How to Test for One Way Leakers

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In recent years the hybrid microelectronics industry has been plagued with an apparent phenomenon or condition called "one-way-leaker" on various styles of hermetic glass-to-metal seal packages. The application of monolithic integrated circuit requirements for hermeticity testing of large area hybrid devices, Mil-Std-883, Test Method 1014, Condition C further highlights the problem.

The condition appears to be most prevalent under the 60 psig gross leak bomb pressure and least prevalent under 30 psig bomb pressure. Table III of Test Method 1014 recognizes potential package limitations and provides for the range of test conditions found in table 1.

Normal hybrid packages are shown in figures la, 1b, and 1c. Figures 2a, 2b, and 2c are exaggerated views of the packages shown while being subjected to 60 psig bomb pressure.

The Phenomenon

The fine and gross leak testing of Mil-Std-883, Test Method 1014, subject the sealed hybrid packages to various combinations of time-pressure-temperature stresses. Packages produced by various manufacturers either push their state of the an in glass-to-metal seal package manufacturing quality or are incapable of passing this test.

Under various bomb pressures, the intergranular oxide of the glass-to-metal seal appears to be temporarily stressed, thereby, developing minute cracks. This indicates the limits of package manufacturing technology may have been exceeded.

TABLE 1 – TEST CONDITIONS

Bomb Pressure psig Min.	Bomb Duration (Hr.) Min.
30	10
45	6
60	2

During the bombing process, the leak test fluids, along with other gases and potential contaminants, can be injected into the sealed packages. After removal of the various pressures, the developed microcracks apparently reseal, become hermetic again, and test good. With the possible exception of the Radioisotope Test Method, Test Method 1014, Test Condition B, current standard detection methods, including the weight-gain measurement, are incapable of detecting these one way leak conditions.

Indicators

Group C, Subgroup 3 of Mil-Std883, Test Method 5008, Quality Conformance Inspection (QCI), requires an internal water vapor content test in accordance with Test Method 1018. As a result of this test, the one-way leaker is identified.

During an 18 month period, one company' subjected various glass-to-metal seal packages from various manufacturers to over 425 internal water vapor content tests. The packages ranged in volume from 1.2 cc to 17.82 cc and were represented by flatpack, step, and bathtub configurations. The number of package leads ranged from 16 to 136. All packages were weld sealed; four different types of sealing machines were used to eliminate the possibility that the phenomenon was unique to a particular package sealing machine.

Table 2 shows the test results where greater than 5000 ppm of water were detected. The results are listed by ascending water content and package manufacture. The package manufacturers are shown as manufacturer A, B, or C.

Analysis of Data

Ninety-eight packages had moisture content in excess of 5000 ppm. The variables relating to package size, number of leads (pins), package configuration, and sealing machine were eliminated as being significant factors in the test results. During the evaluation period, some of the vacuum bake-out procedures were modified slightly to eliminate this factor. In many of the tests, identical packages were supplied by multiple manufacturers, eliminating the single supplier or uniqueness variable.

The test program utilized packages from three manufacturers with initial acceptable leak rate criteria established by Test Method 1014. All test results of Test Method 1018 were entered into a computer data base, and every form of data reduction and evaluation was considered. One data sort revealed startling results: all moisture levels

above 5000 ppm, and other elements such as fluorocarbons, were traced to two of the three package manufacturers evaluated. The two manufacturers had a "mixed bag" of results, that is, moisture levels above and below 5000 ppm.

Summary of Findings

More one-way leakers were identified when sealed packages were subjected to 60 psig bomb pressure. One-way leakers also were identified under 30 psig.

As many variables as possible were eliminated in order to properly evaluate the test results. The variables eliminated were package styles, number of leads, package area, package and lead finishes, sealing machines, and vacuum bake-out procedures.

All packages were subjected to the element evaluation requirements of Table V of Test Method 5008. In the case of a high usage 36 pin bathtub package, supplied by several manufacturers, subsequent 100 percent hemeticity testing was used prior to evaluations in an attempt to provide a suitable incoming screen. Incoming test results had no bearing in final test results, therefore, it was not evident that any incoming evaluation test could detect potential one-way-leakers.

All detected one-way leakers were verified by die penetrant testing. All leaks occurred around the lead (pin) area. No leaks occurred as a result of improper sealing techniques. Packages having improper teals were initially rejected because of improper leak rates.

Visual criteria of Test Method 2009 is incapable of identifying potential problems. Currently, proposed emulation tests as an alternative to Test Method 2009 are not capable of properly detecting potential problems.

