7:23 to 8:22 Local True Solar Time (the 0.3 time-bin) and 8:22 AM to 9:21 AM (the 0.34 time-bin). These times were shown in Annexes A and B to be associated with highly consistent pressure increases. This report asserts that these pressure spikes are caused by the heater coming on then or by the powering up of some other electronic device that provides heat to pressure transducers trapped behind a dust clot. The purpose of Annex E is to show that the accuracy of the percent difference studies offered in Annex D is vastly improved when the focus is on the time associated with pressure spikes. This is in fact confirmed with the data in this Annex. Whereas the overall percent difference between measured pressures in Annex D was 8.448% between VL-1 sols 1 to 116 and 134 to 350, and just 5.325% between VL-1 sols 200 to 350; the percent difference between VL-1 sols 200 to 350 for the two specific 0.3 and 0.34 time-bins studied in this Annex is only 2.667%. Note the many percent differences shown in red fonts were less than 2%. These are made easier to follow in Annex F.

Data presented in the Appendices to Annex E again has data presented as follows:

A	B	C	D	E	F	G	**H**
VL-1 SOL	LS	MEASURED PRESSURE (Mbar)	Δ PRESS. (Mbar)	° CELSIUS Temp.	KELVIN Temp.	PREDICTED PRESSURE (Mbar)	% Difference From Pressure Law

A = Sol (Martian day) of the Viking Mission. Each sol is divided into 25 equal length intervals or "time-bins." The increase on each line by .04 sols is about 59 minutes. For Viking 1 Sol 1 (landing day) was on July 20, 1976. On the Martian calendar it was month 4, Ls 97, sol 209. For Viking 2 Sol 1 was on September 3, 1976 still in month 4 but at Ls 117.6, sol 253.
B = Ls. This indicates where Mars is in its orbit around the sun. Ls 0 = spring, Ls 90 = summer, Ls 180 = fall, and Ls 270 = winter.
C = Measured pressure (in mbar)
D = change in pressure from the previous time-bin (in mbar)
E = Temperature Celsius.
F = Temperature Kelvin. This figure is required for gas law calculations.
G = Predicted pressure at Viking 1 in accordance with the following formula:
Predicted pressure = 6.51 (minimum pressure in mbar measured at VL-1) * 255.17 (maximum temperature at Viking 1) divide by temperature (Kelvin) for the time bin-bin in question.
H = Percent difference between the predicted pressure and measured pressure.

% Difference = [Absolute value of predicted minus measured pressure] * 100%
(Predicted + Measured pressure)/2

VL-1 SOL	LS	Measured Pressure (mbar)	ΔP from previous time-bin (0.26 or 0.3)	Temperature °C	Temp. Kelvin	Predicted pressure (mbar)	% Difference between measured and predicted pressure. Red fonts are <2%
200.3	201.883	7.82	0.18	-72.99	200.16	8.2991442	**5.9450326**
200.34	201.908	7.82	0	-65.26	207.89	7.9905561	**2.1574961**
201.3	202.498	7.9	0.17	-76.29	196.86	8.4382642	**6.5890016**
201.34	202.523	7.9	0	-67.74	205.41	8.0870294	**2.3397637**
202.3	203.114	7.87	0.21	-76.65	196.5	8.4537237	**7.1518445**
202.34	203.139	7.85	-0.02	-62.55	210.6	7.8877336	**0.4795305**
203.3	203.731	7.85	0.19	-75.86	197.29	8.4198728	**7.0052518**
203.34	203.756	7.85	0	-65.66	207.49	8.0059603	**1.9672134**
204.3	204.349	7.96	0.17	-81.95	191.2	8.6880581	**8.7464622**
204.34	204.373	7.99	0.03	-71.16	201.99	8.2239551	**2.8858492**
205.3	204.967	7.93	0.2	-76.2	196.95	8.4344082	**6.1646986**
205.34	204.992	7.9	-0.03	-66.8	206.35	8.05019	**1.8832374**
206.3	205.587	7.96	0.21	-78.74	194.41	8.5446052	**7.0841466**
206.34	205.611	7.93	-0.03	-67.77	205.38	8.0882106	**1.9753846**
207.3	206.207	7.95	0.21	-78.44	194.71	8.5314401	**7.0556952**
207.34	206.232	7.93	-0.02	-67.22	205.93	8.0666086	**1.707969**
208.3	206.828	7.93	0.2	-78.15	195	8.5187523	**7.1586257**
208.34	206.853	7.93	0	-66.68	206.47	8.0455112	**1.4461035**
209.3	207.45	7.87	0.17	-74	199.15	8.3412337	**5.8136691**
209.34	207.475	7.87	0	-63.66	209.49	7.9295274	**0.7535342**
210.3	208.072	8.31	0.26	-78.61	194.54	8.5388953	**2.7170368**
210.34	208.097	8.31	0	-74.13	199.02	8.3466822	**0.4404508**
211.3	208.696	8.48	0.39	-79.36	193.79	8.5719423	**1.0783793**
211.34	208.721	8.49	0.01	-71.32	201.83	8.2304747	**3.104282**

212.3	209.32	8.37	0.35	-75	198.15	8.3833293	**0.1591241**
212.34	209.345	8.36	-0.01	-68.75	204.4	8.1269897	**2.8265957**
213.3	209.945	8.34	0.34	-75.21	197.94	8.3922234	**0.6242255**
213.34	209.97	8.34	0	-68.99	204.16	8.1365434	**2.4696515**
214.3	210.571	8.25	0.33	-74.24	198.91	8.3512981	**1.2203633**
214.34	210.596	8.29	0.04	-66.66	206.49	8.0447319	**3.0030251**
215.3	211.198	8.4	0.29	-77.67	195.48	8.4978346	**1.1579538**
215.34	211.223	8.49	0.09	-73.16	199.99	8.3061988	**2.1886046**
216.3	211.825	8.22	0.35	-71.51	201.64	8.23823	**0.2215307**
216.34	211.85	8.29	0.07	-66.4	206.75	8.0346152	**3.1288304**
217.3	212.453	8.22	0.3	-73.33	199.82	8.3132654	**1.1282156**
217.34	212.478	8.36	0.14	-68.61	204.54	8.1214271	**2.8950514**
218.3	213.082	8.19	0.32	-72.91	200.24	8.2958285	**1.2838725**
218.34	213.107	8.36	0.17	-67.66	205.49	8.083881	**3.3583195**
219.3	213.711	8.22	0.28	-74.11	199.04	8.3458435	**1.5193135**
219.34	213.736	8.38	0.16	-67.84	205.31	8.0909683	**3.5095898**
220.3	214.342	8.28	0.34	-74.67	198.48	8.3693909	**1.0738035**
220.34	214.367	8.42	0.14	-69.93	203.22	8.1741792	**2.9627351**
221.3	214.973	8.31	0.35	-75.24	197.91	8.3934955	**0.9997372**
221.34	214.998	8.47	0.16	-69.36	203.79	8.1513161	**3.8346415**
222.3	215.604	8.31	0.29	-76.34	196.81	8.440408	**1.5570726**
222.34	215.63	8.49	0.18	-70.65	202.5	8.203243	**3.4356061**
223.3	216.237	8.4	0.31	-77.43	195.72	8.4874142	**1.0352581**
223.34	216.262	8.49	0.09	-71.51	201.64	8.23823	**3.010121**
224.3	216.87	8.37	0.28	-77.57	195.58	8.4934896	**1.4645797**
224.34	216.895	8.42	0.05	-71.52	201.63	8.2386386	**2.1773857**

225.3	217.504	8.38	0.29	-76.41	196.74	8.4434111	**0.7538436**
225.34	217.529	8.4	0.02	-71.19	201.96	8.2251768	**2.1031143**
226.3	218.138	8.49	0.31	-78.08	195.07	8.5156954	**0.3021975**
226.34	218.163	8.47	-0.02	-73.27	199.88	8.31077	**1.897768**
227.3	218.773	8.4	0.29	-77.58	195.57	8.4939239	**1.1119254**
227.34	218.799	8.4	0	-73.98	199.17	8.3403961	**0.7120961**
228.3	219.409	8.46	0.28	-78.8	194.35	8.5472431	**1.0259525**
228.34	219.434	8.4	-0.06	-81.83	191.32	8.6826087	**3.3087302**
229.3	220.045	8.37	0.21	-76.95	196.2	8.4666498	**1.1480888**
229.34	220.071	8.36	-0.01	-73.89	199.26	8.336629	**0.2799484**
230.3	220.682	8.64	0.28	-80.89	192.26	8.6401576	**0.001824**
230.34	220.708	8.58	-0.06	-76.39	196.76	8.4425529	**1.6148829**
231.3	221.32	8.58	0.22	-81.05	192.1	8.647354	**0.7819423**
231.34	221.345	8.58	0	-76.58	196.57	8.4507132	**1.5182778**
232.3	221.958	8.46	0.17	-79.85	193.3	8.5936715	**1.5676565**
232.34	221.984	8.49	0.03	-74.17	198.98	8.3483601	**1.6823475**
233.3	222.597	8.49	0.2	-80.45	192.7	8.6204292	**1.5245575**
233.34	222.623	8.49	0	-74	199.15	8.3412337	**1.7677404**
234.3	223.236	8.49	0.18	-80.5	192.65	8.6226665	**1.5505064**
234.34	223.262	8.49	0	-73.96	199.19	8.3395587	**1.7878221**
235.3	223.876	8.4	0.15	-78.09	195.06	8.516132	**1.3730321**
235.34	223.902	8.42	0.02	-72.29	200.86	8.2702215	**1.7948048**
236.3	224.517	8.58	0.07	-81.7	191.45	8.676713	**1.1208737**
236.34	224.542	8.58	0	-76.64	196.51	8.4532935	**1.4877514**
237.3	225.158	8.52	0.1	-80.63	192.52	8.628489	**1.2652892**

237.34	225.183	8.58	0.06	-74.61	198.54	8.3668616	**2.5153732**
238.3	225.799	8.64	0.13	-80.92	192.23	8.641506	**0.0174291**
238.34	225.825	8.67	0.03	-81.64	191.51	8.6739946	**0.0460629**
239.3	226.441	8.58	0.07	-81.59	191.56	8.6717305	**1.0634357**
239.34	226.467	8.63	0.05	-75.05	198.1	8.3854452	**2.8745033**
240.3	227.084	8.64	-0.03	-83.45	189.7	8.7567565	**1.3422785**
240.34	227.11	8.67	0.03	-77.01	196.14	8.4692398	**2.3426963**
241.3	227.727	8.64	0.13	-84.1	189.05	8.7868643	**1.6854934**
241.34	227.753	8.67	0.03	-76.66	196.49	8.4541539	**2.5209549**
242.3	228.371	8.58	0.07	-82.4	190.75	8.7085541	**1.4871588**
242.34	228.397	8.65	0.07	-76.62	196.53	8.4524332	**2.3103939**
243.3	229.015	8.7	0.1	-82.71	190.44	8.72273	**0.2609234**
243.34	229.041	8.76	0.06	-76.58	196.57	8.4507132	**3.5941191**
244.3	229.66	8.67	0.07	-81.68	191.47	8.6758067	**0.0669517**
244.34	229.685	8.67	0	-75.49	197.66	8.4041116	**3.114521**
245.3	230.305	8.67	0.11	-81.54	191.61	8.6694677	**0.0061401**
245.34	230.33	8.67	0	-75.43	197.72	8.4015613	**3.1448641**
246.3	230.95	8.85	0.09	-83.76	189.39	8.7710898	**0.8956334**
246.34	230.976	8.85	0	-77.79	195.36	8.5030544	**3.9986694**
247.3	231.596	8.82	0.1	-84.5	188.65	8.8054954	**0.164587**
247.34	231.622	8.85	0.03	-76.67	196.48	8.4545842	**4.5700702**
248.3	232.242	8.76	0.07	-84.45	188.7	8.8031622	**0.4915079**
248.34	232.268	8.81	0.05	-78.15	195	8.5187523	**3.3614387**
249.3	232.889	8.7	0.05	-83.97	189.18	8.7808262	**0.9247412**
249.34	232.915	8.76	0.06	-77.83	195.32	8.5047957	**2.9563545**

