

Reliability of Bvgdo Degraded Power X-Band GaAs MESFET

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The purpose of this memorandum is to summarize the results of the tests performed concerning time dependent BVgdo slump on EOS-AM/Landsat-7 X-band power GaAs FETs. Manufacturer-supplied analysis stated that the slump was most likely due to unstable surface state defects generated during wafer processing and this mechanism would not lead to catastrophic failure. To support the conclusions of the manufacturer's analysis, two conditions were imposed by NASA:

1. Four post-2000 hour overdrive life test devices were to be subjected to an iterative reverse breakdown stress test. All four devices passed this test. The devices proved to be extremely robust. The test setup and data are summarized below. This test demonstrated that instantaneous failure of the devices in the application is unlikely. This testing was performed at the manufacturer's facility under supervision of H. Shaw, NASA/GSFC and H. Huang, LMMS Consultant. Vgd was applied at -15V and incremented -2V up to -25V. The dwell time at each voltage was 1 minute. The device RF performance and BVgdo at 1mA Ig was baselined before the test. After each reverse bias voltage, the RF performance and BVgdo were measured. In addition, the DC reverse breakdown current and Igrf were recorded. The devices survived very high breakdown currents. The results are summarized in Table A. The test circuit is shown in Figure A.

Table A
Reverse Breakdown Stress Test

Device No.	Vg =					
4Z01-030	2.01					
Bias Point	Ig	Bvgdo	PO1	Igrf @ PO1	PO2	Igrf @PO2
	mA	Igd=1mA	Pin=32.5d Bm	mA	Pin=22.5d Bm	uA
Initial		-13	38.03		30.07	
-15	-5	-13.35	38.76		30.62	
-17	-23	-13.55	38.66	-0.638	30.51	-19
-19	-75	-13.7	38.63	-0.545	30.51	-17
-21	-272	-13.7	35.52	-0.426	30.53	-16
-23	-492	-13.7	38.55	-0.571	30.49	-17
-25	-758	-13.6	38.59	-0.604	30.5	-19

Device No.	Vg =					
4Z01-032	2.49					
Bias Point	Ig	Bvgdo	PO1	Igrf @ PO1	PO2	Igrf @PO2
	mA	Igd=1mA	Pin=32.5d Bm	mA	Pin=22.5d Bm	uA
Initial		-10.95	39.29		30.26	
-15	-28	-11.65	39.19		30.09	

-17	-90	-11.85	39.26	-7.9	30.26	-54
-19	-262	-11.9	39.24	-7.9	30.26	-49
-21	-513	-11.9	39.17	-7.74	30.17	-48
-23	-752	-12	39.19	-7.94	30.19	-52
-25	-970	-12.15	39.26	-8.1	30.26	-50

Device No.	Vg = 2.43					
4Z01-034						
Bias Point	Ig	Bvgdo	PO1	Igrf @ PO1	PO2	Igrf @PO2
	mA	Igd=1mA	Pin=32.5d Bm	mA	Pin=22.5d Bm	uA

Initial		-11.05	39.11		29.96	
-15	-25	-11.7	39.09		29.95	
-17	-76	-11.8	39.06	-6.49	29.99	-45
-19	-216	-11.9	39.11	-6.43	30.08	-44
-21	-446	-11.9	39	-6.34	30.07	-43
-23	-642	-11.9	39.07	-6.54	29.95	-50
-25	-939	-12.05	39.07	-6.89	29.94	-44

Device No.	Vg = 2.1					
4Z01-034						
Bias Point	Ig	Bvgdo	PO1	Igrf @ PO1	PO2	Igrf @PO2
	mA	Igd=1mA	Pin=32.5d Bm	mA	Pin=22.5d Bm	uA

Initial		-15.55	38.36		30.74	
-15	0	-15.65	38.43		30.9	
-17	-2	-15.45	38.36	-0.468	30.72	-15
-19	-10	-15.75	38.4	-0.253	30.8	-15
-21	-31	-15.7	38.37	-0.262	30.8	-14
-23	-266	-15.9	38.39	-0.37	30.74	-14
-25	-595	-16.2	38.42	-0.34	30.78	-14

Notes:

Empty cells mean data was not recorded
Pout was set with Vds=8.0V, Ids(Rf off)=1.4A, f=8.0GHz, Tc=40C

2. Eight devices from the same overdrive life test were to continue to 5000 hours with significant change in device performance. This would validate the assertion that the surface state defects annealed out of the samples early in the life test (under approximately 1000 hours) and the long term device characteristics were stable. At the time this condition was imposed the devices were between 2000 and 3000 hours. The 5000 hour test is now complete and the results are summarized below in three parts.

PART I	Gm, vp, idss, PO1, PO2, igss & igxs	Page 2
PART II.	BVgdo and BVgso	Page 11
PART III.	Predicted performance over mission life	Page 15

All of the data provided to NASA from the 5000 hour test was analyzed using Statistica and Excel. The last two digits of each heading correspond to a serial number from the test. For example: ZPO1_02 is the PO1 data for S/N 02. The Z means that S/N 02 was a device that started with BVgdo < 17 Volts.

Part I. Gm (transconductance), vp (pinch-off), idss (drain current), PO1 (Pout: Pin=+32.5dBm~P_{5ab} point), PO2 (Pout:Pin=+22.5dbm), igss & igsx (gate leakage).

None of the parameters above showed a significant change.

TABLE I
gm: Vd=3V, Ids=2A. No spec limit

HRS	ZGM_02	GM_08	GM_11	GM_12	ZGM_20	ZGM_24	GM_25	ZGM_28	GM_30	ZGM_32	ZGM_34	GM_70
0.1	2.3	2.3	2.3	2.4	2.3	2.3	2.4	2.2	2.2	2.1	2.1	2.1
1000	2.3	2.4	2.4	2.4	2.3	2.3	2.4	2.2	2.2	2.1	2.1	2.2
1240	2.3	2.4	2.4	2.4	2.3	2.3	2.4	2.2	2.2	2.1	2.1	2.2
1500	2.3	2.4	2.4	2.4	2.3	2.3	2.4	2.2	2.2	2.1	2.1	2.2
2000	2.2	2.4	2.4	2.4	2.3	2.3	2.4	2.2	2.2	2.1	2.1	2.2
3000	2.3	2.4	2.4	2.5	2.3	2.4	2.4	2.3				
3780	2.33	2.4	2.08	2.44		2.35	2.42	2.26				
5000	2.32	2.39	2.43	2.45		2.34	2.4	2.25				

TABLE 2
-Vp: Vd=3V, Ids=20mA. Limit: -2.0V (min), -4.0V (max)

HRS	ZVP_02	VP_08	VP_11	VP_12	ZVP_20	ZVP_24	VP_25	ZVP_28	VP_30	ZVP_32	ZVP_34	VP_70
0.1	3.22	3.05	3	2.96	3.21	3.15	2.99	2.93	2.83	3.47	3.38	2.99
1000	3.25	3.07	3.03	2.98	3.22	3.17	3.01	2.96	2.85	3.52	3.43	2.98
1240	3.25	3.07	3.03	2.98	3.22	3.17	3.01	2.96	2.85	3.51	3.42	2.99
1500	3.25	3.07	3.03	2.97	3.22	3.17	3	2.96	2.86	3.51	3.42	2.99
2000	3.24	3.06	3.02	2.97	3.21	3.16	3	2.96	2.86	3.5	3.43	3
3000	3.23	3.05	3.01	2.97	3.21	3.16	3	2.96				
3780	3.22	3.05	3	2.95		3.15	3	2.94				
5000	3.22	3.04	2.99	2.95		3.15	2.99	2.93				

There was virtually no change in pinch-off characteristics.

TABLE 3
 -I_{gss}: V_{gs}=-5V, V_{ds}=0V. Limit: - 100uA (max)

HRS	ZIGS_02	IGS_08	IGS_11	IGS_12	ZIGS_20	ZIGS_24	IGS_25	ZIGS_28	IGS_30	ZIGS_32	ZIGS_34	IGS_70
0.1	0.222	0.255	0.224	0.24	0.265	8.49	0.235	0.232	0.195	0.223	0.273	0.173
1000	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112
1240	0.329	0.351	0.308	0.315	0.349	3.08	0.319	0.297	0.248	0.278	0.313	0.198
1500	0.345	0.368	0.321	0.323	0.363	3.84	0.339	0.295	0.25	0.276	0.318	0.203
2000	0.389	0.373	0.331	0.331	0.416	10.6	0.345	0.303	0.262	0.28	0.33	0.227
3000	0.406	0.374	0.324	0.34	0.429	10.2	0.345	0.307				
3780	0.383	0.353	0.291	0.315	0.45	5.28	0.328	0.284				
5000	0.408	0.391	0.307	0.335		4.5	0.332	0.294				

Note that all of the 1000 hour data is 0.112uA. S/N 24 has much higher leakage under these conditions, but the level is an order of magnitude below the spec limit.