Conclusions

Prior to the test program described here, it was commonly believed that the phenomenon of the one-way leaker was a large area hybrid circuit fact of life. It was readily accepted that all packages, regardless of their manufacturing origin, could be the victim of the one-way leaker phenomenon.

However, computer manipulation of the derived data clearly shows that not all hybrid packages are created equal. The test results cl4arly show that identical packages supplied by different manufacturers have sufficiently different manufacturing technologies, materials, and quality to provide vastly differing performance results.

Lastly, the only immediate remedy to this apparent problem is "Caveat Emptor," let the buyer beware, and carefully select suitable suppliers capable of providing consistently acceptable results.

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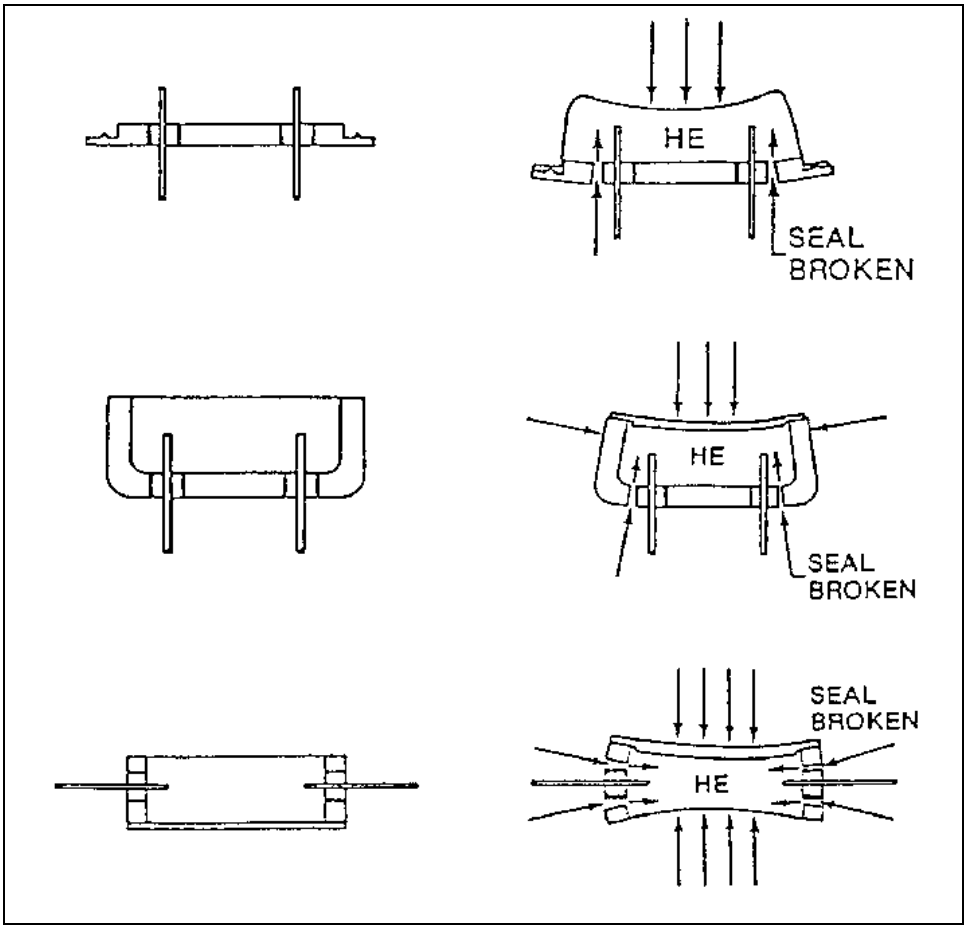

Figure 1a, 1b, 1c left, normal hybrid package. Figures 2a, 2b, 2c, right, exaggerated views of the package while being subjected to 60 psig bomb pressure.