250.3	233.536	8.91	0.09	-86.24	186.91	8.8874683	**0.2532012**
250.34	233.562	8.94	0.03	-80.95	192.2	8.6428548	**3.3799422**
251.3	234.183	8.76	0.11	-85.12	188.03	8.8345301	**0.8471966**
251.34	234.209	8.82	0.06	-79.19	193.96	8.5644293	**2.9402258**
252.3	234.831	8.76	0.07	-83.97	189.18	8.7808262	**0.2374597**
252.34	234.857	8.76	0	-77.35	195.8	8.4839464	**3.2017454**
253.3	235.479	8.91	0.08	-85.36	187.79	8.8458209	**0.7229081**
253.34	235.505	8.89	-0.02	-79.75	193.4	8.589228	**3.4414789**
254.3	236.128	8.79	0.12	-83.58	189.57	8.7627615	**0.3103613**
254.34	236.153	8.83	0.04	-76.89	196.26	8.4640614	**4.2319562**
255.3	236.776	8.85	0.09	-84.11	189.04	8.7873291	**0.7106616**
255.34	236.802	8.85	0	-80.73	192.42	8.6329732	**2.4827221**
256.3	237.425	8.91	0.13	-84.99	188.16	8.8284263	**0.9197395**
256.34	237.451	8.87	-0.04	-79.11	194.04	8.5608983	**3.5465956**
257.3	238.075	8.94	0.13	-86.01	187.14	8.8765454	**0.7123113**
257.34	238.101	8.94	0	-79.34	193.81	8.5710577	**4.2138204**
258.3	238.724	8.91	0.06	-86.35	186.8	8.8927018	**0.1943321**
258.34	238.75	8.94	0.03	-79.76	193.39	8.5896722	**3.9969696**
259.3	239.374	8.94	0.09	-86.75	186.4	8.9117849	**0.3161043**
259.34	239.4	8.94	0	-79.97	193.18	8.5990097	**3.888364**
260.3	240.024	8.94	0.06	-88.34	184.81	8.9884568	**0.5405573**
260.34	240.05	8.94	0	-81.06	192.09	8.6478042	**3.3227098**
261.3	240.675	8.94	0.09	-89.03	184.12	9.0221415	**0.9146074**
261.34	240.701	8.96	0.02	-78.39	194.76	8.5292498	**4.9258848**
262.3	241.325	9.03	0.14	-87.56	185.59	8.95068	**0.8822804**
262.34	241.351	9.03	0	-80.71	192.44	8.632076	**4.5059712**

263.3	241.976	9	0.11	-87.62	185.53	8.9535746	**0.5171714**
263.34	242.002	9.03	0.03	-80.7	192.45	8.6316274	**4.5111648**
264.3	242.627	9.03	0.09	-88.65	184.5	9.0035594	**0.2932383**
264.34	242.653	9.05	0.02	-82.63	190.52	8.7190673	**3.724818**
265.3	243.278	8.85	0.07	-87.09	186.06	8.92807	**0.8782728**
265.34	243.304	8.89	0.04	-80.61	192.54	8.6275927	**2.9959287**
266.3	243.93	9	0.17	-87.55	185.6	8.9501977	**0.5548938**
266.34	243.956	9.03	0.03	-81.85	191.3	8.6835165	**3.9120807**
267.3	244.581	8.97	0.1	-88.03	185.12	8.9734048	**0.0379506**
267.34	244.607	8.98	0.01	-81.4	191.75	8.6631379	**3.5919014**
268.3	245.233	8.94	0.13	-87.85	185.3	8.9646881	**0.2757722**
268.34	245.259	8.94	0	-81.39	191.76	8.6626862	**3.1508126**
269.3	245.885	9	0.11	-89.29	183.86	9.0348999	**0.3870265**
269.34	245.911	9.05	0.05	-79.41	193.74	8.5741545	**5.3999239**
270.3	246.536	9.03	0.14	-89.02	184.13	9.0216516	**0.0924951**
270.34	246.562	9.03	0	-82.77	190.38	8.725479	**3.4301632**
271.3	247.188	9.03	0.09	-89.49	183.66	9.0447386	**0.1630856**
271.34	247.215	9.03	0	-82.91	190.24	8.7319002	**3.3566202**
272.3	247.84	9.03	0.12	-90.27	182.88	9.0833153	**0.5886861**
272.34	247.866	9.03	0	-83.82	189.33	8.7738694	**2.8772461**
273.3	248.493	9.15	0.1	-90.61	182.54	9.1002339	**0.5453747**
273.34	248.519	9.12	-0.03	-84.58	188.57	8.8092311	**3.4666177**
274.3	249.145	9.18	0.13	-91.85	181.3	9.1624749	**0.1910876**
274.34	249.171	9.12	-0.06	-85.84	187.31	8.8684891	**2.7963534**
275.3	249.797	9.03	0.14	-88.66	184.49	9.0040474	**0.2878181**

275.34	249.823	9.03	0	-81.62	191.53	8.6730888	**4.0321911**
276.3	250.449	9.03	0.05	-91.55	181.6	9.1473387	**1.2910433**
276.34	250.475	9.03	0	-85.53	187.62	8.8538359	**1.9700925**
277.3	251.101	9.12	0.14	-91.19	181.96	9.129241	**0.1012759**
277.34	251.127	9.05	-0.07	-84.58	188.57	8.8092311	**2.6962969**
278.3	251.753	9.12	0.09	-91.31	181.84	9.1352656	**0.1672462**
278.34	251.779	9.12	0	-84.59	188.56	8.8096982	**3.461316**
279.3	252.406	9.03	0.14	-90.39	182.76	9.0892794	**0.6543238**
279.34	252.432	9.03	0	-84.4	188.75	8.8008302	**2.5704894**
280.3	253.058	9.06	0.12	-90.94	182.21	9.1167153	**0.6240438**
280.34	253.084	9.1	0.04	-84.92	188.23	8.8251432	**3.0667183**
281.3	253.71	9.12	0.14	-91.58	181.57	9.14885	**0.3158385**
281.34	253.736	9.12	0	-85.52	187.63	8.8533641	**2.967012**
282.3	254.362	9.03	0.14	-91.71	181.44	9.1554051	**1.3791839**
282.34	254.388	9.03	0	-85.73	187.42	8.8632841	**1.863447**
283.3	255.014	9.03	0.14	-91.33	181.82	9.1362705	**1.1699758**
283.34	255.04	9.03	0	-85.25	187.9	8.8406424	**2.1192035**
284.3	255.666	9.09	0.13	-92.52	180.63	9.1964607	**1.1643666**
284.34	255.692	9.12	0.03	-86.35	186.8	8.8927018	**2.5237544**
286.3	256.969	8.97	0.1	-90.8	182.35	9.1097159	**1.5455545**
286.34	256.995	8.98	0.01	-83.56	189.59	8.7618371	**2.4593043**
287.3	257.62	9.18	0.13	-93.19	179.96	9.2306996	**0.5507623**
287.34	257.646	9.21	0.03	-88.32	184.83	8.9874842	**2.4455669**
288.3	258.272	9.15	0.12	-94	179.15	9.2724348	**1.3291927**
288.34	258.298	9.14	-0.01	-87.53	185.62	8.9492334	**2.1091731**

289.3	258.923	9	0.13	-92.56	180.59	9.1984977	**2.1814735**
289.34	258.949	9.03	0.03	-86.12	187.03	8.881766	**1.6551575**
290.3	259.574	9.12	0.18	-92.61	180.54	9.2010452	**0.8847224**
290.34	259.6	9.12	0	-87.61	185.54	8.9530921	**1.8470325**
291.3	260.225	9.18	0.13	-93.97	179.18	9.2708824	**0.9851274**
291.34	260.251	9.21	0.03	-87.86	185.29	8.9651719	**2.694094**
292.3	260.875	9.12	0.11	-94.83	178.32	9.3155939	**2.1219157**
292.34	260.901	9.12	0	-88.44	184.71	8.993323	**1.3987158**
293.3	261.526	9.03	0.09	-94.42	178.73	9.2942242	**2.8838792**
293.34	261.552	9.07	0.04	-88.55	184.6	8.998682	**0.7894099**
294.3	262.176	9.18	0.13	-94.78	178.37	9.3129826	**1.4381949**
294.34	262.202	9.21	0.03	-89.02	184.13	9.0216516	**2.0661699**
295.3	262.826	9.27	0.13	-93.99	179.16	9.2719173	**0.0206805**
295.34	262.852	9.28	0.01	-89	184.15	9.0206717	**2.8340847**
296.3	263.475	9	0.11	-93.22	179.93	9.2322386	**2.5475604**
296.34	263.501	9.03	0.03	-87.22	185.93	8.9343124	**1.065308**
297.3	264.125	9	0.13	-93.47	179.68	9.245084	**2.6865762**
297.34	264.151	9.03	0.03	-88.11	185.04	8.9772844	**0.5854923**
298.3	264.774	9.09	0.13	-94.72	178.43	9.3098509	**2.3897033**
298.34	264.8	9.12	0.03	-89.57	183.58	9.0486801	**0.7850858**
299.3	265.422	9.06	0.1	-94.36	178.79	9.2911052	**2.5187061**
299.34	265.448	9.1	0.04	-89.54	183.61	9.0472017	**0.5818894**
300.3	266.071	8.85	0.09	-93.33	179.82	9.2378862	**4.288906**
300.34	266.097	8.89	0.04	-86.69	186.46	8.9089172	**0.2125657**
301.3	266.719	8.91	0.1	-94.74	178.41	9.3108946	**4.4003829**
301.34	266.745	8.94	0.03	-89.31	183.84	9.0358828	**1.0667941**

302.3	267.367	8.85	0.04	-94.52	178.63	9.2994273	**4.9525233**
302.34	267.392	8.94	0.09	-89.27	183.88	9.0339172	**1.0450391**
303.3	268.014	8.85	0.09	-93.34	179.81	9.2384	**4.2944647**
303.34	268.04	8.87	0.02	-88.38	184.77	8.9904027	**1.3482637**
304.3	268.661	8.94	0.09	-94.48	178.67	9.2973454	**3.9188311**
304.34	268.687	8.98	0.04	-89.57	183.58	9.0486801	**0.7618987**
305.3	269.308	8.97	0.12	-94.22	178.93	9.2838356	**3.4385713**
305.34	269.333	9.03	0.06	-88.91	184.24	9.0162652	**0.1522177**
306.3	269.954	8.94	0.09	-94.91	178.24	9.319775	**4.1596901**
306.34	269.98	9.01	0.07	-89.43	183.72	9.0417848	**0.3521511**
307.3	270.6	8.85	0.09	-94.82	178.33	9.3150715	**5.1205028**
307.34	270.625	8.85	0	-89.68	183.47	9.0541053	**2.2799833**
308.3	271.245	8.88	0.03	-95.08	178.07	9.3286724	**4.928118**
308.34	271.271	8.94	0.06	-89.95	183.2	9.0674492	**1.4155168**
309.3	271.89	8.94	0.09	-94.31	178.84	9.2885076	**3.8237645**
309.34	271.916	8.94	0	-89.99	183.16	9.0694295	**1.4373521**
310.3	272.535	8.67	0.04	-94.12	179.03	9.2786499	**6.7821251**
310.34	272.56	8.76	0.09	-89.84	183.31	9.0620081	**3.3891588**
311.3	273.179	8.76	0	-94.37	178.78	9.2916249	**5.8900504**
311.34	273.204	8.76	0	-89.66	183.49	9.0531184	**3.29104**
312.3	273.822	8.7	0.1	-94	179.15	9.2724348	**6.3701422**
312.34	273.848	8.76	0.06	-85.54	187.61	8.8543079	**1.0708099**
313.3	274.465	8.79	0.12	-92.26	180.89	9.1832423	**4.3758638**
313.34	274.491	8.92	0.13	-88.51	184.64	8.9967326	**0.8565464**
314.3	275.108	8.82	0.19	-86.35	186.8	8.8927018	**0.8209004**

314.34	275.133	8.94	0.12	-84.18	188.97	8.7905842	**1.6854017**
315.3	275.75	8.79	0.1	-86.67	186.48	8.9079617	**1.3330542**
315.34	275.775	8.96	0.17	-84.71	188.44	8.8153083	**1.6280075**
316.3	276.391	9	0.17	-85	188.15	8.8288956	**1.9194059**
316.34	276.417	9.16	0.16	-83.54	189.61	8.7609129	**4.4538699**
317.3	277.032	9.18	0.17	-85.14	188.01	8.8354699	**3.8248248**
317.34	277.058	9.36	0.18	-83.94	189.21	8.779434	**6.4011483**
318.3	277.673	9.18	0.31	-83.46	189.69	8.7572181	**4.7140187**
318.34	277.698	9.39	0.21	-82.52	190.63	8.7140361	**7.4675493**
319.3	278.313	9.27	0.46	-80.63	192.52	8.628489	**7.1683259**
319.34	278.338	9.36	0.09	-80.01	193.14	8.6007906	**8.4540753**
320.3	278.952	9.3	0.49	-80.8	192.35	8.6361149	**7.4027749**
320.34	278.978	9.36	0.06	-80.45	192.7	8.6204292	**8.226398**
321.3	279.591	9.42	0.46	-82.75	190.4	8.7245625	**7.6655196**
321.34	279.616	9.41	-0.01	-82.91	190.24	8.7319002	**7.4755098**
322.3	280.229	9.45	0.58	-82.53	190.62	8.7144932	**8.0982911**
322.34	280.255	9.3	-0.15	-82.98	190.17	8.7351144	**6.2642866**
323.3	280.867	9.36	0.55	-82.16	190.99	8.6976109	**7.3363983**
323.34	280.892	9.23	-0.13	-82.76	190.39	8.7250207	**5.6249364**
324.3	281.503	9.36	0.53	-82.57	190.58	8.7163223	**7.1217774**
324.34	281.529	9.24	-0.12	-83.18	189.97	8.7443107	**5.5124639**
325.3	282.14	9.3	0.43	-83.65	189.5	8.7659984	**5.9116753**
325.34	282.165	9.23	-0.07	-83.64	189.51	8.7655359	**5.1619929**
326.3	282.775	9.27	0.46	-83.25	189.9	8.747534	**5.7995288**
326.34	282.801	9.25	-0.02	-83.49	189.66	8.7586033	**5.457355**