TABLE 4
 -I_{gsx}: V_{ds}=10V, I_{ds}=2.0A, Limit: -400uA (max)

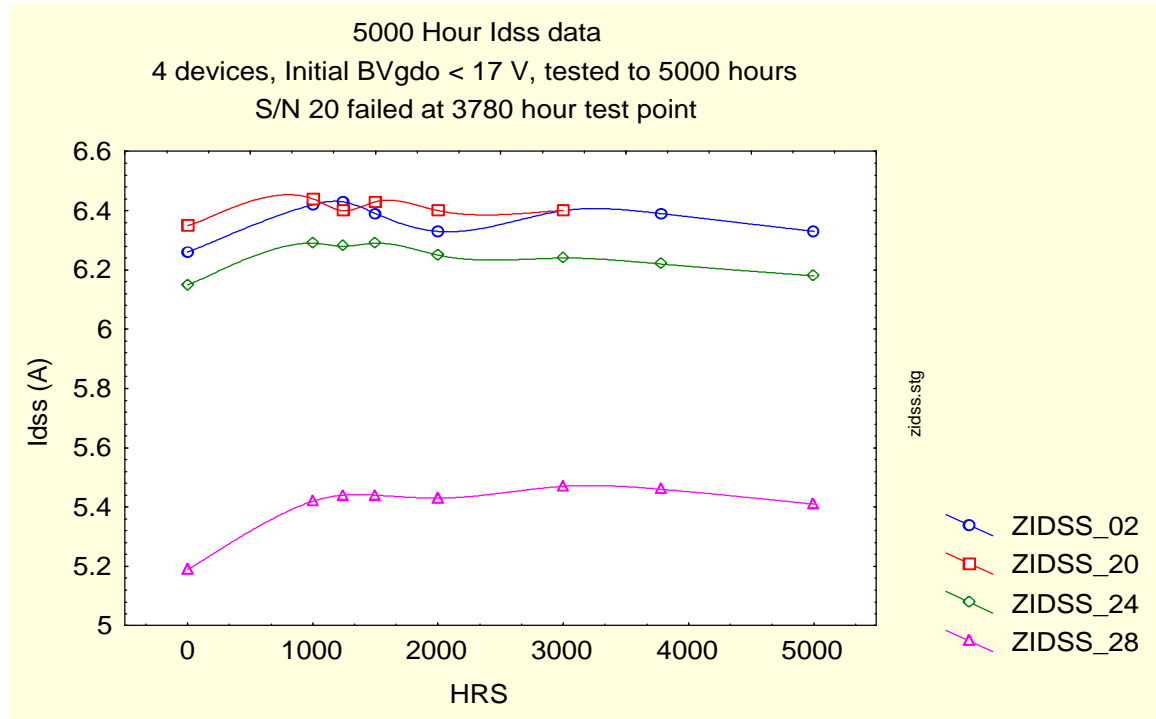
HRS	ZIGSX_02	IGSX_08	IGSX_11	IGSX_12	ZIGSX_20	ZIGSX_24	IGSX_25	ZIGSX_28	IGSX_30	ZIGSX_32	ZIGSX_34	IGSX_70
0.1	16.8	12.9	14.5	17.5	16.8	24.8	15.4	9.2	8.5	15.9	15.5	29
1000	49	39.1	37.5	42.6	49.9	51.9	38	26.3	27.3	52.4	40.2	44.2
1240	31.9	25.8	22.7	24.8	32.8	24	22.3	16.8	28.6	36.2	24.4	15
1500	48.4	39.7	43.6	48.3	50.6	58.7	41.6	28.3	29.3	54	44.1	48.1
2000	58.5	43.7	46.6	53.6	57.5	69	45.1	29.8	32	57.7	45.3	52.5
3000	50.4	42.3	38.6	52.6	50	62	40.7	26.7				
3780	54.1	44.2	44.4	64.3	62.4	72.1	44.3	30.9				
5000	56.4	48.4	50.8	72.7		77.2	46.3	31.7				

TABLE 5
 I_{dss}: V_{ds}=3.0V, V_g=0V. Limit: 5.2A (min), 6.8A (max)

HRS	ZIDSS_02	IDSS_08	IDSS_11	IDSS_12	ZIDSS_20	ZIDSS_24	IDSS_25	ZIDSS_28	IDSS_30	ZIDSS_32	ZIDSS_34	IDSS_70
0.1	6.26	6.13	6.09	6.09	6.35	6.15	5.98	5.19	5.12	6.17	6.11	5.32
1000	6.42	6.21	6.16	6.11	6.44	6.29	6.06	5.42	5.3	6.38	6.21	5.27
1240	6.43	6.17	6.12	6.08	6.4	6.28	6.06	5.44	5.35	6.32	6.16	5.29
1500	6.39	6.2	6.14	6.1	6.43	6.29	6.07	5.44	5.37	6.35	6.22	5.31
2000	6.33	6.16	6.1	6.06	6.4	6.25	6.01	5.43	5.35	6.29	6.23	5.33
3000	6.4	6.13	6.1	6.03	6.4	6.24	6.02	5.47				
3780	6.39	6.08	5.8	6		6.22	6.02	5.46				
5000	6.33	6.11	6.09	6.01		6.18	5.98	5.41				

Very stable. Little degradation except that S/N 20 failed at 3780 hours. MELCO attributed to mis-aligned test contacts. Such a failure during a high current test is very possible. TABLE 6

TABLE 6



The tables below compare the distribution of Idss, Igss and Igsx values for all 12 samples. This device provided very repeatable results. In all cases s/n 20 exhibits much the same behavior as the other devices in this test. The variability of s/n is smaller than most of the other devices in this test. There is nothing in the data to indicate imminent, catastrophic failure is about to occur on s/n 20.

TABLE 7
Idss distribution for all life test samples

	Valid N	Mean	Std.Dev.	Standard Error
ZIDSS_02	8	6.368750	.057430	.020305
IDSS_08	8	6.148750	.044541	.015748
IDSS_11	8	6.075000	.113892	.040267
IDSS_12	8	6.060000	.042088	.014880
ZIDSS_20	6	6.403333	.031411	.012824
ZIDSS_24	8	6.237500	.051755	.018298
IDSS_25	8	6.025000	.035456	.012536
ZIDSS_28	8	5.407500	.090040	.031834
IDSS_30	5	5.298000	.102811	.045978
ZIDSS_32	5	6.302000	.081056	.036249
ZIDSS_34	5	6.186000	.050299	.022494
IDSS_70	5	5.304000	.024083	.010770

TABLE 8
Igss distribution for all life test samples

				Standard
	Valid N	Mean	Std.Dev.	Error
ZIGSS_02	8	.324250	.105085	.037153
IGSS_08	8	.322125	.094546	.033427
IGSS_11	8	.277250	.074787	.026441
IGSS_12	8	.288875	.078120	.027620
ZIGSS_20	7	.340571	.118331	.044725
ZIGSS_24	8	5.762750	3.687406	1.303695
IGSS_25	8	.294375	.081989	.028988
ZIGSS_28	8	.265500	.066365	.023463
IGSS_30	5	.213400	.062288	.027856
ZIGSS_32	5	.233800	.072147	.032265
ZIGSS_34	5	.269200	.090447	.040449
IGSS_70	5	.182600	.043878	.019623

TABLE 9
Igsx distribution for all life test samples

				Standard
	Valid N	Mean	Std.Dev.	Error
ZIGSX_02	8	45.68750	14.21673	5.026375
IGSX_08	8	37.01250	11.78818	4.167752
IGSX_11	8	37.33750	12.49891	4.419031
IGSX_12	8	47.05000	18.58886	6.572154
ZIGSX_20	7	45.71429	15.70503	5.935945
ZIGSX_24	8	54.96250	20.44707	7.229131
IGSX_25	8	36.71250	11.48433	4.060324
ZIGSX_28	8	24.96250	7.88379	2.787340
IGSX_30	5	25.14000	9.45902	4.230201
ZIGSX_32	5	43.24000	17.36240	7.764702
ZIGSX_34	5	33.90000	13.25236	5.926635
IGSX_70	5	37.76000	15.49526	6.929690

The following table presents all of the data for S/N 20. Excepting the decrease in breakdown voltage (the impetus for this investigation), the device appears to be stable. Power output is stable and there is no RF output power slump, dc parameters are stable.