TABLE 2 – RGA SUMMARY OF PARTS TESTED IN 1986 AND 1987

S/N	Moisture ppm	Nitrogen %	Oxygen ppm	Argon ppm	CO2 ppm	Hydrogen ppm	Helium ppm	Fluoro-carbons %	Ammonia ppm	Date tested	Seal date	Package type	Manufac-turer
225	5023	94.9	3348	683	4891	ND	3.49	.1921	546	4/11/86	2/09/86	48 PIN FLATPACK	C
733	5081	88.6	1227	396	4863	1380	7.82	.2319	20100	5/05/86	3/27/86	40 PIN TUB	B
2168	5119	88.7	55500	2878	<100	1679	4.65	.1019	ND	7/02/86	6/04/86	40 PIN TUB	C
26952	5140	93.2	ND	727	11300	ND	3.71	.0952	12300	6/26/87	5/08/87	36 PIN BATHTUB	C
6039	5271	89.6	ND	995	55500	290	3.92	ND	3377	7/29/86	1/08/86	24 PIN DIP	B
7870	5576	96.4	ND	800	5170	432	2.42	ND	ND	6/21/87	6/13/87	24 PIN PLATFORM	C
2112	5584	91.8	5668	968	2655	ND	4.58	1.53	6462	5/18/86	4/29/86	30 PIN FLATPACK	B
4287	5676	96.2	ND	816	4489	112	2.23	ND	4377	4/06/87	1/15/86	36 PIN BATHTUB	C
5231	5761	94.4	ND	799	7943	ND	4.04	ND	972	6/27/87	5/06/87	40 PIN BATHTUB	A
152	5803	83.4	504	1547	12100	335	5.36	4.72	45100	11/20/86	7/15/86	32 PIN FLATPACK	C
5964	5938	92.9	ND	2021	3896	157	4.66	ND	12700	7/14/87	7/01/87	40 PIN BATHTUB	A
206	5990	98.9	3259	1272	910	174	ND	ND	853	2/05/86	1/16/86	78 PIN TUB	B
7658	6184	89.1	ND	ND	6901	310	3.49	2.79	32700	6/21/87	6/06/87	36 PIN BATHTUB	C
137	6548	85.1	69100	3825	4939	ND	1.93	4.37	1636	1/30/86	1/07/86	40 PIN TUB	C
7259	6568	95.0	ND	935	8145	223	ND	ND	34000	6/21/87	6/03/87	24 PIN BATHTUB	B
1146	6663	72.6	88900	4392	4558	186	3.70	8.81	43900	8/04/86	6/19/86	24 PIN FLATPACK	C
4	6701	92.0	28600	2391	3926	ND	2.45	1.00	4170	8/29/86	8/12/86	24 PIN DIP	B
1532	6809	89.3	54500	3103	7722	ND	2.22	1.22	ND	6/12/87	5/22/87	36 PIN BATHTUB	C
2443	6819	88.5	18600	1240	21700	ND	4.88	1.79	ND	2/15/86	2/01/86	24 PIN DIP	C
7729	6841	94.6	ND	ND	2496	<100	3.48	ND	9797	6/21/87	6/06/87	36 PIN BATHTUB	C
5371	6846	93.6	ND	653	11700	<100	4.00	ND	4573	6/27/87	5/06/87	40 PIN BATHTUB	A
170	6855	96.9	11100	1457	1480	358	.9013	ND	943	2/05/86	1/16/86	78 PIN TUB	B
19174	6989	88.0	24100	2933	8722	140	5.39	1.80	5321	7/29/87	7/02/87	36 PIN BATHTUB	C
4286	7241	96.0	ND	789	3964	603	2.46	ND	2529	4/06/87	1/15/86	36 PIN BATHTUB	C
3220	7333	85.0	90600	4915	1573	290	3.37	.1974	9275	5/18/86	4/28/86	30 PIN FLATPACK	B
5951	7385	93.4	ND	1871	6218	ND	4.19	ND	8191	7/14/87	7/01/87	40 PIN BATHTUB	A
896	7552	85.3	ND	624	19100	510	9.03	.0289	28700	9/13/86	4/12/86	78 PIN TUB	B
2543	7618	94.0	ND	603	15000	999	3.43	ND	1241	2/15/86	1/24/86	24 PIN DIP	C
4609	7629	86.2	93900	4563	4068	ND	2.19	1.58	ND	6/22/86	12/10/85	30 PIN FLATPACK	C
8317	7827	86.0	61400	3221	4220	ND	3.15	3.05	1736	03/29/87	03/12/87	36 PIN BATHTUB	C
3935	7864	85.4	12100	998	14500	ND	5.95	5.00	1364	9/17/86	4/18/86	40 PIN TUB	C
134	7689	86.8	4050	1917	11100	329	5.67	.2157	48700	11/20/86	7/15/86	32 PIN FLATPACK	C
474	7928	86.2	ND	657	9107	310	8.63	.4085	22700	9/13/86	4/19/86	78 PIN TUB	B
491	7986	89.3	3265	1044	10900	496	3.95	.0272	43900	9/13/86	4/19/86	78 PIN TUB	B
2545	8029	93.9	ND	441	14900	921	3.45	ND	2210	2/15/86	1/24/86	24 PIN DIP	C
2191	8119	92.2	ND	841	15200	290	5.36	ND	466	5/05/86	4/08/86	24 PIN TUB	B
8027	8325	83.1	77600	3964	5441	ND	2.57	3.04	17000	8/04/86	6/20/86	56 PIN TUB	C