327.3	283.41	9.3	0.45	-83.83	189.32	8.7743329	**5.8167251**
327.34	283.436	9.34	0.04	-83.49	189.66	8.7586033	**6.4247688**
328.3	284.045	9.33	0.46	-84.28	188.87	8.7952385	**5.9007386**
328.34	284.07	9.34	0.01	-84.28	188.87	8.7952385	**6.0077674**
329.3	284.678	9.33	0.52	-84.4	188.75	8.8008302	**5.8372374**
329.34	284.704	9.32	-0.01	-84.45	188.7	8.8031622	**5.7036165**
330.3	285.312	9.39	0.58	-84.21	188.94	8.79198	**6.5781615**
330.34	285.337	9.34	-0.05	-84.62	188.53	8.8111001	**5.827745**
331.3	285.944	9.36	0.58	-83.59	189.56	8.7632238	**6.5857623**
331.34	285.969	9.23	-0.13	-84.19	188.96	8.7910494	**4.8715317**
332.3	286.576	9.36	0.62	-84.21	188.94	8.79198	**6.2584909**
332.34	286.601	9.25	-0.11	-84.78	188.37	8.8185842	**4.7753142**
333.3	287.206	9.27	0.51	-84.91	188.24	8.8246744	**4.9221737**
333.34	287.232	9.3	0.03	-85.2	187.95	8.8382905	**5.0909924**
334.3	287.837	9.21	0.47	-86.15	187	8.8831909	**3.6125092**
334.34	287.862	9.36	0.15	-85.87	187.28	8.8699098	**5.3767709**
335.3	288.466	9.3	0.54	-86.47	186.68	8.8984181	**4.413371**
335.34	288.491	9.39	0.09	-86.16	186.99	8.883666	**5.5416798**
336.3	289.095	9.27	0.53	-87.76	185.39	8.960336	**3.397238**
336.34	289.12	9.32	0.05	-87.66	185.49	8.9555054	**3.9888865**
337.3	289.723	9.27	0.46	-87.22	185.93	8.9343124	**3.6880011**
337.34	289.748	9.32	0.05	-86.92	186.23	8.91992	**4.3868614**
338.3	290.35	9.18	0.44	-86.1	187.05	8.8808164	**3.3130689**
338.34	290.375	9.25	0.07	-85.99	187.16	8.8755968	**4.1312095**
339.3	290.977	9.12	0.4	-86.28	186.87	8.8893707	**2.5612146**
339.34	291.002	9.28	0.16	-85.89	187.26	8.8708571	**4.5082488**

340.3	291.602	9.03	0.31	-87.54	185.61	8.9497155	**0.893056**
340.34	291.627	9.25	0.22	-86.78	186.37	8.9132194	**3.70838**
341.3	292.227	9.15	0.41	-87.25	185.9	8.9357542	**2.369222**
341.34	292.252	9.23	0.08	-86.92	186.23	8.91992	**3.4168747**
342.3	292.852	9.15	0.39	-87.66	185.49	8.9555054	**2.1484579**
342.34	292.877	9.25	0.1	-87.24	185.91	8.9352735	**3.4613335**
343.3	293.475	9.15	0.37	-88.34	184.81	8.9884568	**1.7812233**
343.34	293.5	9.21	0.06	-88.37	184.78	8.9899161	**2.4185154**
344.3	294.097	9.12	0.29	-89.01	184.14	9.0211616	**1.0896588**
344.34	294.122	9.23	0.11	-88.51	184.64	8.9967326	**2.5596188**
345.3	294.719	9.12	0.29	-89.79	183.36	9.059537	**0.6651767**
345.34	294.744	9.21	0.09	-89.24	183.91	9.0324436	**1.9466297**
346.3	295.34	9.03	0.2	-89.55	183.6	9.0476944	**0.19576**
346.34	295.365	9.21	0.18	-88.89	184.26	9.0152866	**2.1367395**
347.3	295.96	9.06	0.23	-89.91	183.24	9.0654699	**0.0603557**
347.34	295.985	9.21	0.15	-89.15	184	9.0280255	**1.99555**
348.3	296.58	9.09	0.26	-89.81	183.34	9.0605253	**0.3247812**
348.34	296.604	9.21	0.12	-89.15	184	9.0280255	**1.99555**
349.3	297.198	9	0.26	-89.57	183.58	9.0486801	**0.5394316**
349.34	297.223	9.12	0.12	-88.81	184.34	9.0113741	**1.1982093**
350.3	297.816	8.94	0.2	-89.58	183.57	9.0491731	**1.2137642**
350.34	297.84	9.12	0.18	-88.85	184.3	9.0133299	**1.1765087**
AVERAGE							2.667244

ANNEX F TO THE CASE FOR HIGHER THAN ADVERTISED MARTIAN AIR PRESSURE
(Based on data from http://www-k12.atmos.washington.edu/k12/resources/mars_data-information/data.html

Percent Difference Flow Chart for Viking-1 Sols 1 to 113, and 134 to 350

Annex F sums up the percent differences between Viking-1 measured pressures, for its Sols 1 to 113 and 134 to 350, and its predicted pressures as found in Appendices 1 and 2 to Annex D. Annex F only shows whether each pressure predicted had less than a 2% percent difference from what was measured. Where this was the case, the cell appears in red and the temperature (Kelvin) is indicated with white font in the red cell. Where the percent difference was greater than 2%, the cell is left uncolored. From Annex F it is readily apparent that when the heater had to come, the pressure at the transducer was forced up and into line with the pressure predicted for a gas being heated in a confined (dust clot, sealed space). For example, there was less than a 2% difference at the 0.3 time-bins every day between VL-1 sols 211 and 287. This corresponds to about 7:23 AM Local True Solar Time, a good time to warm up equipment for morning operations. There was also a consistent series of good agreements with the predictions for afternoon operations and late night operations when it was necessary to prevent damage to the lander equipment. The time of the best agreement shifted as the year progressed from summer to winter. Figure 1 shows the overall success rate for predicting pressures in each cell (336 sols * 25 time-bins per cell = 8,400 predictions).

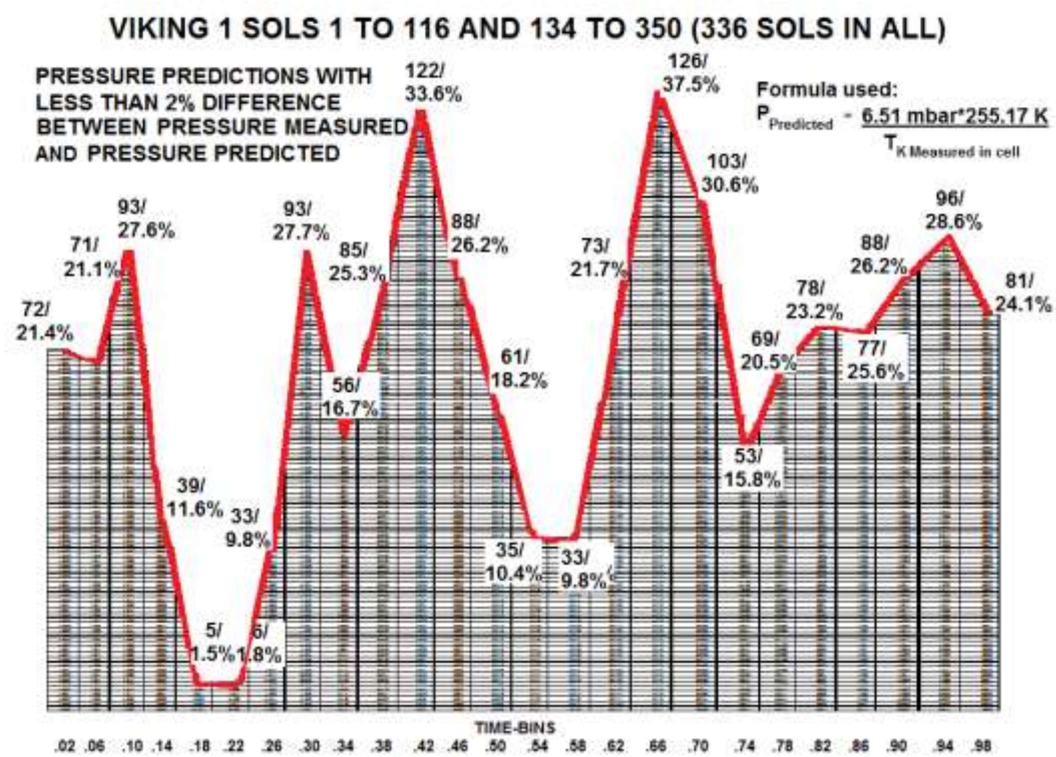
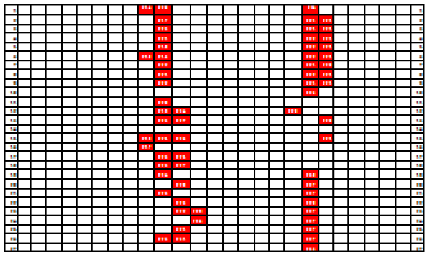
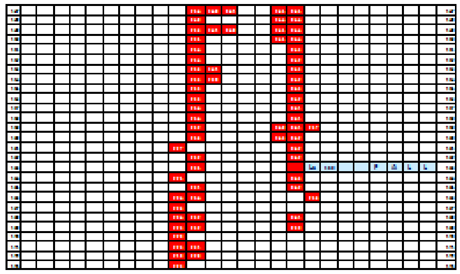


Figure 1 – Prediction success totals per time-bin and corresponding % of successful predictions.

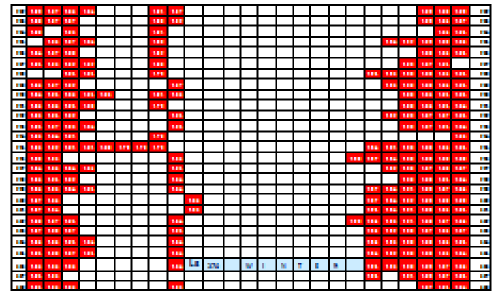
VL-1 SOLS 1-27



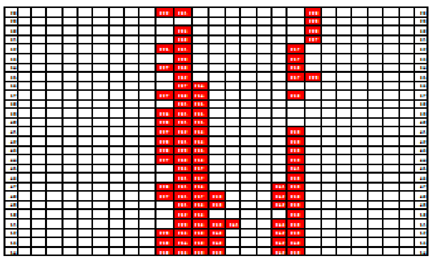
VL-1 SOLS 147-173



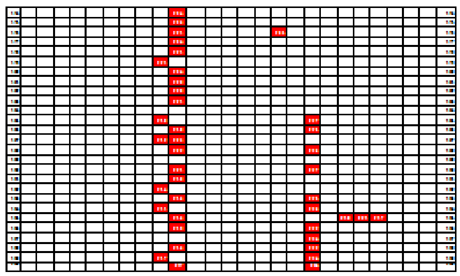
VL-1 SOLS 282-308



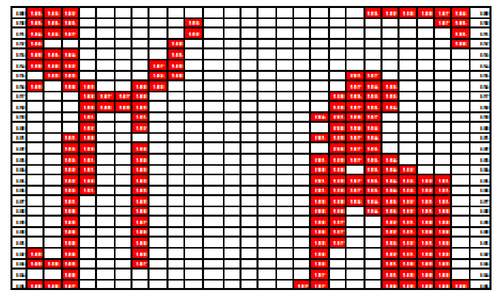
VL-1 SOLS 28-54



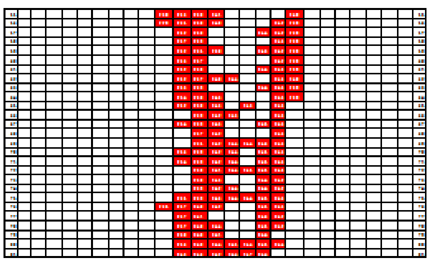
VL-1 SOLS 174-200



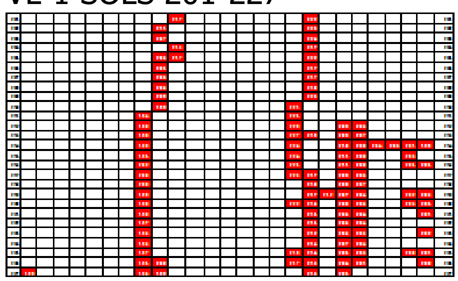
VL1 SOLS 309-336



VL-1 SOLS 55-81



VL-1 SOLS 201-227



SOLS 336-350

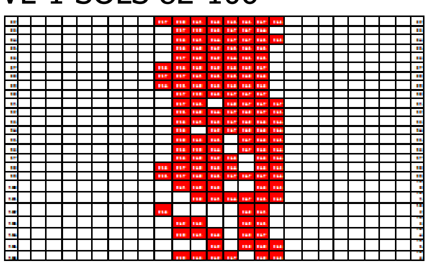
Figure 2 - % Differences between measured and predicted pressures as a function of time.