TABLE 10
S/N 20 LIFE TEST RESULTS

HRS	ZGM_20	ZIGSS_20	ZVP_20	ZIDSS_20	ZIGSX_20	ZPO1_20	ZPO2_20	ZVGD_20	ZVGS_20
0.1	2.3	0.265	3.21	6.35	16.8	38.99	30.81	16.9	19.3
1000	2.3	0.112	3.22	6.44	49.9	38.88	30.88	12.3	17.7
1240	2.3	0.349	3.22	6.4	32.8	38.83	30.87	12.1	17.6
1500	2.3	0.363	3.22	6.43	50.6	39	30.84	12	17.5
2000	2.3	0.416	3.21	6.4	57.5	38.82	30.86	11.7	17.5
3000	2.3	0.429	3.21	6.4	50	38.97	30.81	11.3	17.2
3780		0.45			62.4	38.91	30.63	11.2	18.3
5000									

S/N 20 is not distinctly different from the other devices and the failure scenario presented seems plausible. This is a very high current test; Id is set far above a normal operating point for this device. All devices show a small initial increase in Idss between the initial and 1000 hour measurement and then Idss settles. Thus, the failure of S/N 20 is discounted.

PO1 and PO2:

PO1: Vds=8.0V, Vgs (final test setting), Pin=32.5dBm, f=8Ghz. Limit: 37.8dBm (min)

PO2: Vds=8.0V, Vgs (final test setting), Pin+22.5dBm, f=8Ghz Limit: 28.8dBm (min)

Delta limit for both tests is -0.2dBm.

TABLE 11
PO1 and PO2

HRS	ZPO1_02	P01_08	P01_11	P01_12	ZPO1_20	ZPO1_24	P01_25	ZPO1_28	P01_30	ZPO1_32	ZPO1_34	P01_70
0.1	38.91	39.03	38.85	38.61	38.99	39.14	38.84	38.89	38.69	39.06	38.6	39.06
1000	39.07	39	38.86	38.61	38.88	39.08	38.75	39.19	38.8	39.48	39.27	39.48
1240	39	38.9	38.7	38.62	38.83	38.95	38.69	39.11	38.78	39.47	39.26	39.47
1500	39.12	39.12	38.69	38.65	39	39.09	38.77	39.2	38.9	39.48	39.36	39.49
2000	38.97	38.99	38.45	38.62	38.82	39.1	38.78	39.01	38.62	39.41	39.23	39.41
3000	38.98	38.89	38.61	38.62	38.97	38.97	38.67	39.02				
3780	39.02	38.9	38.59	38.58	38.91	39	38.68	39.02				
5000	38.887	38.87	38.56	38.57		38.97	38.64	38.85				
HRS	ZPO2_02	P02_08	P02_11	P02_12	ZPO2_20	ZPO2_24	P02_25	ZPO2_28	P02_30	ZPO2_32	ZPO2_34	P02_70
0.1	30.7	30.91	30.84	30.91	30.81	30.89	30.72	30.51	30.54	30.34	29.97	30.75
1000	30.76	31.07	30.85	30.91	30.88	31.09	30.86	30.63	30.65	30.35	30.12	30.9
1240	30.77	31	30.91	30.94	30.87	30.97	30.86	30.62	30.62	30.35	30.06	30.87
1500	30.79	31.09	30.85	30.92	30.84	30.98	30.8	30.58	30.58	30.28	30.03	30.77
2000	30.76	30.97	30.81	30.89	30.86	30.97	30.81	30.6	30.6	30.29	30.02	30.91
3000	30.7	31.03	30.83	30.92	30.81	30.93	30.82	30.52				
3780	30.7	30.92	30.79	30.88	30.63	30.87	30.78	30.53				
5000	30.67	30.99	30.75	30.85		30.85	30.76	30.54				

PO1 and PO2 are stable, although some devices exceeded the 0.2dBm delta limit for PO1. This out-of-spec condition had been previously noted and is not a cause for concern. S/N 12 had a decrease in Pout under 5dB overdrive of 0.24 dBm after 5000 hours. S/N 11 had a decrease of 0.3 dBm after 5000 hours under the same conditions. The next 3 plots show PO1 for all 12 devices.

TABLE 12

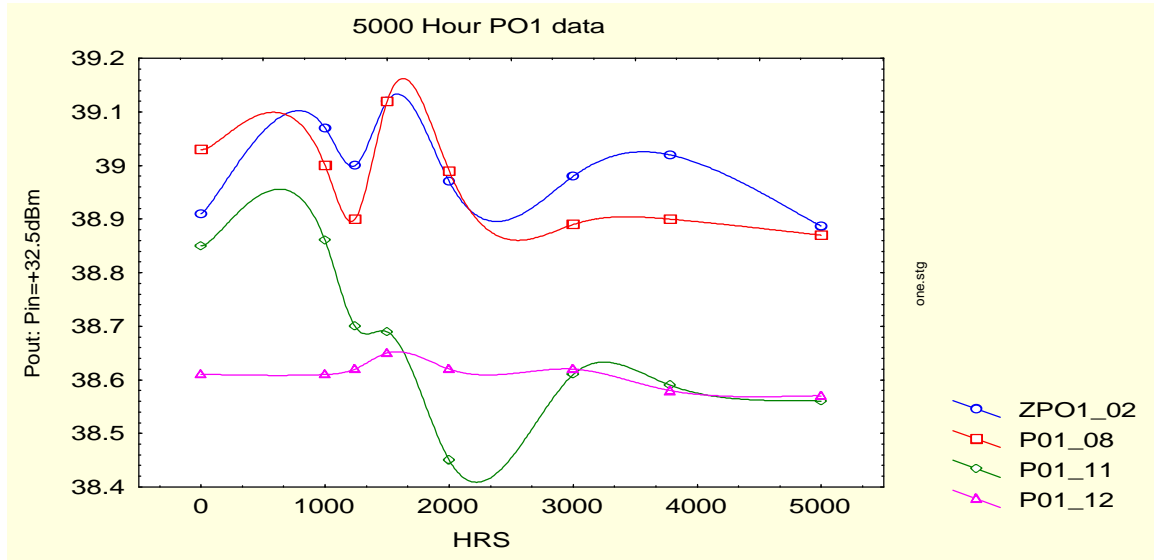


TABLE 13

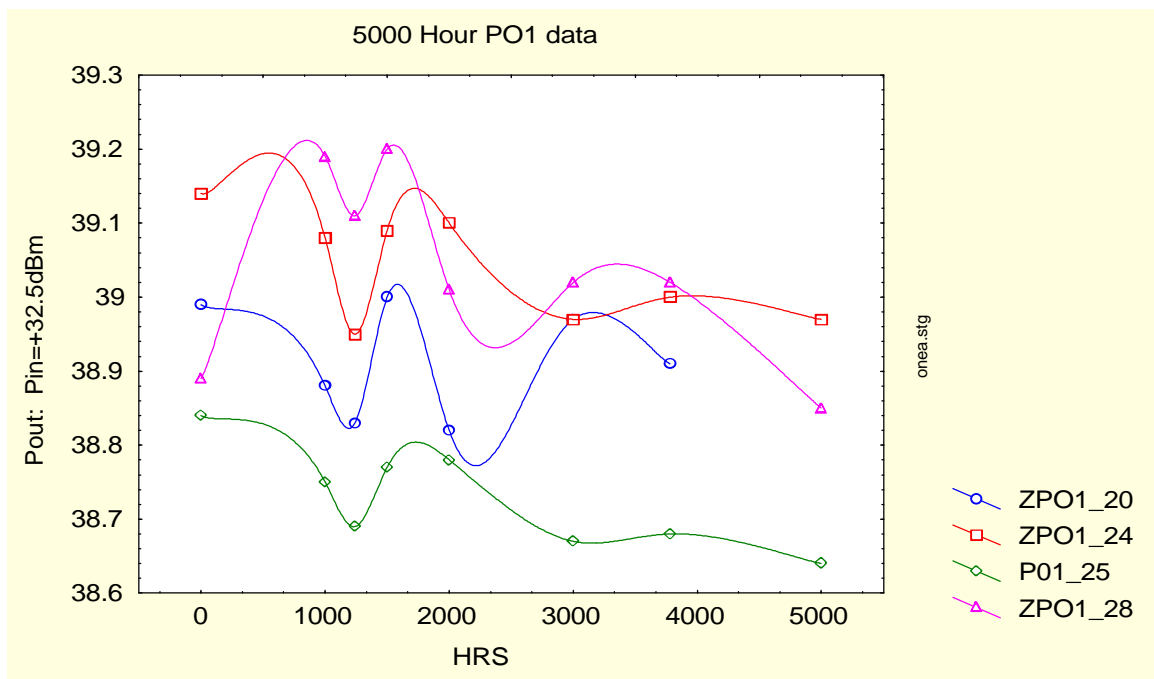


TABLE 14



The next plot shows PO2 for the same devices. These measurements were conducted in the linear drive region as opposed to the 5dB compressed condition of PO1 and show stable Pin/Pout characteristics. The application operating level of the C40 MESFETs is at P_{-2.8dB} compression.