7639	8347	94.9	ND	ND	2158	<100	3.48	ND	5256	6/21/87	5/06/87	36 PIN BATHTUB	C
2996	8473	84.8	46300	2787	11200	ND	3.41	4.99	ND	03/12/87	03/22/87	36 PIN BATHTUB	C
1018	8765	92.3	21500	1772	13800	ND	2.75	.3067	969	2/13/87	1/07/87	32 PIN TUB	C
24373	8773	92.5	6552	1303	9154	ND	3.86	.7186	3595	05/23/87	05/07/87	36 PIN BATHTUB	C
4616	8999	74.4	97400	4774	4258	ND	2.71	11.3	ND	6/22/86	12/10/85	30 PIN FLATPACK	C
5462	9244	90.6	ND	724	11900	251	4.36	ND	28500	6/21/87	5/05/87	40 PIN BATHTUB	A
17315	9508	84.3	107000	4372	666	ND	.6569	2.92	ND	7/02/86	6/03/86	24 PIN DIP	B
6567	9660	91.7	ND	1244	42300	350	2.92	ND	ND	7/11/86	1/08/86	24 PIN DIP	B
14295	10000	87.6	86200	3831	6511	ND	.6805	.1591	8884	7/02/86	5/17/86	36 PIN TUB	C
553	10100	84.6	75600	3403	1243	131	2.32	3.79	2225	8/04/86	6/20/86	24 PIN DIP	B
11790	10100	92.0	14600	1640	3445	273	3.09	1.87	ND	6/12/87	5/08/87	36 PIN BATHTUB	C
59953	10800	82.2	67000	3625	5419	ND	1.12	7.96	ND	6/12/87	5/07/87	36 PIN BATHTUB	C
5942	11200	92.5	ND	1883	8785	ND	4.13	ND	11900	7/14/87	7/01/87	40 PIN BATHTUB	A
413	11200	78.0	52700	2434	7218	697	3.83	10.4	3356	6/25/86	4/30/86	68 PIN TUB	B
6381	11500	94.0	ND	525	13300	494	3.32	ND	1046	1/28/86	12/25/85	36 PIN TUB	C
3711	11600	81.1	66800	2456	1379	ND	.0106	10.7	ND	5/05/86	4/08/86	24 PIN TUB	B
3154	11800	76.9	ND	860	81400	376	5.44	ND	81700	8/04/86	2/04/86	40 PIN TUB	C
1238	11900	68.6	118000	5335	7190	ND	3.59	13.2	2754	6/11/86	5/11/86	48 PIN FLATPACK	C
7048	12100	93.8	ND	911	1379	<100	4.50	2818		8/20/87	8/03/87	36 PIN BATHTUB	C
2977	12400	80.7	56700	4275	12700	ND	2.78	7.90	ND	05/12/87	03/22/87	36 PIN BATHTUB	C
4930	12600	88.9	49400	2255	2486	ND	3.50	.9001	1348	2/15/86	1/15/86	48 PIN FLATPACK	C
11777	12600	86.5	42100	2949	2537	ND	2.05	5.48	ND	6/12/87	5/08/87	36 PIN BATHTUB	C
1974	13600	85.1	ND	995	51000	147	5.87	ND	24300	8/04/86	2/04/86	40 PIN TUB	C
11734	14300	72.9	193000	6894	3953	ND	1.25	2.80	12800	11/20/86	8/21/86	36 PIN TUB	C
4908	14500	89.1	58300	2784	2635	ND	2.55	.3253	1549	2/15/86	1/15/86	48 PIN FLATPACK	C
26971	14800	83.9	56700	3958	14600	ND	2.91	3.47	7378	6/19/87	5/06/87	36 PIN BATHTUB	C
364	15200	94.7	ND	585	3629	410	3.35	ND	ND	7/02/86	5/29/86	24 PIN DIP	C
42	15300	84.9	83400	4177	5299	ND	2.34	2.02	ND	6/25/86	4/03/86	8 PIN FLATPACK	C
27111	15500	89+	85000	4100	5100	ND	1.08	.2900	ND	6/27/87	4/14/87	36 PIN BATHTUB	C
3831	16100	75.2	219000	9331	482	ND	.3155	ND	ND	7/02/86	6/04/86	40 PIN TUB	C
11804	16100	63.2	219000	9701	4156	ND	1.27	10.2	4403	11/20/86	8/21/86	36 PIN TUB	C
1012	16700	90.1	ND	527	33700	ND	3.94	ND	8413	2/13/87	1/07/87	32 PIN TUB	C
8258	17200	82.1	141000	4944	1538	183	1.33	ND	866	1/02/86	12/05/85	24 PIN FLATPACK	C
2575	18300	39.6	122000	4602	2702	ND	ND	45.6	ND	4/13/86	3/18/86	24 PIN TUB	B
24377	18900	89.5	27500	2754	12300	ND	2.12	1.80	3789	05/23/87	05/07/87	36 PIN BATHTUB	C
3719	19300	66.3	303000	8522	1933	ND	2953	<.01	ND	9/17/86	4/18/86	40 PIN TUB	C
19160	19800	85.8	52000	4194	9879	ND	3.98	1.42	2188	7/29/87	7/02/87	36 PIN BATHTUB	C
3860	20100	70.6	227000	9201	4235	ND	ND	3.32	ND	5/11/86	4/21/86	24 PIN TUB	B
1261	20800	92.4	ND	574	4535	204	3.23	ND	17300	9/27/86	7/25/86	40 PIN TUB	C