Cells in red have <2% difference between Viking-1 measured pressures and pressures predicted by formula:

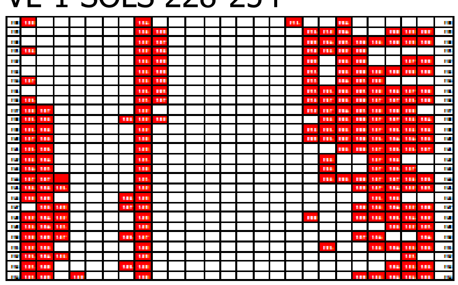
$$P = \frac{6.51 * 255.17\ K}{\text{Temperature K in Time-bin}}$$

Where:
P = pressure in mbar
6.51 = minimum pressure in mbar measured at Viking 1 between its sols 1 and 350.
255.17 = Maximum Temperature (Kelvin) measured at Viking 1 between its sols 1 and 350.

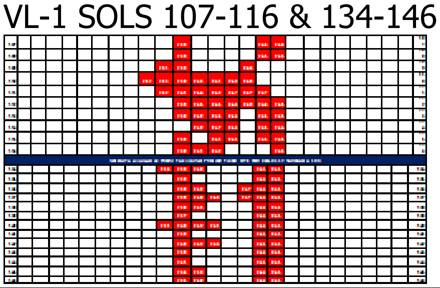
VL-1 SOLS 82-106



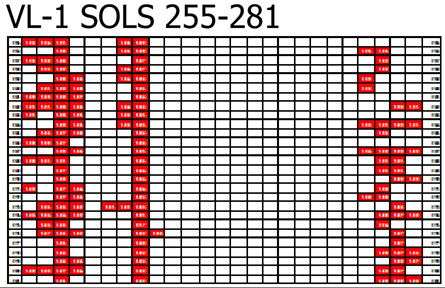
VL-1 SOLS 228-254



VL-1 SOLS 107-116 & 134-146



VL-1 SOLS 255-281



It can be seen from Figure 2 that there was a first degree of moderate success in accurately predicting pressures in the mornings around the .38 and .42 time bins from the Viking-1 landing until its Sol 116 when data suddenly stopped until sol 134. There was also a good degree of success in making predictions in the afternoons for the 0.7 to the 0.78 time-bins, gradually shifting to the 0.62 to 0.66 time-bins, then merging with the morning success just before data stopped. So the predictions became accurate for the time-bins from about 0.42 to 0.66. This was all in the summer.

After the data break, predictions were generally better than 2% off for the 0.42, 0.62 and 0.66 time-bins for the rest of the summer. As fall ensued, the morning accuracy shifted earlier into the 0.38, then 0.34 and finally the 0.3 time-bin that first caught my attention.

In line with the expectation that the heater would have to come on and increase pressures the most as it got colder outside, the predictions grew better over more night time-bins as the fall came to an end and winter ensued. As the study came to an end on sol 350, there were often very accurate predictions for the hours centering around midnight and for several hours on either side of that time.

Professor James Tillman has been helpful a number of times in this study, which could never have occurred without his Viking Project's efforts in posting the data that my father and I to reformat and manipulate. However, the one question that Professor Tillman has not answered pertains to the thermostat or timer employed for the RTGs. Just what caused the heaters to come on when they did? At best, without a definitive answer from him, his team, or other competent authority, the only solution is to let the data speak for itself. That data seems to indicate that if there was a timer, its settings were gradually shifted as the summer drifted into fall, and finally winter arrived.

The size of the errors, at least initially, was also particularly telling. For example, as one flips through Appendices 1 and 2 to Annex D, it is apparent that often in early hours of the sols, rows are shaded in yellow or blue. This means that there was no recorded pressure change for at least four hours, often at times when it was most cold. The blue shading means that the temperature was colder than -75° C (198.15 K), and often it was colder than -85° C (188.15 K) then. This would be a time that my formula would predict the highest temperatures, but something was not working right when it came to recording and transmitting the pressures felt at the transducer.

Did the formula work for warm and cold temperatures seen across the 336 sols studied? Yes. Too see this it is necessary to look at the temperatures shown in white fonts in the red cells of Appendix 1 to this Annex and in Appendix 2 to this Annex which is a histogram of the temperatures that produced under a 2% difference between measured and predicted pressures.

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
1									214	220									224							1
2										217									221	221						2
3										223									221	221						3
4										221									222	221						4
5										218									222	221						5
6									218	216									222	221						6
7										222									221	220						7
8										221									222	221						8
9										222									221	221						9
10																			226							10
11										220																11
12										219	224							228								12
13										223	227									220						13
14																										14
15									219	225	226									221						15
16									217																	16
17										223	225															17
18										223	227															18
19										224									230							19
20											228								227							20
21										223									227							21
22											223								228							22
23											222	229							227							23
24												226							227							24
25											221								227							25
26										223	231								227							26
27																			233							27
VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
28										222	231								228							28
29																			229							29
30											226								228							30
31											230								227							31
32										225	231							237								32
33											228							237								33
34										227	230							238								34
35											232							237	229							35
36											227	234														36
37										227	230	234						238								37
38											231	235														38
39										226	231	235														39
40										228	231	235														40
41										227	232	236						239								41
42										229	231	236						239								42
43										228	229	235						239								43
44										227	230	236						239								44
45											233	237						241								45
46											231	237						239								46
47										228	231	236					241	239								47
48										227	231	237	239				242	238								48
49											231	236	239				242	239								49
50											232	236						238								50
51											229	236	239	241			243	239								51
52										229	233	238	240				242	239								52
53										230	234	238	240				242	240								53
54										230	233	239	239				242	239								54
VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
55										230	233	238	241					240								55
56										229	235	238	240				242	239								56
57											232	238				244	242	239								57
58											237	239					243	239								58
59											232	235	238			243	242	239								59
60											233	237					242	239								60
61											232	238				244	243	239								61
62											232	237	240	244			243	240								62
63											233	239				244	243	239								63
64											234	238	243				243	239								64
65											232	238	243		243		243									65
66												239	242	243			243									66
67											234	239	243			245	243									67
68												237	242				243									68
69												235	242	244	244	246	243									69
70											236	239	242	244		245	243									70
71											234	239	242	244		245	243									71
72												238	241	244	245	245	243									72
73												238	243			244	242									73
74												239	242	244		244	242									74
75											235	239	243	244	244	245	243									75
76										235	237	240	242			245	243									76
77											237	241				246	242									77
78											237	240	244			245	242									78
79											238	240	241			244										79
80											236	240	244	245	244	245	244									80
81											243	246	242	244	247	244										81

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
82										237	238	241	246	245	245	247	246									82
83											237	239	243	247	247	244										83
84											236	241	244	247	247	245	243									84
85											236	240	242	245	245	245										85
86											237	240	242	244	245	245										86
87										236	236	240	242	246	249	247										87
88										237	237	241	245	245	248	246										88
89										234	235	240	243	246	246	246										89
90											237	239	243	247	247	247										90
91											237	245		248	247	247	247									91
92											235	240	244	247	248	247	245									92
93											236	241	243	247	248	246	244									93
94											236		242	247	248	246	244									94
95											238	243	245		247	246	245									95
96											236	239	244		247	246	244									96
97											236	240	242	246		246	244									97
98										236	237	240	243	244		246	243									98
99										235	237	240	245	247	247	247	244									99
100											241	240	243			246	243									100
101												238	241	244	247	245	243									101
102										236					248	241										102
103											242	246			249	245										103
104											239	241	246		249	247										104
105													242		250	248	246									105
106											239	243	242	247		248	246									106

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
107											239					246	246									107
108											239					245	245									108
109										231	239				246											109
110									232	233	238	243	241	248	248											110
111										232	241	244	242	247	247	247										111
112											239	245	245	246	249	246	245									112
113											238	242	245	246		245	245									113
114												242	247	246		245	244									114
115											238		241	245		245	245									115
116											238	241	242				245									116
NO DATA AVAILABLE FROM THE VIKING PROJECT WEB SITE FOR SOLS 117 THROUGH 133																										
134										233	239	240				245	245									134
135											239					246	245									135
136											239	242			247	246	245									136
137											239	240	243		247	246	245									137
138											238	243				246	246									138
139											237					246	245									139
140										231	240	242	241			246	245									140
141											239					245	245									141
142											240	242	243			245	245									142
143											239					246	245									143
144											241					245	245									144
145											236	239				246	245									145
146											235	240				246	245									146
VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
147											234	240	241			245	245									147
148											240					244	244									148
149											236	241	240			245	244									149
150											235					245	244									150
151											234						243									151
152											234						242									152
153											236	241					243									153
154											233	239					242									154
155											233						243									155
156											233						242									156
157											234						241									157
158											234						241									158
159											232					240	241	237								159
160											236					243	242									160
161										227							242									161
162											232						242									162
163											235							**Ls**	**180**			**F**	**A**	**L**	**L**	163
164										225							243									164
165											231						242									165
166										224	234							236								166
167										226																167
168										224	232						241									168
169										223	232						239									169
170										229																170
171										223	231															171
172										219	228															172
173										223																173
VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	VI1 SOL
174										224																174
175										226																175
176										221						235										176
177										224																177
178										221																178
179									221																	179
180										224																180
181										220																181
182										220																182
183										221																183
184																										184
185									218									227								185
186										218								225								186
187									212	223																187
188										222								226								188
189																										189
190										221								227								190
191										218																191
192									214																	192
193										216								225								193
194									211									226								194
195										216										218	221	217				195
196										219								222								196
197																		224								197
198										216								222								198
199									217									224								199
200										217								224								200

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	VI1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
201										217								222								201
202									211									223								202
203									207									224								203
204										213								217								204
205									206	217								222								205
206									205									217								206
207									206									217								207
208									206									218								208
209									209									223								209
210									199								221									210
211								194									225									211
212								198									229			209	206					212
213								198									227	219		209	207					213
214								199									224			210	208	204	203	201	199	214
215								195									224			211	208			203		215
216								202									225			211	208			205	205	216
217								200									223	217		209	206					217
218								200										218		208	207					218
219								199										217	212	207	204			202	203	219
220								198									222	216		208	206			203	205	220
221								198										215		206	204				201	221
222								197										215		206	204					222
223								196										212		206	203				202	223
224								196										214		207	204					224
225								197									219	214		205	203			200	201	225
226								195	200								217	213		204	201				200	226
227	199							196	199									213		205						227
VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
228	198							194									215			204						228
229								196	199									215	210	204			200	199	202	229
230								192	197									209	204	201	198	196	198	199	198	230
231	196							192	196									210	206	202	200					231
232								193	199									209		203	200			197	199	232
233								193	199									211		203	200	198	198	200	198	233
234	197							193	199									211		304	201	200				234
235								195	201									211	205	203	201	198	196	197	198	235
236	195							191	197									213	207	203	200	197	197	195	198	236
237	198	197						192										212	207	204	201	198	198	200		237
238	195	193					193	192	192										206	203	200	197	197	196	194	238
239	195	196						192										213	205	203	200	197	195	196	196	239
240	197	193						190										209	205	202	198	195	194	194	193	240
241	195	195						189												203	200	197	195	195	197	241
242	196	194						191											206			197	196			242
243	194	191						190											206			197	195	197		243
244	197	197						191											206	203	200	197	197	196	195	244
245	196	196	195					192													199	197	194	192	191	245
246	190	189					186	189														195	193			246
247		193	189				187	189													198	196	194	192	190	247
248	192	194	192					189										208			199	196	195	194	192	248
249	193	194	191					189															193	192	191	249
250	190	189	187				185	187													197	194			194	250
251	192	193						188											205			196	194	193	193	251
252	195	194	193					189																191		252
253	191	188					185	188															194	193	193	253
254	191	189		192				190													199	196	194	194	193	254
VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
255	193	194	191				186	189																		255
256			190				185	188														195	193			256
257	193	190	188					187															192			257
258		193	189				184	187															192			258
259			188	186			184	186														192				259
260		191	189	188				185														193				260
261	189	189	189	187				184																		261
262	191	191	188	186			184	186																190	191	262
263	191		188	185			183	185																		263
264			189	185			183	185														193	191	189	191	264
265		186	187	190				186															193			265
266	190	190	187					186																		266
267			189	186				185														194	192	190	189	267
268	190	191	191					185															191	191		268
269			187					184															191	191		269
270			189					184																189	189	270
271	189		187	184				184															190			271
272			187	186				183														190	188			272
273		185	183	182		181	181	183																186		273
274	186	184	184	182				181															188	187	188	274
275		183	183					217															224			275
276		187	183	182				182	188															187		276
277			185					188																187		277
278			186					182															189	187	186	278
279			186	186				183																188	187	279
280	189	189	187	184				182															189	187		280
281			185					182															189	188	188	281
VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
282	189	187	186	184				181	187														189	188	189	282
283	188	187	187					180	182														189	186	187	283
284	188		183					181																186	185	284
285		186	187	184				180													194	192	189	188	186	285
286	184	187	188					182															188	186	185	286
287	185	183	182	182				180														189	187	185		287
288			185	185				179												195	193	190	188	186	185	288
289	186	187	182						187												193	190	188	186	185	289
290	184	185	186	185	183			181	186													188	186	185	185	290
291	186	186	185	180				179														188	186	185	184	291
292	183	185	182						185												192	189	187	187	185	292
293	185	187	183	184					185													190	187	185	184	293
294	183	184	181					178																	183	294
295	183	182	181	181	180	179	178	179												194	191	190	188	186	185	295
296	188	183							186										198	197	194	190	188	188	188	296
297	184	186	184	186					185												192	190	187	188	187	297
298	186	185	182						184													190	188	185	184	298
299	186	183	184	185					184											197	194	191	189	187	186	299
300	187	186								186										197	194	192	189	188	189	300
301	187	184								183										195	194	191	188	186	185	301
302	188	187	185						184										199	196	193	191	188	187	186	302
303	187	188	187						185											196	192	190	187	186	187	303
304	186	186	185	184					184											196	193	190	188	186	185	304
305	185	188	187	185					184											194	192	190	188	186	184	305
306	186	186	186						184	**Ls**	**270**		**W**	**I**	**N**	**T**	**E**	**R**		195	193	190	189	187	186	306
307	185	183																		195		191	189	187	185	307
308	185	186	186						183														187	185	184	308