TABLE 15

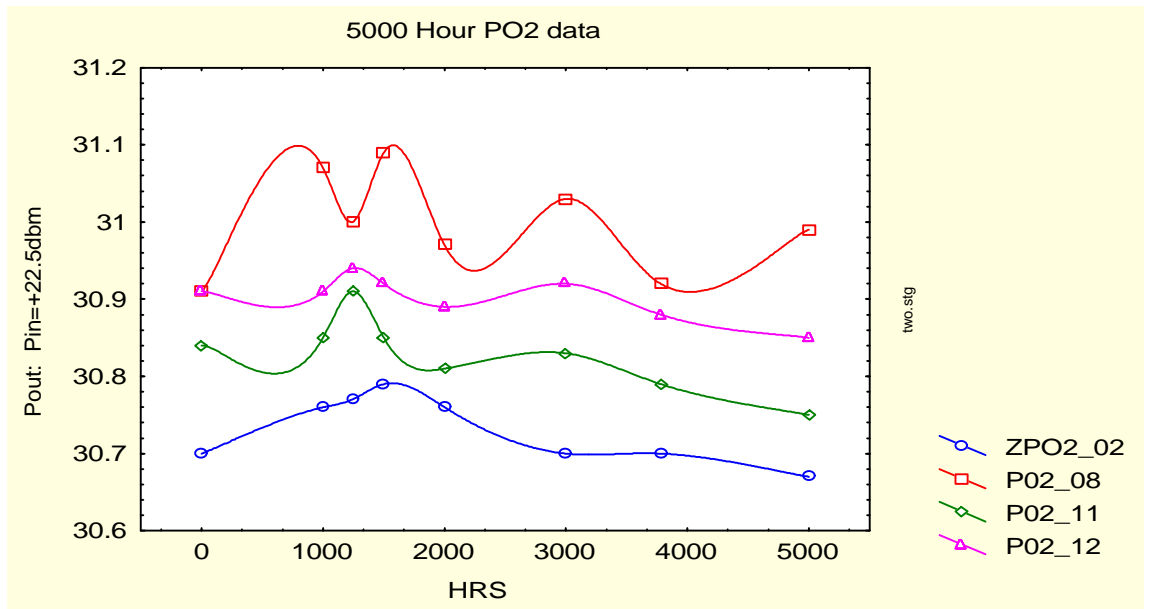


TABLE 16

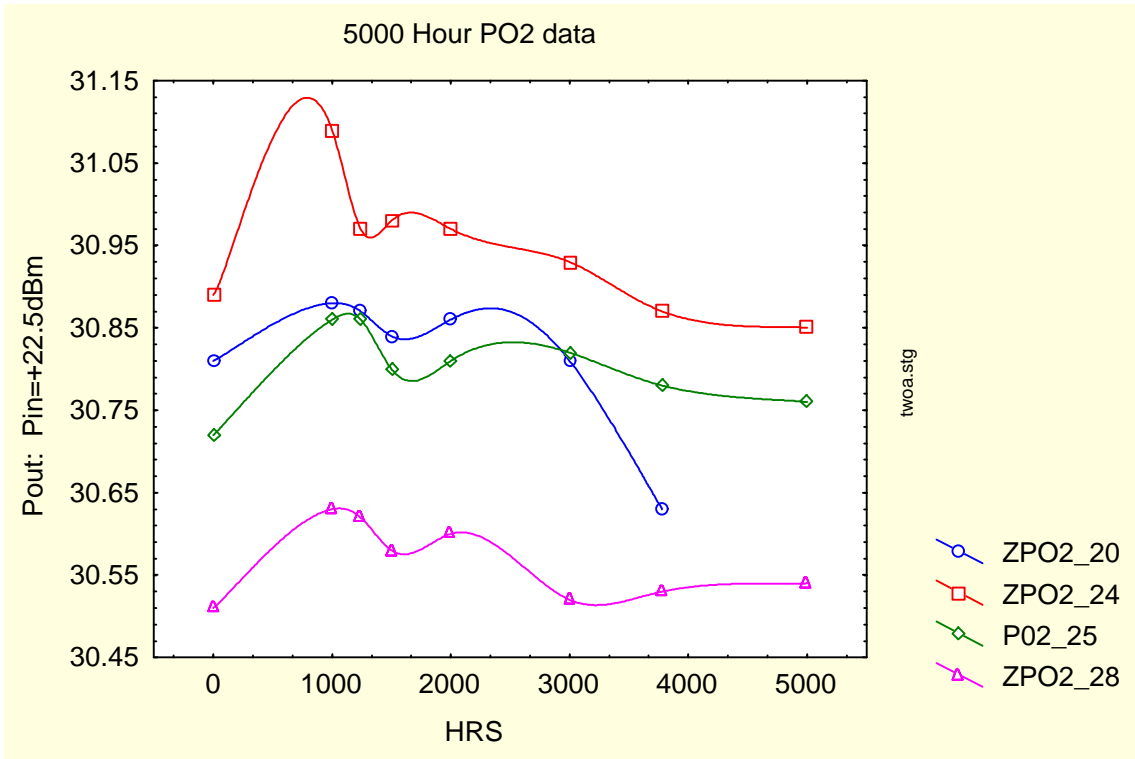
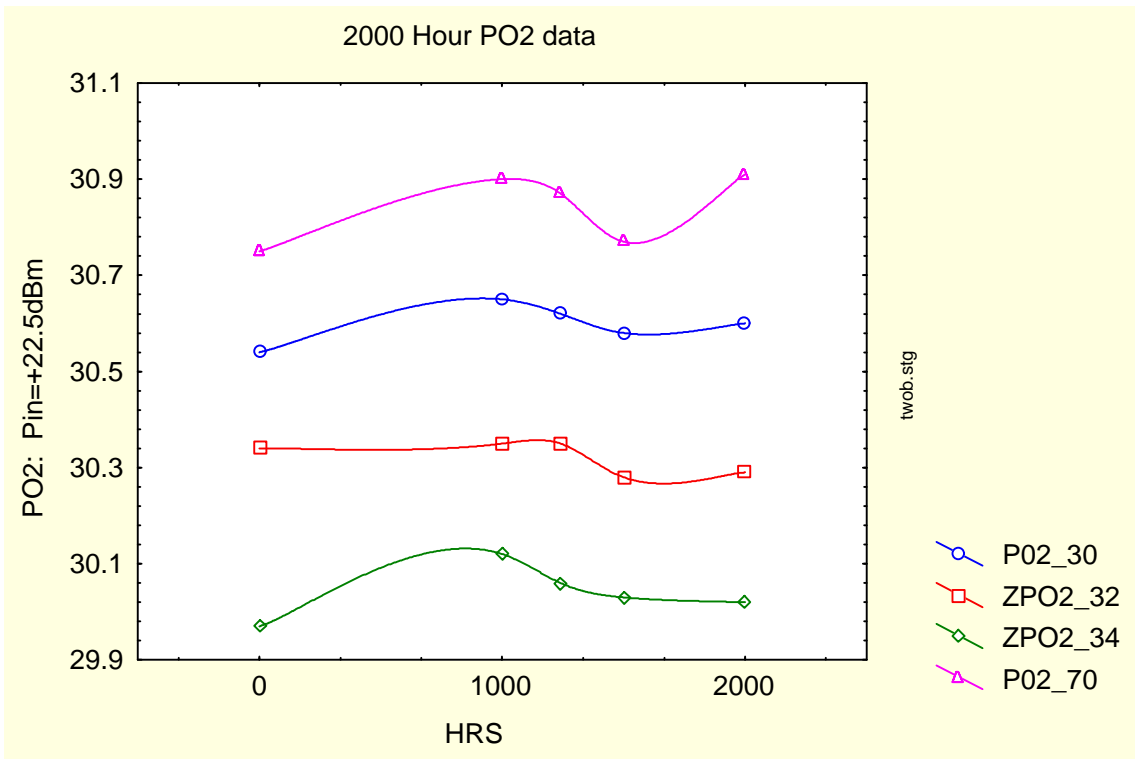


TABLE 17



The following two tables compare the PO1 and PO2 variations for all 12 samples. The only noteworthy data was that s/n 20 was close (0.18dB) to the 0.2dB Pout degradation limit at 3780 hours for PO2.