TABLE 2 – CONTINUED

S/N	Moisture ppm	Nitrogen %	Oxygen ppm	Argon ppm	CO2 ppm	Hydrogen ppm	Helium ppm	Fluoro-carbons %	Ammonia ppm	Date tested	Seal date	Package type	Manufac-turer
5678	21200	75.9	126000	7038	8531	161	.2538	3.23	ND	1/28/85	1/03/85	36 PIN TUB	C
27374	21500	74.2	167000	6346	8443	ND	.1892	5.29	ND	6/07/87	3/22/87	36 PIN BATHTUB	C
2985	21900	79.5	85900	5864	13100	ND	2.18	5.68	ND	05/07/87	03/09/87	36 PIN BATHTUB	C
49	22000	80.4	38600	3176	4721	359	11.9	1.67	ND	7/11/86	4/03/86	8 PIN FLATPACK	C
25933	22200	62.7	102000	5047	6564	ND	1.41	22.30	ND	6/26/87	5/08/87	36 PIN BATHTUB	C
27404	23400	87.2	32000	2021	8579	ND	0.59	2.57	ND	6/07/87	3/22/87	36 PIN BATHTUB	C
17098	25100	69.9	198000	9295	4423	115	3.26	8.72	5081	7/29/85	5/31/85	24 PIN DIP	E
1982	25100	61.8	11400	619	1422	ND	.4282	34.0	ND	12/11/86	11/15/86	78 PIN TUB	B
173	26600	95.9	4400	1216	3451	579	ND	ND	4364	2/05/85	1/20/86	78 PIN TUB	B
14289	28100	69.3	220000	9500	5624	178	2.02	1.68	4077	7/29/85	11/14/85	24 PIN DIP	B
6290	28400	83.7	86400	6232	16600	ND	.3059	ND	22200	05/23/87	05/09/87	24 PIN BATHTUB	B
179	31100	95.5	4416	1201	2665	449	.0809	ND	4852	2/05/86	1/20/86	78 PIN TUB	B
26961	32400	71.0	108000	5536	10300	ND	.9986	12.30	ND	6/19/87	5/05/87	36 PIN BATHTUB	C
8569	33900	85.9	1381	856	9706	327	4.13	7771	45200	8/31/87	7/12/87	56 PIN BATHTUB	C
37349	34000	93.7	ND	744	5602	110	2.21	ND	ND	4/06/87	1/15/86	36 PIN BATHTUB	C
2121	36100	78.4	22900	3375	82500	253	2.97	.2825	28200	8/04/86	2/04/86	40 PIN TUB	C
9058	40100	88.8	ND	741	12300	121	3.43	.1474	22500	8/31/87	7/12/87	56 PIN BATHTUB	C
6003	41400	70.6	155000	6657	19300	ND	1.27	5.90	ND	6/25/86	1/09/86	24 PIN DIP	B
14295	47300	67.0	219000	9245	5169	107	2.66	1.38	7155	7/26/85	11/14/85	24 PIN DIP	B
2998	50700	72.5	94900	7938	40500	ND	.0507	8.05	ND	6/12/87	3/05/87	36 PIN BATHTUB	C
875	70700	89.3	ND	642	4438	195	3.08	ND	ND	8/27/86	7/25/86	40 PIN TUB	C
401	73200	41.3	170000	5415	10000	ND	ND	32.4	4175	9/10/86	4/12/86	78 PIN TUB	B