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
309	185	183	182																	195	192	190	188	187	186	309
310	185	185	185							193														187	185	310
311	184	186	187							192															185	311
312	186								188																188	312
313	189	185	184						185																	313
314	190	188	192					187	189																	314
315		189	189					186	188										201	197						315
316	189		190	189			188	188											197	194	193					316
317				188	187	187	188											198	195	193	193					317
318				190	189	189	189											199	197	195	194					318
319				191			191										204	201	199	197						319
320				192			192											200	198	196						320
321			191	190													201	199	197	194						321
322			193	190			190											200	197	195						322
323			193	191			190										201	199	197	195	194					323
324			192	191			189										200	198		195	194	192				324
325			192	190			189										201	199	197	195	194	193	192	191		325
326			193	191			189										201	199	197	195	194	193	192	191		326
327			191				189										199	198	196	194	193	192	191	191		327
328			190				188										200	198		194	193	192	191	190		328
329			189				187										198	197			192	191	190	190		329
330			188				188										198	197			192	191	190	190		330
331			190				188										199	197			193	192	191	190		331
332	189		190				188										198				192	191	190	190		332
333	189	190	189				187										198				191	190	189	189		333
334			188														197				191	189	188	188		334
335	188	188	187													197	197				190	189	188	188	188	335
VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
336		187	186													197	196				190	188	188	188	188	336
337		188	187				185									199	198				191	190	189	189	189	337
338			189													200	200				192	191	189	189	189	338
339			189														201	197			192	191	189	189	188	339
340			187				186										199	197			191	190	189	188	188	340
341			189														199	198			192	190	189	188	188	341
342	188		189														200	198			191	189	189	188	188	342
343			188					185									201	198			191	190	188	188	188	343
344	188	188	186					184									201	198			191	189	188	187	187	344
345	189	186	185					183	184								201	198			191	189	188	187	187	345
346			187					184									202	199				189	188	187	187	346
347		189	186					183	184								201	198			191	189	188	187	187	347
348	187		188					183	184								202	199			191	189	187	187	186	348
349			188					184	184								204	201				190	188	187	187	349
350	188	190	187					183	184									201				190	188	187	187	350

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL

.02	.06	.10	.14	.18	.22	.26	.30	.34	.38	.42	.46	.50	.54	.58	.62	.66	.70	.74	.78	.82	.86	.90	.94	.98
199	197	195	192	246	246	193	194	214	220	224	229	239	241	243	244	241	228	224	221	221	217	203	201	199
198	193	189	186	183	181	186	198	218	217	227	226	239	244	244	243	242	237	221	221	206	204	200	203	205
196	196	192	188	180	179	187	198	219	223	226	234	239	243	245	244	242	237	221	221	207	196	198	205	203
197	193	191	187	187	187	185	199	217	221	225	234	240	244	244	244	243	238	222	221	208	198	198	202	205
195	195	187	186	189	189	185	195	232	218	227	235	240	244	244	245	242	237	222	221	208	200	196	203	201
198	194	193	185			186	202	221	216	228	235	239	244	247	246	242	238	222	220	208	198	197	200	202
195	191	191	185			185	200	218	222	223	235	241	244	245	245	242	239	221	221	206	197	198	199	201
195	197	190	190			184	200	212	221	222	236	240	244	247	245	242	239	222	221	207	198	197	199	200
197	196	188	186			184	199	214	222	221	236	238	244	247	245	242	239	221	220	204	197	195	197	202
195	189	189	184			184	198	211	220	231	235	240	245	245	244	243	239	226	221	206	197	194	200	198
196	193	188	186			183	198	217	219	231	236	243	244	245	244	242	241	230	218	204	195	195	197	199
194	194	189	182			183	197	211	223	226	237	243	245	249	245	242	239	227	209	204	197	196	195	198
197	194	189	182			181	196	207	225	230	237	242	247	248	245	243	239	227	209	203	197	195	200	198
196	189	188	182			178	196	206	223	231	236	243	247	246	246	243	238	228	210	204	197	197	196	198
190	193	188	186			188	197	205	223	228	237	242	245	247	245	243	239	227	211	203	197	194	196	194
192	194	189	184			188	195	206	224	230	236	242	244	247	244	243	238	227	211	201	197	193	194	196
193	188	187	184			189	196	206	223	232	236	242	246	248	245	243	239	227	209	198	195	194	195	193
190	189	187	184			191	194	209	223	227	236	242	245	248	244	243	239	227	208	200	196	195	197	197
192	194	189	182			192	196	199	222	230	238	241	246	248	247	243	240	233	207	200	196	193	196	195
195	190	191	185			190	192	200	225	231	238	243	247	247	244	243	239	228	208	200	194	194	192	191
191	193	187	185			190	192	199	227	231	239	242	248	247	245	243	240	229	206	201	196	194	192	190
191	191	189	180			189	193	199	227	231	238	243	247	247	245	243	239	228	206	201	196	194	194	192
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189	186	183	186			189	195	199	227	229	239	241	246	249	246	242	239	180	205	200	193	192	191	193
191	190	184	185			188	191	199	229	230	235	244	244	249	246	242	239	212	204	200	193	191	193	193
191	191	183	184			187	192	199	228	233	237	242	247	250	247	243	239	210	205	198	194	193	194	193
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190	184	185	189			188	192	197	228	231	237	243	247	248	247	242	239	206	204	200	192	191	189	191
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186	187	186	190			187	189	188	229	231	238	242	247	249	246	244	237	207	202	198	190	190	191	189
189	189	187	191			185	191	187	230	232	238	242	246	247	246	246	236	207	203	199	190	188	191	188
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188	186	187	190				192	186	229	234	237	243	245		246	245	226	205	203	194	189	189	187	188
184	187	183	191				189	185	235	233	235	243			247	244	227	206	203	193	190	189	224	189
185	183	187	191				189	185	237	233	239	244			246	244	225	206	204	193	190	189	187	187
186	187	188	190				189	186	236	235	239	243			245	245	226	206	203	192	190	189	187	185
184	185	182	191				189	185	237	232	238	242			241	244	222	205	203	191	190	189	187	186
186	186	185					187	184	234	237	238	245			245	244	224	198	202	194	190	188	188	185
183	185	182					188	184	236	232	239	244			247	243	222	199	203	192	191	187	187	185
185	187	186					189	184	235	233	239	242			248	244	224	201	203	194	192	188	188	185
183	184	185					188	185	236	232	240	243			248	243	224	197	195	194	191	188	188	185
183	182	182					190	184	231	232	241	245			245	243	222	195	194	194	191	186	186	184
188	183	183					189	184	233	233	240	243			247	246	223	197	197	193	190	186	186	185
184	186	181					188	184	232	234	240	241			246	246	224	199	197	192	190	187	188	184
186	185	181					187	183	233	232	240	246			245	245	217	198	197	193	190	187	186	183
186	183	184					187	188	231	234	246	242			245	245	222	197	195	192	190	188	185	185
187	186	182					186	185	227	236	241	242			245	245	217	197	196	193	191	188	186	188
187	184	184					185	189	225	234	239	241			245	244	217	197	196	192	190	187	186	187
188	187	185					184	188	224	235	241	242			246	245	218	197	196	193	192	188	185	184
187	188	187					186	184	226	237	240	245			246	245	223	197	194	193	193	189	185	186
186	186	185					185	184	224	237	240	245			246	245	219	196	195	194	193	189	187	189
185	188	187					185	184	223	237	240	247			246	245	217		195	194	192	188	185	185
186	186	186					186	184	229	238	241	241			246	245	218		195	194	192	188	186	186
185	183	186					186	184	223	236	240	242			246	245	217		197	194	191	187	188	187
185	186	182					185		219	243	239	243			245	246	216		194	194	191	188	188	185
185	183	185					185		223	238	245	241			245	245	215		193	193	192	188	185	184
185	185	187					184		224	237	240	243			246	245	215		195	193	191	189	187	186
184	186	184					184		226	236	241	241			245	245	212		197	192	190	189	188	185
186	185	192					184		221	236	243	240			246	245	214		196	192	189	187	186	184
189	188	189					183		224	237	239				246	245	214		194	193	189	188	187	186
190	189	190					183		221	236	240				245	245	213		195	192	188	192	186	185
189	190	191					181		224	237	240				244	245	213		195	191	190	192	186	185
189	188	193					217		220	235	240				245	245	215		195	191	191	191	186	188

.02	.06	.10	.14	.18	.22	.26	.30	.34	.38	.42	.46	.50	.54	.58	.62	.66	.70	.74	.78	.82	.86	.90	.94	.98
189	187	193					182		220	237	240				245	245	209		195	190	191	191	187	188
188	188	192					188		221	237	238				240	244	210		195	190	190	190	187	188
188	188	192					182		218	235	246				243	244	209		194	191	190	190	185	189
188	186	193					183		223	236	241				235	244	211		194	192	189	191	187	189
189	189	191					182		222	236	243				197	243	211			192	190	190	187	188
187	190	190					182		221	238	243				197	242	211			191	189	189	191	188
188		189					181		218	236	244				199	243	213			192	189	188	191	188
		188					180		216	236	245				200	242	212			191	189	188	191	188
		190					181		216	237	242					243	213			191	189	188	190	188
		190					180		219	237	242					242	209			191	189	189	190	187
		189					182		224	241	241					241	208			191	190	189	190	187
		188					180		216	242	240					241	198			191	190	189	190	187
		187					179		217	239	242					241	199			191		189	190	187
		186					181		217	239	240					242	201					189	189	186
		187					179		213	239	243					242	200					189	188	187
		189					178		217	239	242					242	199					188	188	187
		189					179		186	238	242					243	200					188	188	
		187					187		183	241	239					242	199					188	189	
		189					186		193	239	240					241	198					188	189	
		189					188		192	238	240					239	199					188	189	
		188					185			238	241					221	199					187	188	
		186					184			238	241					225	198					188	188	
		185					183			239	239					229	198					188	188	
		187					184			239						227	197						188	
		186					183			239						224	197						187	
		188					183			239						224	197						187	
		188					184			238						225	197						187	
		187					183			237						223	197						187	
										240						222	198						187	
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ANNEX G
to
THE CASE FOR HIGHER THAN ADVERTISED MARTIAN AIR PRESSURE
Tavis Transducer Specifications and Test Results

This Annex presents data from the NASA Ames Historical Archives and other sources in an attempt to clarify the question of what transducers were available to go to Mars during the Viking1 and 2 plus Pathfinder missions. The initial operating assumption was that Professor James Tillman is correct about 18 mbar Tavis transducers used for Vikings 1 and 2, with a 12 mbar Tavis sensor sent on Pathfinder, but all of them suffered from problems related to dust-jammed air intake tubes and clogged dust filter. However, exactly which sensors were sent to Mars is still an issue. The first entering argument against the 25 mbar sensor it is based on the Alvin Seiff Collection as summed up in Figure 1 below:

I. Viking Project

NATIONAL SPACE SCIENCE DATA CENTER NSSDC.GSFC.NASA.GOV
RIGHT CORNER ACCESS SERVICE MASTER CATALOGUE
ON LEFT SPACE CRAFT VIKING VIKING LANDER OR CLICK ON DATA COLLECTIONS
IMAGING AND METEOROLOGY. SPACE CRAFT LINK IS BETTER.