TABLE 18
PO1 distribution for all 12 samples

	Valid N	Mean	Minimum	Maximum	Std.Dev.	Standard Error
ZPO1_02	8	38.99463	38.887	39.12	0.077125	0.027268
P01_08	8	38.9625	38.87	39.12	0.087137	0.030808
P01_11	8	38.66375	38.45	38.86	0.141415	0.049998
P01_12	8	38.61	38.57	38.65	0.025071	0.008864
ZPO1_20	7	38.91429	38.82	39	0.074578	0.028188
ZPO1_24	8	39.0375	38.95	39.14	0.07285	0.025756
P01_25	8	38.7275	38.64	38.84	0.067981	0.024035
ZPO1_28	8	39.03625	38.85	39.2	0.12716	0.044958
P01_30	5	38.758	38.62	38.9	0.107331	0.048
ZPO1_32	5	39.38	39.06	39.48	0.181246	0.081056
ZPO1_34	5	39.144	38.6	39.36	0.307945	0.137717
P01_70	5	39.382	39.06	39.49	0.182675	0.081695

TABLE 19
PO2 distribution for all 12 samples

	Valid N	Mean	Minimum	Maximum	Std.Dev.	Standard Error
ZPO2_02	8	30.73125	30.67	30.79	0.043569	0.015404
P02_08	8	30.9975	30.91	31.09	0.064752	0.022893
P02_11	8	30.82875	30.75	30.91	0.04734	0.016737
P02_12	8	30.9025	30.85	30.94	0.028158	0.009955
ZPO2_20	7	30.81429	30.63	30.88	0.085802	0.03243
ZPO2_24	8	30.94375	30.85	31.09	0.076893	0.027186
P02_25	8	30.80125	30.72	30.86	0.04794	0.016949
ZPO2_28	8	30.56625	30.51	30.63	0.047189	0.016684
P02_30	5	30.598	30.54	30.65	0.041473	0.018547
ZPO2_32	5	30.322	30.28	30.35	0.034205	0.015297
ZPO2_34	5	30.04	29.97	30.12	0.055227	0.024698
P02_70	5	30.84	30.75	30.91	0.074833	0.033466

PART II. BVgdo (gate-drain breakdown) and BVgso (gate-source breakdown)

BVGDO: IG=-1.0mA. LIMIT: -17 V (MIN)

BVGSO: IG=-1.0mA . LIMIT: -17 V (MIN)

Both parameters have +/- 10% delta limit.

Both parameters show significant slump from their initial, pre-life test measurements. However, the slump decelerated significantly after the initial 1000 hours to the end of the test.

TABLE 20
BVgdo

HRS	ZVGD_02	VGD_08	VGD_11	VGD_12	ZVGD_20	ZVGD_24	VGD_25	ZVGD_28	VGD_30	ZVGD_32	ZVGD_34	VGD_70
0.1	16.8	17.2	17.8	17.6	16.9	16.3	17.4	16.6	17.5	16.1	16.5	19.1
1000	12	13.5	15.1	14.6	12.3	12.4	13.7	13	13.7	11.5	11.7	16.1
1240	12	13.3	14.8	14.4	12.1	12.2	13.5	13.1	13.6	11.5	11.8	16.1
1500	11.9	13.4	14.7	14.2	12	12.2	13.4	13	13.6	11.4	11.7	16.1
2000	11.6	13.2	14.6	14	11.7	11.9	13.2	13.1	13.5	11.4	11.5	15.8
3000	11.5	12.6	14.3	13.4	11.3	11.4	13.1	13				
3780	11.5	12.5	14.1	13.1	11.2	11.3	13	12.9				
5000	11.7	12.5	14	12.9		11.4	12.7	13				

TABLE 21
BVgso

HRS	ZVGS_02	VGS_08	VGS_11	VGS_12	ZVGS_20	ZVGS_24	VGS_25	ZVGS_28	VGS_30	ZVGS_32	ZVGS_34	VGS_70
0.1	19.6	19.4	19.5	19.2	19.3	19.3	19.6	19.5	20	18.8	18.7	21.2
1000	17.9	18.6	18.6	18.6	17.7	18.3	19	18.2	18.7	17.5	17.6	20.1
1240	17.7	18.5	18.5	18.5	17.6	18.1	18.9	18.2	18.6	17.4	17.6	20
1500	17.5	18.3	18.3	18.4	17.5	18	18.7	18.1	18.5	17.2	17.4	19.9
2000	17.5	18.4	18.3	18.4	17.5	18	18.8	18.3	18.6	17.3	17.6	19.9
3000	17.2	18.1	18.1	18.2	17.2	17.6	18.6	17.9				
3780	17	17.9	18	18	18.3	17.3	18.4	17.8				
5000	16.9	17.9	18	17.9		17.2	18.7	17.7				

The next charts plot BVgdo for all 12 devices.

TABLE 22

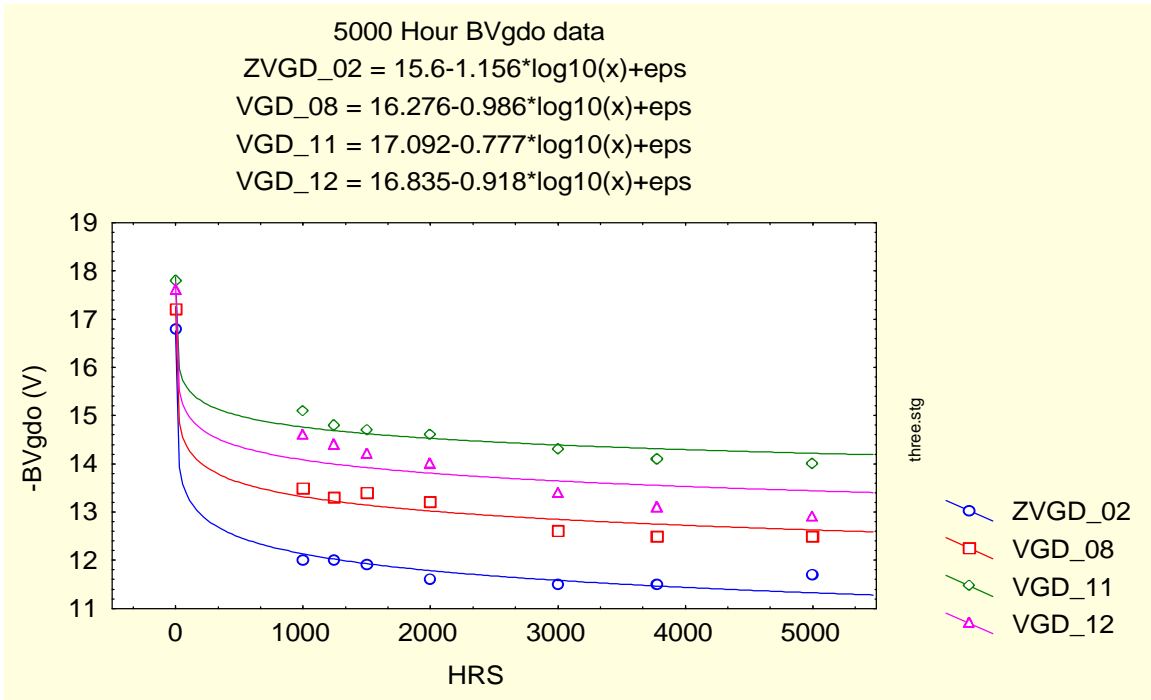


TABLE 23

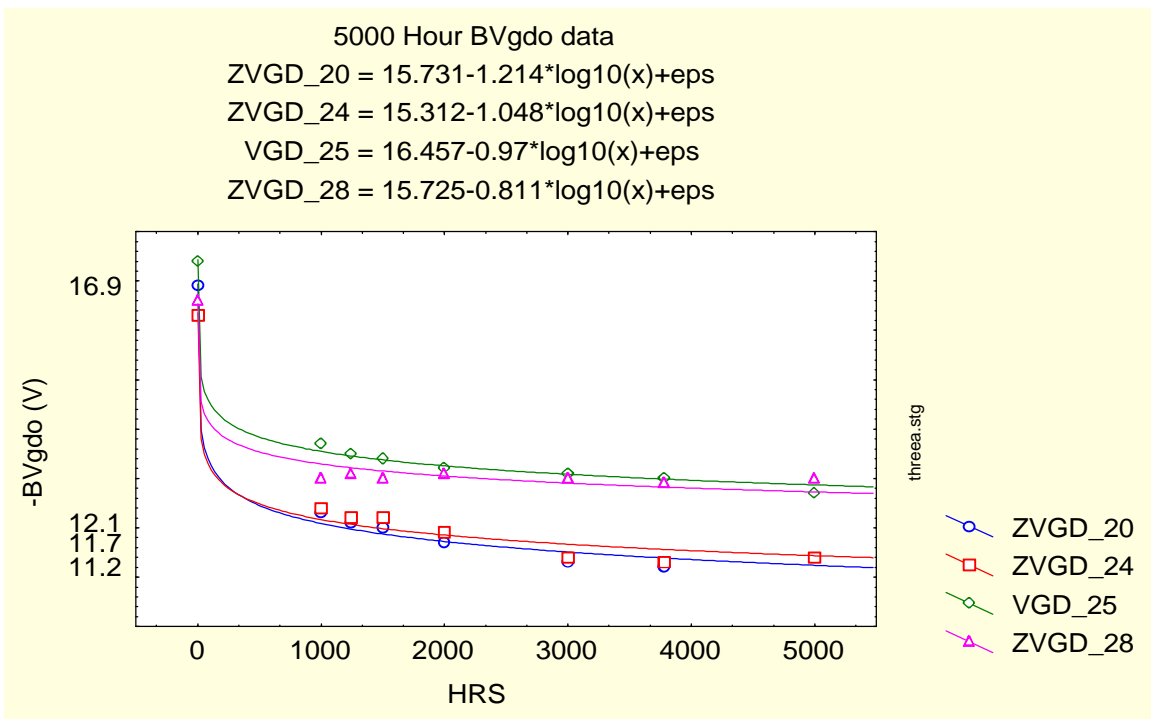
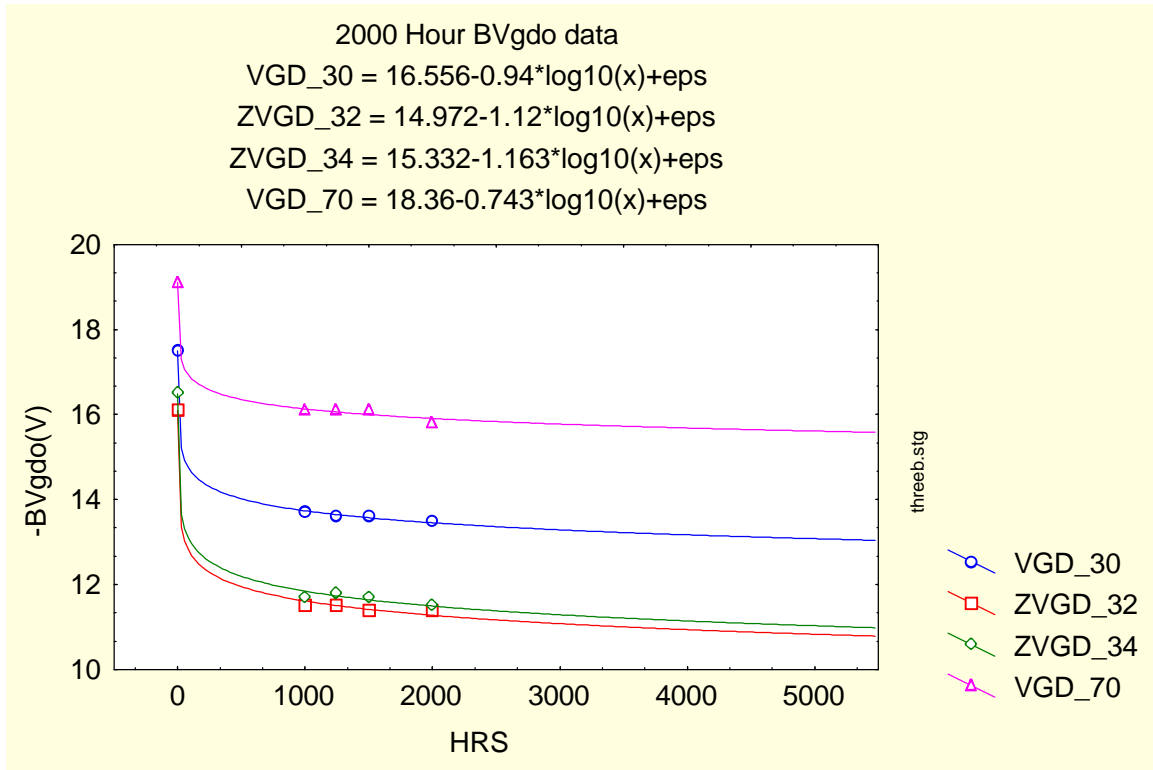


TABLE 24



The following 2 charts show the 5000 hour performance with the first 1000 hours of data removed to account for annealing of the shallow surface states suspected of causing the BVgdo slump.

TABLE 25

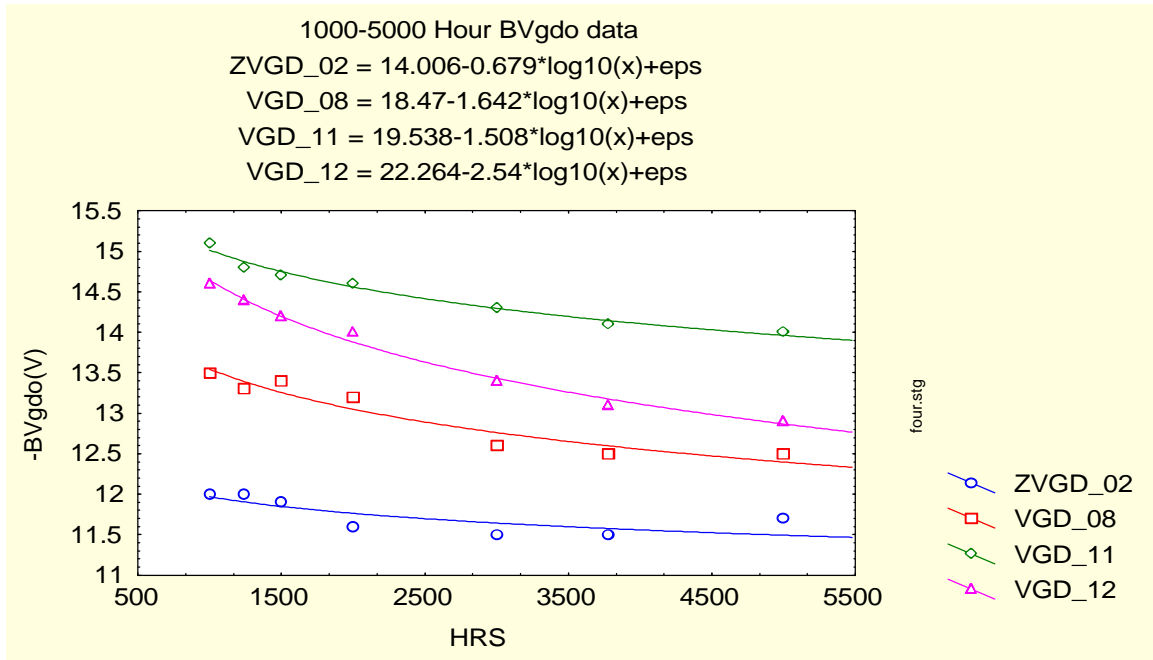
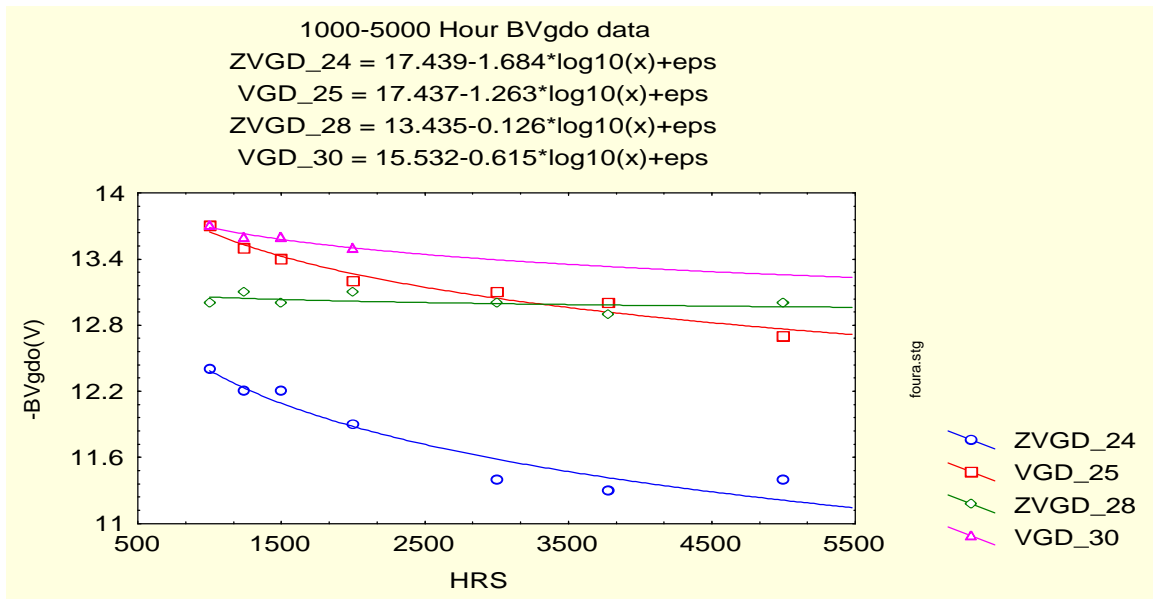


TABLE 26



PART III. Predicted performance over mission life

The next step is look at the trend in gate-source leakage (Igsx) for the 8 devices that went beyond 2000 hours.