1. Pressure Sensors

Box 1, Folder 1	Viking Project Pre-Test Report for Investigation to Determine Location of Terminal Descent/Landed Pressure Sensor Orifice, 1971
Box 1, Folder 2	Conrac and Tavis Base Pressure Sensors, Flight Acceptance Test and Calibration Data, (Folder 1 of 2), 1973-1975
Box 1, Folder 3	Conrac and Tavis Base Pressure Sensors, Flight Acceptance Test and Calibration Data, (Folder 2 of 2), 1973-1975
Box 1, Folder 4	Tavis 0-25 millibars Sensors Test Data, Science Testing, (Folder 1 of 2), 1973-1974
Box 1, Folder 5	Tavis 0-25 millibars Sensors Test Data, Science Testing, (Folder 2 of 2), 1973-1974
Box 1, Folder 6	Flight Acceptance Test and Calibration Data. Tavis Pressure Sensors for F.C. A and B and Flight Spare. Tavis' Explanation of Mechanisms. Letters from Specification Sheets, (Folder 1 of 2), 1974-1976
Box 1, Folder 7	Flight Acceptance Test and Calibration Data. Tavis Pressure Sensors for F.C. A and B and Flight Spare. Tavis' Explanation of Mechanisms. Letters from Specification Sheets, (Folder 2 of 2), 1974-1976
Box 2, Folder 1	Viking Entry Science Team Tests of the Parachute Phase Pressure Sensor 0 to 25 millibars Range, 1974
Box 2, Folder 2	Engineering Evaluation Test Report for a 0.1 Absolute Pressure per Square Inch Tavis P-4A Pressure Transducer, 1973
Box 2, Folder 3	Vibrating Diaphragm Pressure Transducer, 1966-1967
Box 2, Folder 4	Evaluation Testing of Tavis 25 millibars Pressure Sensors, 1973
Box 2, Folder 5	Pressure Sensor, Viking Project, (Folder 1 of 2), 1969-1975
Box 2, Folder 6	Pressure Sensor, Viking Project, (Folder 2 of 2), 1969-1975

SCIENTIFIC & TECHNICAL DATA BASE WWW.STI.NASA.GOV
PUBLICALLY AVAILABLE INFO
THE A NASA LIBRARIAN
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NASA HQ HISTORY

Link to this information provide by April Gage, NASA Ames Archivist

Figure 1 to Annex G – Tavis pressure sensors tested according to the Alvin Seiff papers. Data compiled by Adrian, S.P., (n.d.). *Guide to the Alvin Seiff papers*. Retrieved from http://www.oac.cdlib.org/data/13030/08/kt738nd508/files/kt738nd508.pdf

The records on Figure 1 cover the period between 1969 and 1975. Viking 1 launched on August 20, 1975. Viking 2 was launched on September 9, 1975. Note that no sensor listed was for 18 mbar. There are four references to 0-25 mbar sensors, and one reference to a P-4A rated at 0.1 Absolute Pressure per Square Inch (PSIA).

By 25 mbar, it is apparent that this rating is actually a rounded figure that pertains to the Tavis sensor rated at 0.36 PSIA. The 0.36 PSIA figure equals 24.82 mbar. The Tavis CAD for that sensor was shown earlier as Figure 9A in the Basic Report, but for convenience it is shown again below in this Annex as Figure 2.

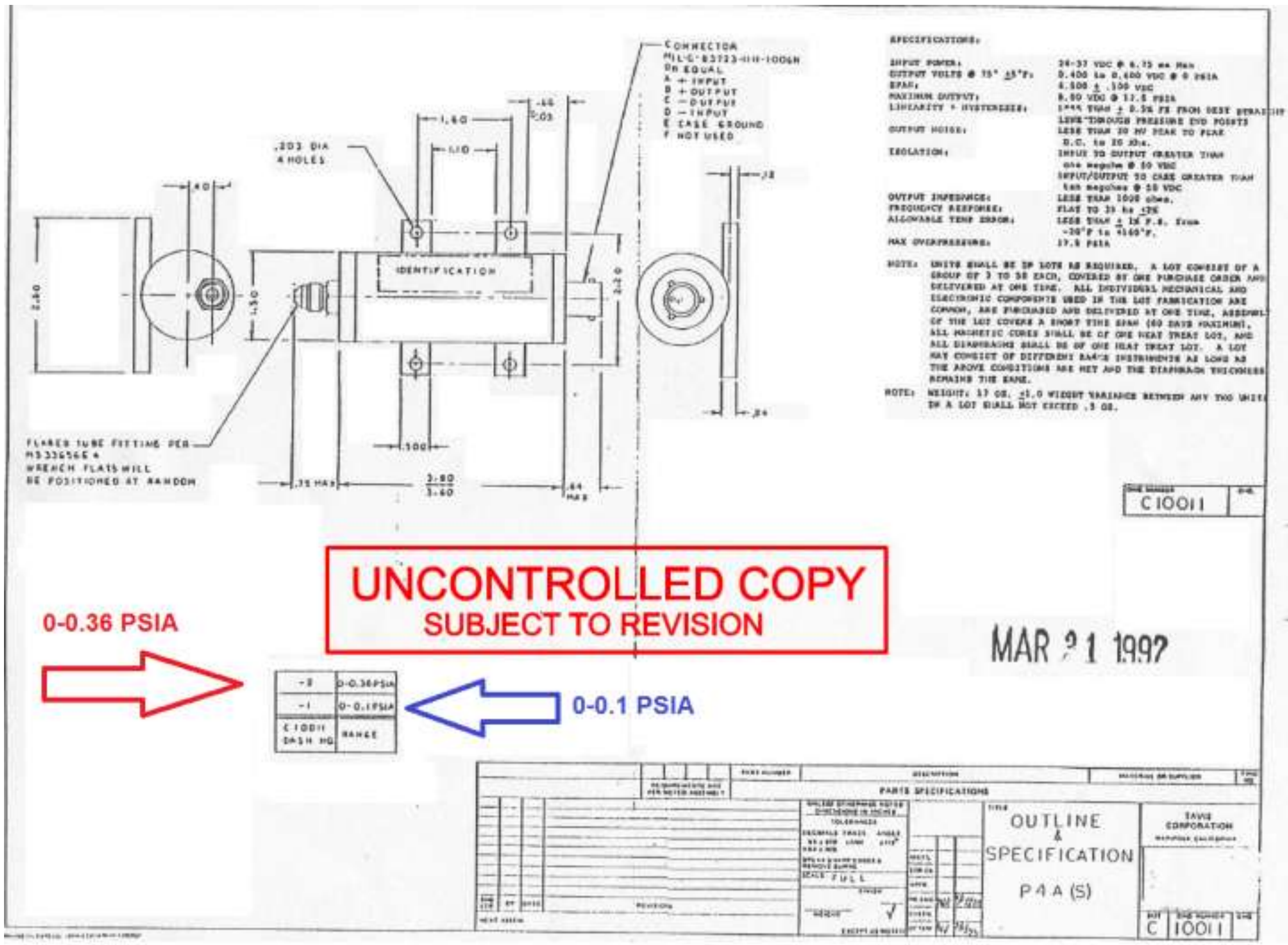

Figure 2 - Adapted from Tavis CAD Diagram 10011. For Vikings Tavis Dash No -2 had a 0.36 PSIA limit (24.82 mbar). However, Pathfinder Tavis Dash No -1 had a 0.1 PSIA limit (6.9 mbar). Source: Personal communication, Tavis Corporation 10/29/2009.

So, the question must be asked, does any NASA document back the 18 mbar figure given the Professor Tillman, the Director of the Viking Computer Facility? The answer is yes. His numbers are supported by the NASA Report TM X-74020, *Evaluation of Viking Lander Barometric Pressure Sensor* (dated March 19877) by Michael Mitchell (hereafter referred to as the Mitchell Report). Its abstract in block 16 is of particular interest. See Figure 3 below:

1. Report No. NASA TM X-74020	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Evaluation of Viking Lander Barometric Pressure Sensor		5. Report Date March 1977
		6. Performing Organization Code 1277
7. Author(s) Michael Mitchell		8. Performing Organization Report No.
9. Performing Organization Name and Address NASA Langley Research Center Hampton, Virginia 23665		10. Work Unit No. 815-10-00-00-06
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautical and Space Administration Washington, D.C. 20546		13. Type of Report and Period Covered Technical Memorandum
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

Two variable reluctance type pressure sensors with a full range of 1.79×10^3 N/M^2 (18 mb) were evaluated to determine their performance characteristics related to Viking Mission environment levels. Twelve static calibrations were performed throughout the evaluation over the full range of the sensors using two point contact manometer standards. From the beginning of the evaluation to the end of the evaluation, the zero shift in the two sensors was within 0.5 percent and the sensitivity shift was 0.05 percent. The maximum thermal zero coefficient exhibited by the sensors was 0.032% over the temperature range of -28.89°C to 71.11°C. The evaluation results indicated that the sensors are capable of making high accuracy pressure measurements while being exposed to the conditions mentioned herein.

17. Key Words (Suggested by Author(s)) (STAR category underlined) Viking Pressure Sensor Test; Low Pressure Measurement; Pressure Calibrations; Martian Pressure Measurement	18. Distribution Statement		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 108	22. Price* $5.50

(The National Technical Information Service, Springfield, Virginia 22161)

Figure 3 – Adapted from NASA Report No. TM X-74020 (the Mitchell Report) published in March 1977. Page 4 of the report specifies that the two sensors tested were P-4 sensors having serial numbers S/N 1583 and S/N 1591.

Page 4 of the Mitchell Report under Test Results states the following about what sensors it examined: “Two Tavis Corp. Model **P-4 sensors**, having serial numbers S/N 1583 and S/N 1591, were chosen to be evaluated using the Viking Mini-Mission format. On **September 23, 1975**, the sensors were connected to the vacuum system and pumped to less than 10^{-1} N/M^2 (10^{-3} mb).” The full report is 110 pages, but what immediately catches the eye is the sensor tested (the P-4) and the date of the tests (starting on September 23, 1975. This testing was thus begun ***after*** both Vikings had already been launched (Viking 1 launched on August 20, 1975, Viking 2 on September 9, 1975). A picture of the P-4 was supplied to me by April Gage, the NASA Ames historian. The photo clearly indicates that the P-4 was rated at 0.2 PSID – see Figure 4. However, the writing on red ink on the document provided by NASA indicates that Model P-4A was purchased!

Figure 4 – Photo of the Tavis P-4 pressure sensor, and written indication that a P-4A was ordered. The date of this particular order is not clear.

Does the figure above, or its writing in red, support the 18 mbar (or 17.9 mbar) figure offered earlier in the Mitchell Report? No. The P-4 shown in Figure 4 is clearly labeled as having a range of 0 to 0.2 psid (not psai). What does that mean? Differential pressure measurement is the difference between two unknown pressures. Output is zero when the two pressures are the same, regardless of magnitude. Differential Pressures are notated as "D" (PSID). The magnitude of the common pressure is called "static" or "base" pressure. Differential transducers are usually "wet/wet" construction. This definition is taken from http://www.iprocessmart.com/techsmart/pressure_help.htm. However, if we assume that one side of the sensor feels less than 0.001 mbar, then essentially the sensor tested was capable measuring a difference of up to 0.2 psi. That amount converts to 13.79 mbar, not 17.9 not 18 mbar.

What about the red writing that indicates a P-4A was purchased? There is nothing on the document that indicates the date it was purchased. But what was the capability of the P-4A? See Figure 1. According to the *Guide to the Alvin Seiff papers* (Box 2 Folder 2), it is apparent that there was an "Engineering Evaluation Test Report for 0.1 Absolute Pressure per Square Inch Tavis P-4A Transducer, 1973." That is 0.1 PSIA. This amount equates to 6.9 mbar, still not close to 18 mbar. I have pressed Professor Tillman hard on these issues now for most of 2010. On November 25, 2010, he finally sent me an e-mail with two attachments. I was surprised to find that the 110-page Mitchell Report was the first of them. We had debated that report back in May 2010 when he first informed me about the radioisotope thermoelectric heaters (RTGs) that were supposed to protect the transducers from external temperatures that were clearly much colder than the -28.89° C tested (see block 16 – the Abstract on the Mitchell Report shown on Figure 3 above) in the very late tests that occurred well after both Vikings were on their way to Mars.

How much colder than -28.89° C was it on Mars? See Appendix 1 to Annex D of this report. It shows that the temperature reported from the surface of the planet on VL-1 Sol in the 0.22 time-bin was -85.76° C (the first temperature recorded at time-bin 0.02 on VL-1 Sol 1 was -78.28° C (in summer at Ls 97.196).

For Viking 2 the first temperature recorded was also at night. It was -72.05° C in the .06 time-bin (VL-2 Sol 1.06), but by Sol 1.18 it was down to -80.26° C (still in the summer). So the obvious question here is, *Just how fast did the RTGs kick on and was it fast enough to prevent damage to the transducer*? To date, all requests from Professor Tillman for specific information about RTG operations have gone unanswered. It is important to know (1) how fast they began to operate and (2) what triggered their operation – temperature outside, inside, or a simple timer?

The minimum temperature recorded in Viking 1's first day (-85.76° C, or -122.368 °F) was 54.78°C (98.766° F) colder than what was tested for in the Mitchell Report. And yet the Vikings were both subjected to far colder temperatures as they moved from the summer temperatures felt on landing to the winter lows. For Viking 1 the coldest temperature felt (in its tropical location) was -95.96°C (-140.728°F). For Viking 2 the temperature got as low as -121.01°C (-185.18 °F).

Figure 9 in this Annex (the Tavis Corporation's transducer ordering information) yields a -53.89 °C minimum temperature allowed, but that is still not as cold as what was felt by either Viking immediately upon landing.

Now aside from the issue of whether the temperature was too cold for the transducers, there is the issue of the red writing on Figure 4. It is not at all clear as to why NASA would want a transducer that is limited to 0.1 psia/6.9 mbar. As was shown on Table 5 of the Basic Report of my report, Mariner 4 only attempted two pressures readings – and one of them was between 7 and 9 mbar. Mariners 6 and 7 attempted a total of four readings, and two of them ranged from 6.9 to 7.3 mbar. Finally, Mariner 9 saw 10.3 mbar. All of these measurements were in NASA hands well before the Vikings were launched. And yet, the second of two attachments sent to me by Professor Tillman on November 25, 2010 seems to allude to the P-4A (7 mbar) as is seen on Figure 5:

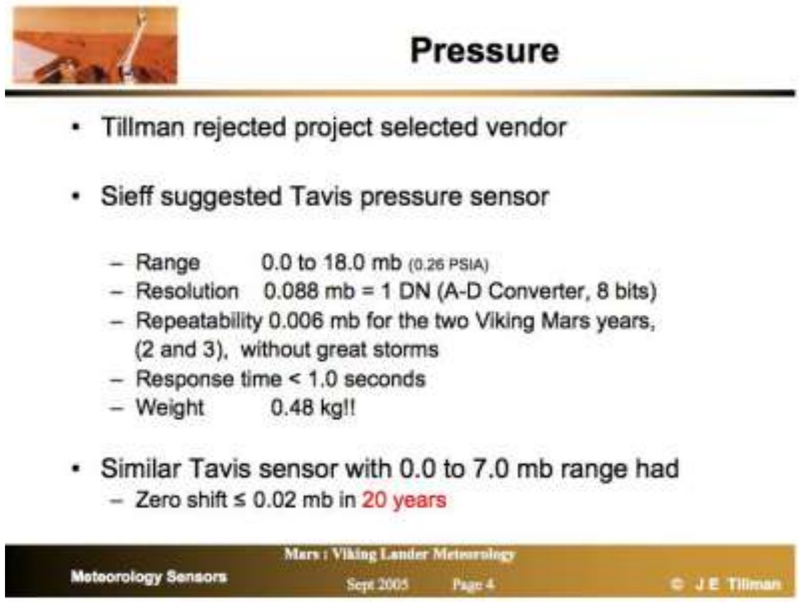

Figure 5 – Transducer Selection Slide by Professor James E. Tillman

While Professor Tillman has not yet answered questions about the mechanism for RTG operation/timing, the above slide was extremely important for three reasons:

(1) It shows that in September 2005, long before my study began in 2009, he was quoting the pressure range of a Sieff (presumably Alvin *Seiff* mentioned earlier in conjunction with Figure 1) suggested Tavis pressure sensor rated at 0.0 to 18.0 mb (mbar). The 0.26 PSIA figure actually converts to 17.926 mbar.

(2) It provides the resolution of the sensor as 0.088 mbar. That matches what I found and discussed in conjunction with Section 2.4.1 of my Basic Report (The issue of Viking pressure reports and digitization).

(3) It mentions a *similar* Tavis sensor with 0.0 to 7.0 mbar range with zero shift ≤ 0.02 mbar in 20 years. This is almost certainly the P-4A. It is not clear from the slide as to which project selected vendor was rejected by Professor Tillman, but since the slide dates from before the launch of the Phoenix, it may be a reference to the Vaisala transducer selected for that mission. Since the Vaisala was limited to 12 mbar, and since Viking 2 measured at least 10.72 mbar on its Sol 277.34, it would not make sense to back a sensor that could only see 12 mbar.

For the benefit of those who want to investigate the issue of possible confusion with respect to Tavis sensors and their capabilities, this Annex will also includes the Tavis CAD for the Pathfinder mission. Shown in the Basic Report as my Figure 9B, it is labeled as Figure 6 in this Annex. Finally, the three pages of the Tavis specifications and parts order information received from the NASA Ames historical office are included as Figures 7, 10 and 11. Note that on Figure 10, for the Tavis P-4, the minimum pressure range is 0.1 psi and the maximum is 100 psi. Again, 0.1 psi is 6.8945 mbar, while **100 psi is 6,894.5** mbar! Thus one Tavis transducer with the same model number could apparently be tweaked by the producer to produce results that differed by three orders of magnitude. This is a thousand fold potential source of error. In looking at Figure 6, there were clearly two entirely different pressures given – 0.174 PSIA (12mbar) and 15 PSIA (1,034 mbar. Martian weather simply does not match the lower pressure range offered.

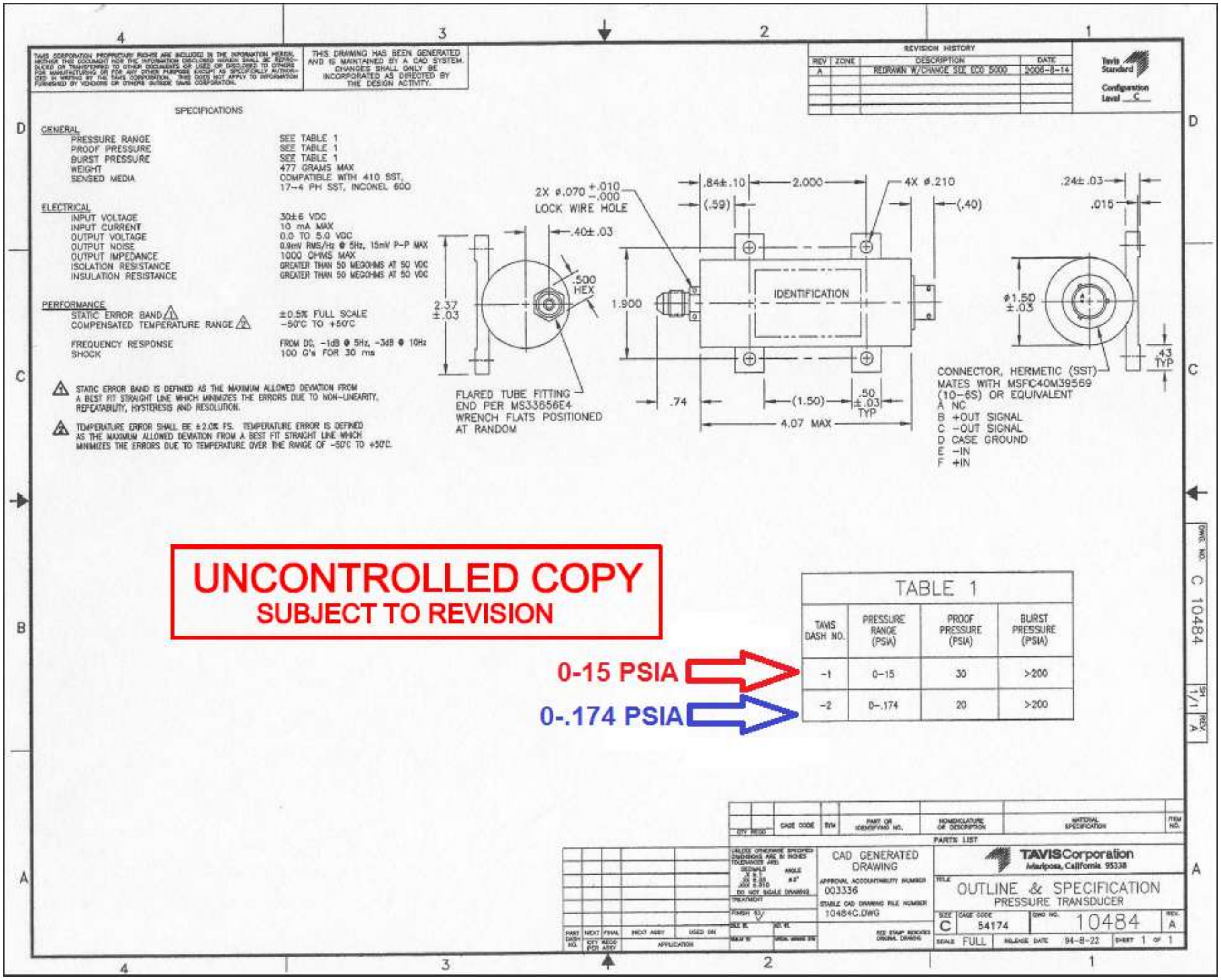

Figure 6 – Adapted from Tavis CAD Diagram 10484. For Mars Pathfinder Tavis Dash No -2 had a 0.174 PSIA limit (12 mbar). However, Pathfinder Tavis Dash No -1 had a 15 PSIA limit (1,034 mbar). Source: Personal communication, Tavis Corporation 10/29/2009.

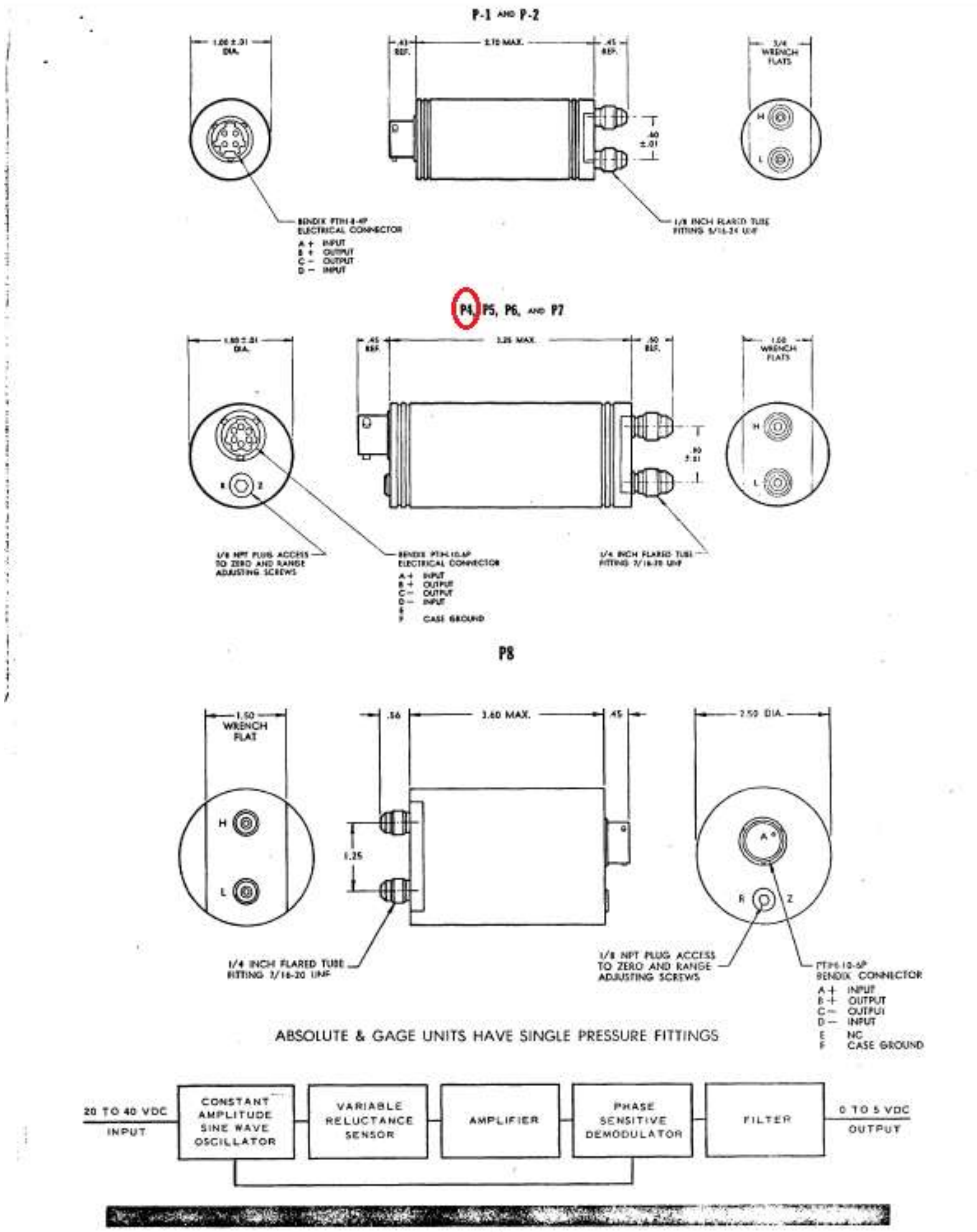

Figure 7 - Design diagrams for Tavis transducers (Models P-1, P-2, P-4, P-5, P-6, P-7 and P-8).