TABLE 27

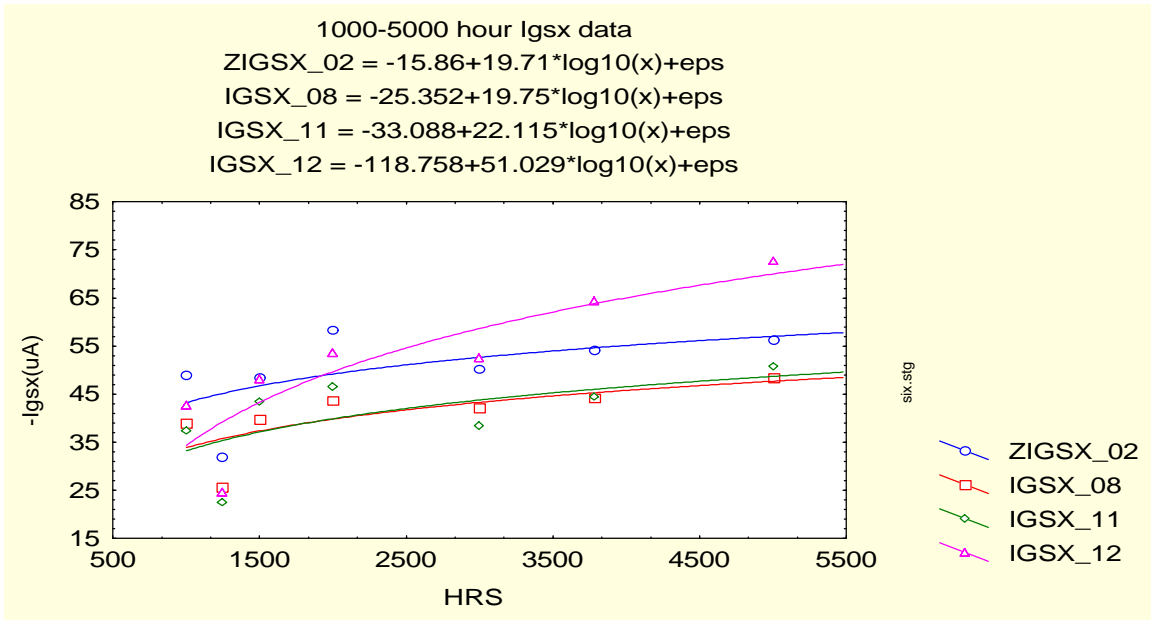
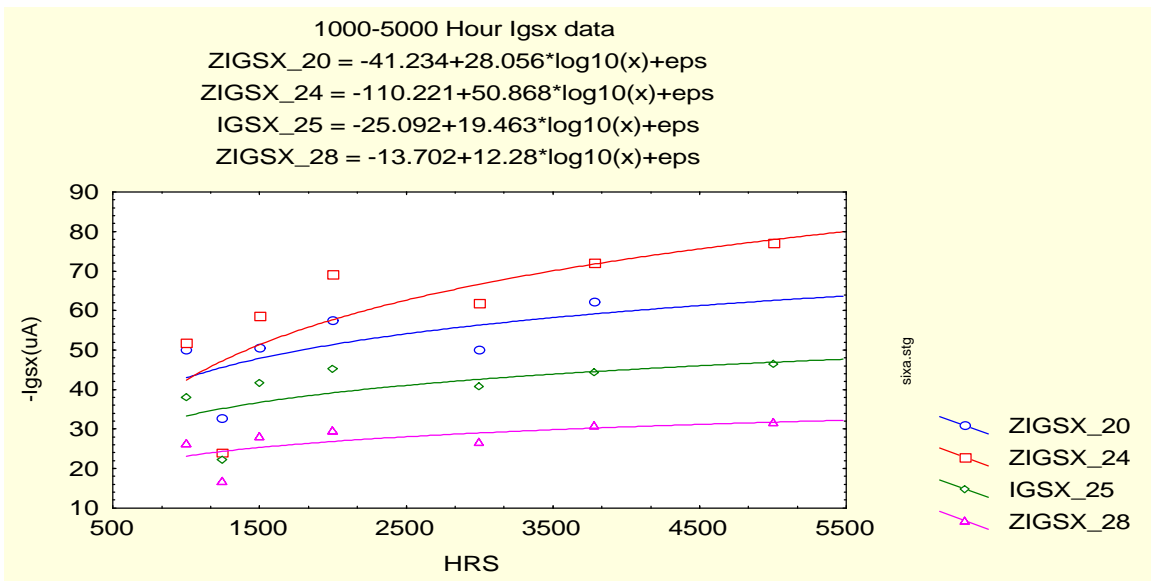
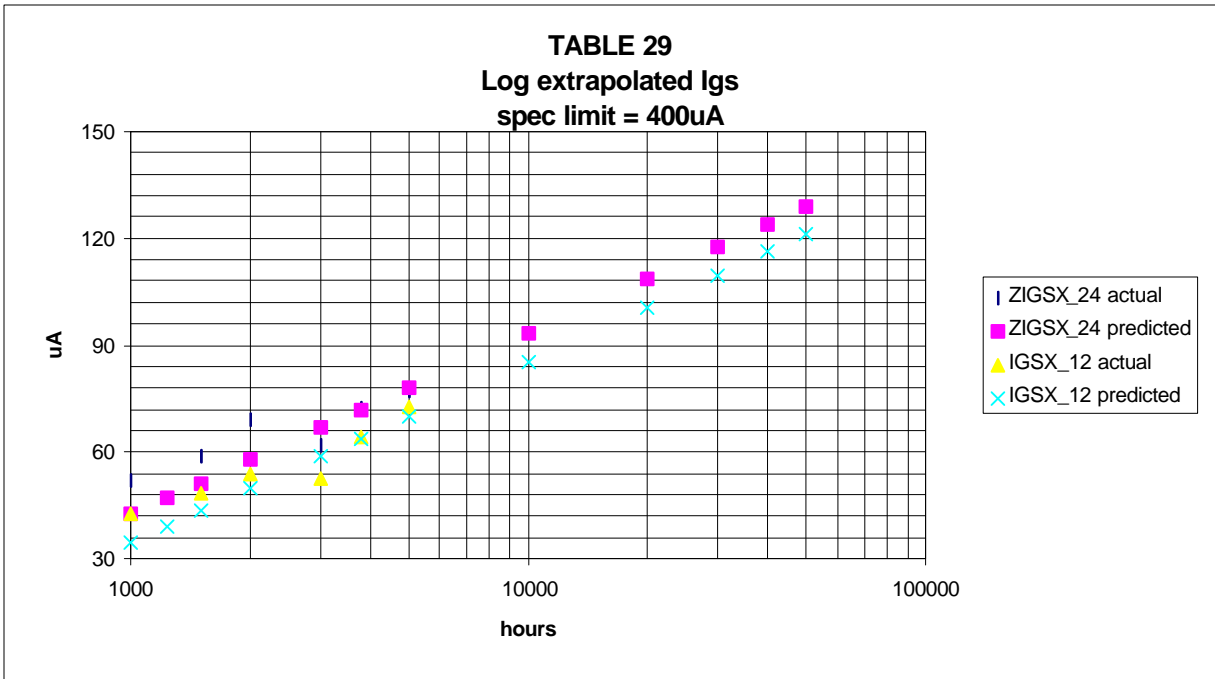


TABLE 28



These graphs show the increase in leakage as a result of the overdrive life condition. The life test at P-5dB compression provides margin over the application level at P-2.8dB compression. The extrapolated leakage is a good indication of the long term state of health of the devices. The spreadsheets below show the extrapolated increase if the test was continued to 50,000 hours for the two devices with the highest gate leakage, s/n 12 and 24. S/N 12 had an initial BVgdo > 17 V; S/N 24 initial BVgdo < 17V.



Testing by the manufacturer showed the MESFETs to be capable of tolerating reverse leakage as high as 970mA without failure. Long term reliability dictates that the total gate stress remain on the order of 1mA. In application the parts see a worst case gate current of 2.06mA for the Engineering Test Model (ETM). If the flight units have similar performance to the ETM, the long term degradation of the devices should not be a problem.

The next step is to compare the final degradation curves to previous projections and determine that the rate of change of breakdown voltage has not increased. The following 4 tables plot the 1000-3780 hour and 1000-5000 hour data assuming log-time degradation. Data for seven samples that completed the life test are used.

TABLE 30

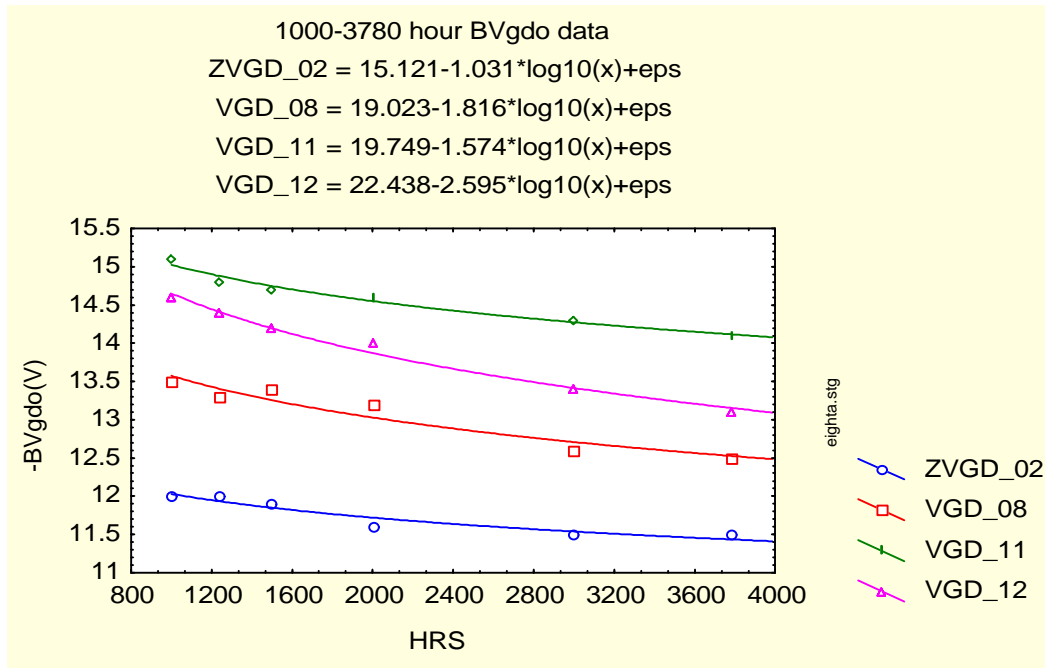


TABLE 31

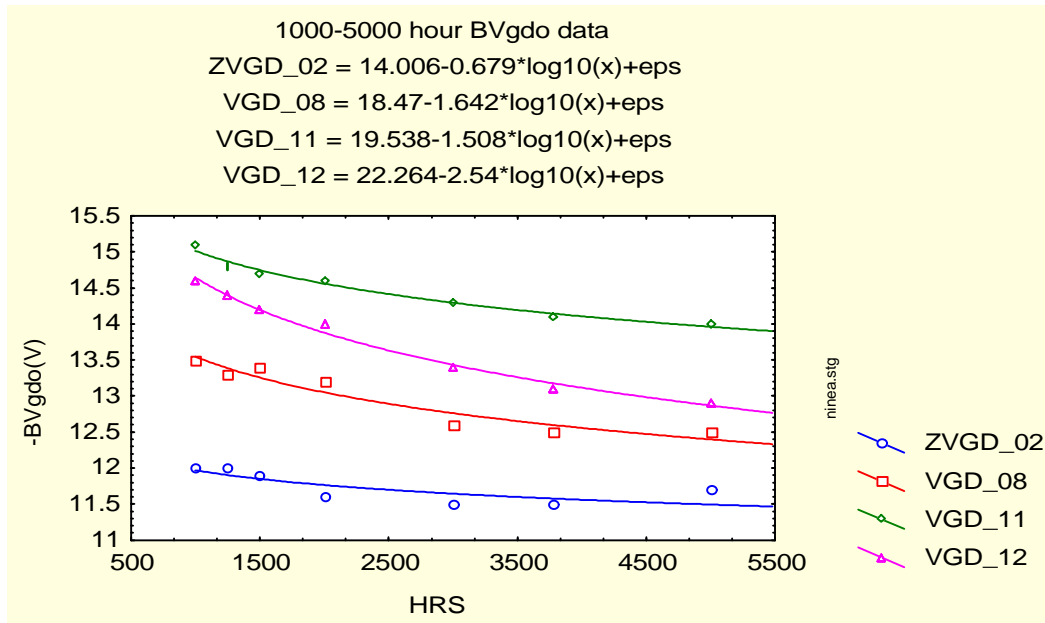


TABLE 32

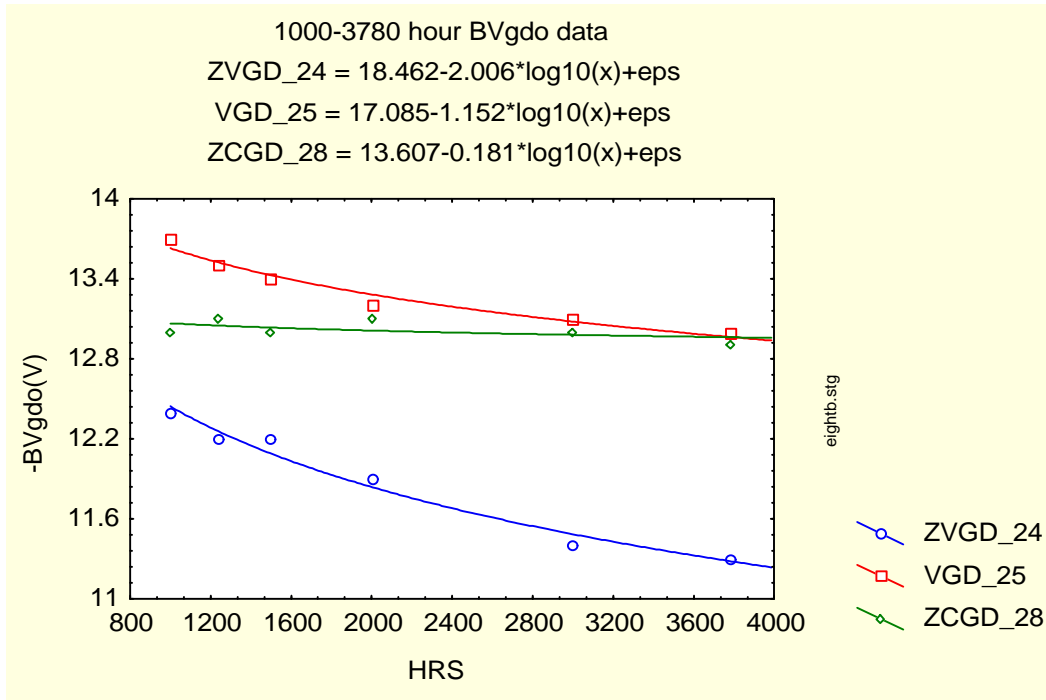
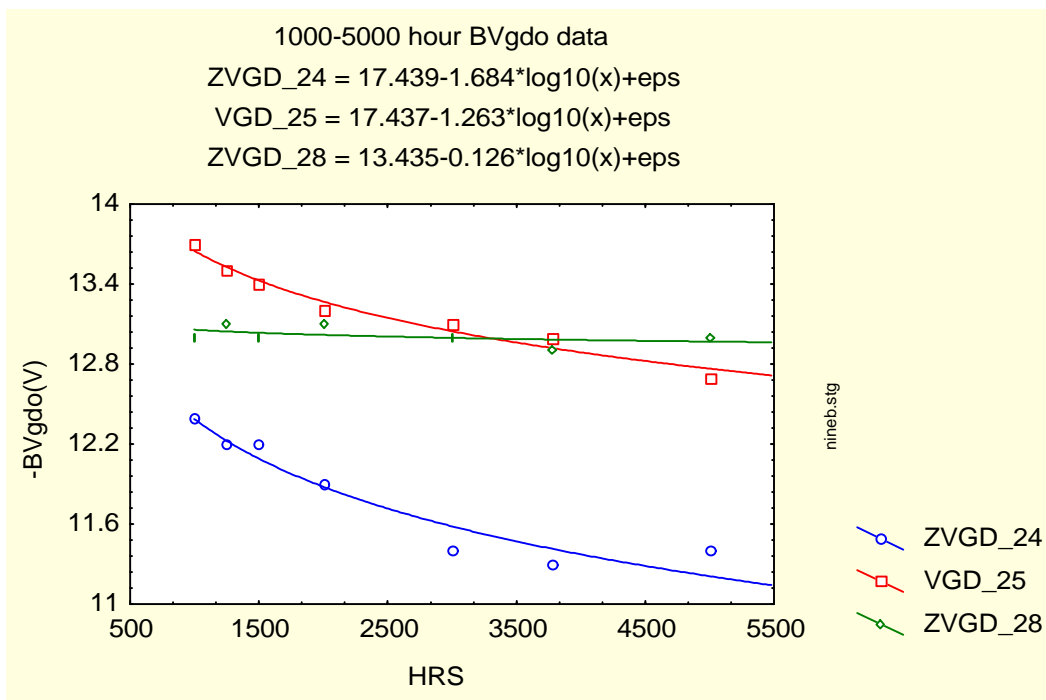


TABLE 33



There is no indication of any significant change in the rate of degradation between the 3780 hour data and the 5000 hour data. The slopes of the 5000 hour curves have decreased from the slopes of the 3780 hour curves for 6 of 7 samples. There is no indication that a sudden decrease in breakdown voltage or a sharp increase in gate leakage is about to occur (“Falling off the table”). Predicted and actual degradations have not diverged.

The final table shows the projected degradation to 50,000 hours using the 1000-5000 hour data for the seven surviving life test samples. There are two assumptions that accompany this data. One: Degradation will continue with time. Two: Actual flight parts will perform no worse than these devices.