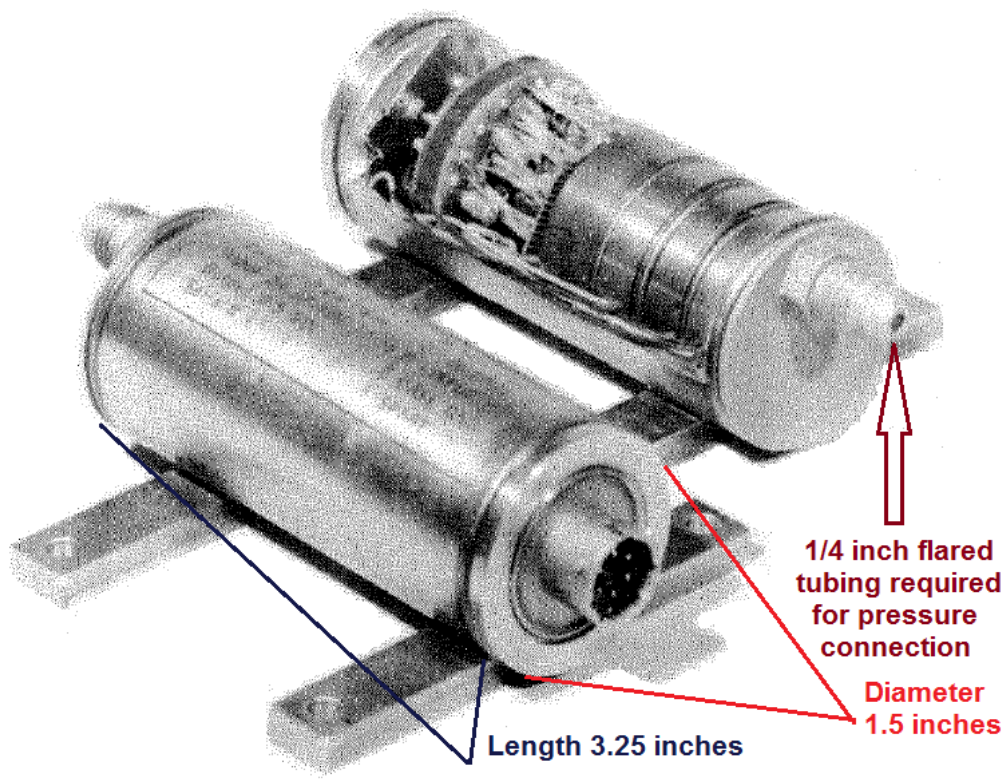

Figure 8 – Tavis P-4 Transducers (S/N 1583 and S/N 1591) used for test of Viking pressures sensors after the launch of the two Vikings. NASA Report TM X-74020 (the Mitchell Report).

Figure 9 – Relative sizes of dust filters used for Tavis and Vaisala pressure transducers.

TABLE OF CHARACTERISTICS

MODEL NUMBER P–		1	2	4	5	6	7	8
MINIMUM PRESSURE RANGE (PSI)		1	100	0.1	0.1	100	100	0.01
DIAPHRAGM NATURAL FREQUENCY (Hz)		3.5K	12K	2K	2K	10K	10K	500
ACCELERATION RESPONSE (%FS/g)		.03	.003	.3	.3	.007	.007	3
MAXIMUM PRESSURE RANGE (PSI)		100	2500	100	100	2500	2500	100
DIAPHRAGM NATURAL FREQUENCY (Hz)		12K	47K	10K	10K	37K	37K	7K
ACCELERATION RESPONSE (%FS/g)		.003	.0005	.007	.007	.0007	.0007	.015
PRESSURE INPUT OPTIONS		GAGE ABSOLUTE DIFFERENTIAL	GAGE ABSOLUTE	GAGE ABSOLUTE DIFFERENTIAL	GAGE ABSOLUTE DIFFERENTIAL	GAGE ABSOLUTE	GAGE ABSOLUTE	GAGE ABSOLUTE DIFFERENTIAL
ADJUSTMENTS	RANGE	NONE	NONE	± 2% F.S.	± 50% F.S.	± 2% F.S.	± 50% F.S.	± 2% F.S.
	ZERO				± 2.5V		± 2.5V	
MAGNETIC SHIELDING		SINGLE	SINGLE	SINGLE	SINGLE	SINGLE	SINGLE	DOUBLE
PRESSURE FITTINGS	Flared Tube	⅛	⅛	¼	¼	¼	¼	¼
DIAMETER (Inches)		1	1	1.5	1.5	1.5	1.5	2.5
LENGTH (Inches) (1)		2.7	2.7	3.25	3.25	3.25	3.25	3.60
WEIGHT (Ounces)		5	5	12.5	12.5	12.5	12.5	40
SPECIAL FEATURES AVAILABLE								
HIGH OVERPRESSURE		X	X	X	X	X	X	X
OUTPUT VOLTAGE CLAMP		X	X	X	X	X	X	X
CALIBRATE SIGNAL				X	X	X	X	X
CORROSION APPLICATION		X	X	X	X	X	X	X
SPECIAL TEMPERATURE COMPENSATION		X	X	X	X	X	X	X
OFFSET ZERO		X	X	X	X	X	X	X

(1) Low pressure ABSOLUTE instruments are slightly longer.

Figure 10 -Table of Characteristics of Tavis transducers (Models P-1, P-2, P-4, P-5, P-6, P-7 & P-8).

-65 °F = -53.89 °C

General Specifications

Static error band	±½% Full Scale	(note 1)
Input voltage	20 to 40 VDC	
Input current	6 ma. nominal value	
Output	0-5 VDC ±50 mv at end points	
Output impedance	50 — 100 ohms	
Output noise	15 mv - maximum	
Frequency response (Electronic circuit)	Flat ±5% Full Scale to 500 Hz	
Insulation resistance	100 megohms min. at 100 VDC	
Maximum overpressure	20 psi or twice rated pressure whichever is greater	
Temperature range	−65° F to + 165° F	(note 1)
Temperature error	Less than ±2% F.S.	(note 1)
Vibration	35 g's peak to 2000 Hz	(note 2)
Shock	1000 g's for 11 ms	(note 2)
Materials in contact with pressure media	410 stainless steel and Inconel 600	(note 3)
Other	Meets MIL-E-5272C for humidity sand and dust, altitude, rain, salt spray, immersion and fungus. Pressure ports must be sealed during test.	

1. Closer tolerances and high temperature operation may be supplied. Consult the factory for your special requirements.
2. Adjustable zero and range - 20 g's (potentiometer limit)
3. Instruments for corrosive applications are made of 17-4 or 17-7 PH and Inconel 600.

Our continuing product improvement program may cause changes in specifications without notice.

Accessories Available

- AC line to 28 VDC Power Converter - Model 1020
- Meter Readout Systems
- Mating Electrical Connectors
- Electrical Cables
- Mating Pressure Fittings
- Pressure Tubing
- Mounting Brackets

OUR REPRESENTATIVE IN YOUR AREA IS:

REPRESENTED BY
EGBERT ENGINEERING
801 WELCH ROAD
PALO ALTO, CALIFORNIA 94304
326-1387

Ordering Information

- Order by Model Number - Pressure Range - Specify Absolute, Gage, or Differential pressure measurement. ie: P-1, 0-15 psia - or - P-1, ±1.0 psid
- All Tavis transducers can be supplied for corrosive media applications. Materials used for this purpose are Inconel, 17-4 PH, and 17-7 PH stainless steels. Model numbers of corrosion resistant pressure transducers are the same as the standard models - plus one hundred. Thus, a P-104 is a corrosion resistant P-4.
- Specify Options and Accessories required.
- Your Purchase Order should include:
  - Complete "Charge to" and "Ship to" information.
  - Method of shipment

  Without specific instructions, your order will be shipped "Best Way", insured.
- FOB: Mariposa, California 95338
- Terms: ½ of 1% 10 days, net 30 days.

U.S. PATENT NO. 3,562,687 OTHER U.S. AND FOREIGN PATENTS PENDING

TAVIS CORPORATION
BOOTJACK ROAD — MARIPOSA, CALIFORNIA 95338
(209) 966-2182

2.5K/10-71

Figure 11 – Tavis Transducer purchasing information. Note that the minimum temperature allowed (-65 °F, or -53.89 °C) is not nearly as cold as what was experienced immediately upon landing (in the summer) on Mars. For Viking 1 the first temperature reported was -78.28° C (Ls 97.196), and for Viking 2 it was -72.05° C at Ls 118.102. Both landers experienced even colder temperatures on their first night on Mars (-85.76°C for Viking 1 and -80.26°C for Viking 2). The temperature limits given are for all Tavis transducers, although higher (but not lower) temperature operation parts were available.

In the Mitchell Report under a section entitled *Cruise Environment* and in conjunction with its Figure 20 there are a number of inconsistencies, typos and problems. The two Tavis Model P-4 pressure sensors tested were S/N 1591 and S/N 1583. The sensors are shown on Figure 8. The Abstract states that these tests were conducted just after the Vikings launched "to determine their performance characteristics related to Viking Mission environment levels."

The document states that:

> *On the 9th day, S/N 1591 and S/N 1583 experienced a drop in* ***zero output voltage*** *of 8 mV and 41 mV, respectively, due to a sudden drop and recovery of approximately 67°C. This temperature drop was due to a temporary malfunction in the thermal environment chamber which dropped the temperature to approximately -51° C in one hour. Figure 20 shows a more detailed account of this incident.*

The Mitchell report's Figure 20 is colorized and relabeled as this Annex's Figure 12. There are numerous issues raised by the above report quotation. First, it seems odd that two sensors, experiencing identical drops in temperature, would have such different voltage drops. Forty-one mV is over 5 times greater than 8. Note that this was during the cruise stage with very low pressure 0.1 N/m^2 (0.001 mbar). Next, the -51ºC temperature is lower than the -28.89ºC temperature specified for the test.

Looking at Figure 10, the top graph Y axis is labeled SENSOR OUTPUT (VOLTS). S/N 1591 started with about 0.49 VOLTS. As the temperature drop ensued, the voltage climbed (according to the graph) to about 0.54 VOLTS and then fell to about 0.41 VOLTs. So, overall, it fell from 0.49 to 0.41, a drop of 0.08 – but not mV unless the y Axis is labeled wrong. It probably should read a drop of 0.049 to 0.041. So there is an apparent one order of one magnitude in error here someplace. Is the error on the write up, or on the graph?

S/N 1583 started with about 0.53 VOLTS. We'll ignore the decimal place for now as it's already addressed in the previous paragraph. As the temperature drop ensued, the voltage climbed (according to the graph) to about 0.61 VOLTS and then fell to about 0.45 VOLTs. So, overall, it fell from 0.53 to 0.45, a drop of 0.08 volts. This does not line up well with the drop of 41 mV as specified in the write up. It looks like the person generating the graph might have confused the minimum voltage there of 0.41 (or, really, 0.041) for sensor 1591 with the drop in voltage for sensor 1583.

Finally, the difference in voltage AFTER the temperature climbed back up to almost the right temperature was only about one sixth of what it was before the temperature drop. What might this indicate? Perhaps after the Viking Tavis pressure sensors experienced the REAL cold temperature on Mars, they would spit out essentially identical, but meaningless pressure readings. In-other-words, they were ruined. The area in red on Figure 11 represents the difference in mV between the two sensors tested. Figure 12 illustrates why it is important to understand how fast the RTGs started heating and maintaining uniform temperatures after landings occurred. To understand how small the Tavis and Vaisala dust filters were, see Figure 9.

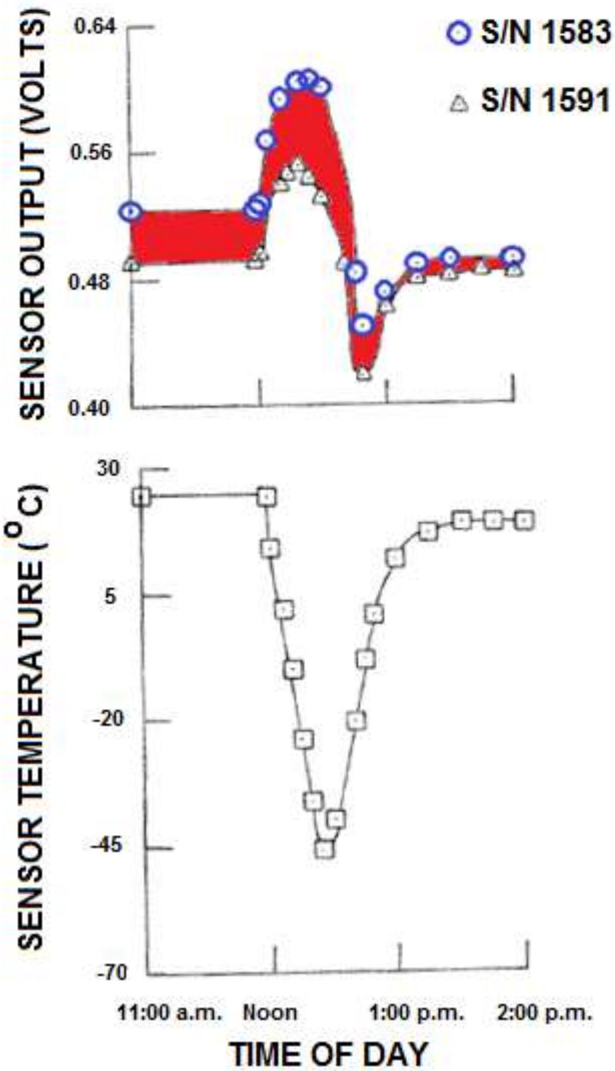

Figure 12 – Temperature Malfunction During (Viking) Cruise Environment. Adapted from Figure 20 in NASA Report TM X-74020 (the Mitchell Report).