Dexter Research Center, Inc.

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Summary Report: MIL-STD-883H Mechanical Shock and Random Vibration Testing of Dexter Silicon Based Thermopiles

1.0 PURPOSE

In response to internal and military application inquires regarding mechanical durability of Dexter silicon based thermopiles; Dexter Research Center, Inc. has undertaken specific MIL-STD-883H mechanical testing of it's single element ST and S60 series TO5 package thermopiles. The present military fire sensor application using the thin film Sb/Bi 1M model has been in use for over 30 years and proven to survive environments of 1,000G mechanical shock, and 30G random vibration. In order to build on that success, the 1M model underwent additional testing as a control for performance comparison to the Silicon based thermopiles.

(Data & excerpts are inserted as applicable from documents published between Dexter Research & Trialon Corporation.)

1.1 Scope

1M and Silicon based thermopile configurations were built according to table 3.0-1 (below) and then subjected to MIL-STD-883H mechanical shock (3 axis), and random vibration (3 axis). Each MIL test was performed at two intensity levels, and all units were electrically tested for integrity between each mechanical test and intensity. The test sequence followed is defined in table 3.1-1 below. As indicated in MIL-STD-883H, the physical fixturing and holding of the units under test may compromise the hermetic package seal. As a result, only the integrity of the internal detector, on-chip resistor, or chip thermistor circuits (resistance or continuity) is reported.

2.0 APPLICABLE DOCUMENTS

The following documents formed an integral part of this test procedure.

MIL-STD-883H Military Standard Mechanical Test Methods
Doc. # 5327 Rev J Dexter Final Test, Process Flowchart
Doc. # 153116 Rev E Customer X Thermopile Detector Sensitivity and Resistance Test Procedure (note that Customer name and part numbers have been removed for privacy purposes.)

3.0 TEST ARTICLES

Test articles for this program were finished thermopiles in the following configurations and quantities, (table 3.0-1):

Table 3.0-1

Detector P/N (or base p/n)	Description of units tested	Qty. under test	Notes:
DX-0017	1M/CF:X GE/.180/GOLD/N2	10	1M on pins
DX-0018	1M/CF:X /.180/GOLD/N2	10	1M on pins
DX-0830	ST60R/SAPPHIRE U1/XE	15	TO5 w/on-chip resistor wired
DX-0783	ST120/T4/SAPPHIRE U1/XE	15	TO5 w/30kohm chip thermistor
DX-0425	ST150/SAPPHIRE/XE	15	TO5 w/no resistor-thermistor
DX-0875	ST60R/TO18/5.0LWPSI1/XE	20	TO18 w/on-chip resistor wired
DX-0409	S60M/HS/.020FAP/8-14 SI 1%/XE	20	TO5 w/.020" internal aperture

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3.1 Test Sequence

Table 3.1-1 defines the test sequence followed.

Table 3.1-1

Test Sequence	Test Description	Location	Test Method and Detail
1	Circuit Integrity	DRC	Resistance Test of DX-0409-0830 units (Ref doc. 5327 Rev J), Sensitivity of DX-0017/DX-0018 (Customer X doc.153116 Rev E)
2	Mechanical Shock	Trialon	MIL-STD-883, Method 2002.5, Condition A (500G).
3	Circuit Integrity	DRC	Resistance Test of DX-0409-0830 units (Ref doc. 5327 Rev J), Sensitivity of DX-0017/DX-0018 (Customer X doc.153116 Rev E)
4	Random Vibration	Trialon	MIL-STD-883, 2026, Cond. II – A (6G Random Vibration)
5	Circuit Integrity	DRC	Resistance Test of DX-0409-0830 units (Ref doc. 5327 Rev J), Sensitivity of DX-0017/DX-0018 (Customer X doc.153116 Rev E)
6	Mechanical Shock	Trialon	MIL-STD-883, Method 2002.5, Condition B (1000G).
7	Circuit Integrity	DRC	Resistance Test of DX-0409-0830 units (Ref doc. 5327 Rev J), Sensitivity of DX-0017/DX-0018 (Customer X doc.153116 Rev E)
8	Random Vibration	Trialon	MIL-STD-883, 2026, Cond. II - J (30G Random Vibration)
9	Circuit Integrity	DRC	Resistance Test of DX-0409-0830 units (Ref doc. 5327 Rev J), Sensitivity of DX-0017/DX-0018 (Customer X doc.153116 Rev E)

4.0 GENERAL TEST INFORMATION

4.1 Test Location

Testing was performed at Dexter Research Center, or Trialon Corporation as noted in Table 3.1-1.

4.2 Test Conditions

All tests were performed at prevailing site altitude, at a room temperature of 20°±5°C (68°±9°F), and relative humidity not exceeding 90% unless otherwise specified. All units were tested at the same time from the same batch.

4.3 Test Reporting

Trialon shock/vibration set-up and profiles are reported in section 5.0, report. Dexter circuit integrity data is tabulated in section 6.0. ..

4.4 Quality Assurance

All tests at Dexter were performed by Quality Assurance personnel. All testing at Trialon was supported by a signed Test Report outlining the equipment name, model number, calibration due date, tolerance, setup, and method of test.

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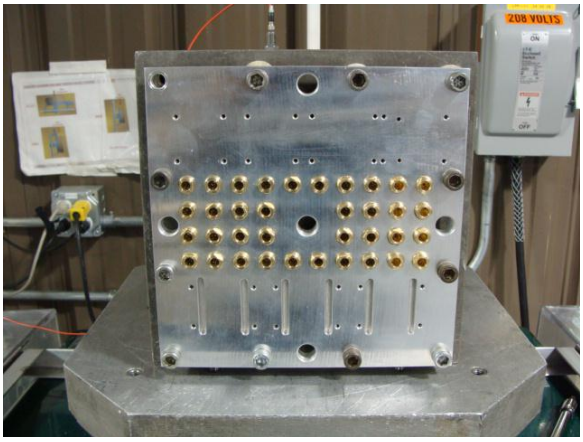
4.5 General Failure Criteria

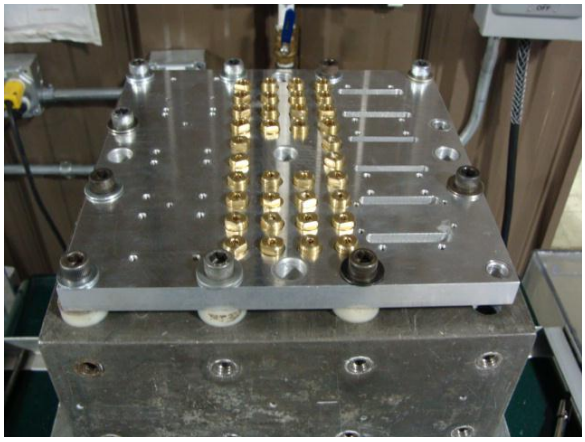
For 'DX-0409-0830' products, a detector circuit, on-chip resistor, or chip thermistor is classified as failing if the resistance value changed by >10% from its baseline (pre-MIL) tested value under Dexter Final Test Procedure (Doc.5327). For parts number DX-0017 and DX-0018 only the sensitivity (uV output) was measured via Customer X doc 153116 Rev E; failure was considered as any drop in output >10% from its baseline (pre-MIL) tested value. In hindsight, the DX-0017 & DX-0018 could have been tested for resistance on the test equipment as well. The presence of output within +/-10% from baseline will satisfy continuity and integrity of the detector pattern for this test.

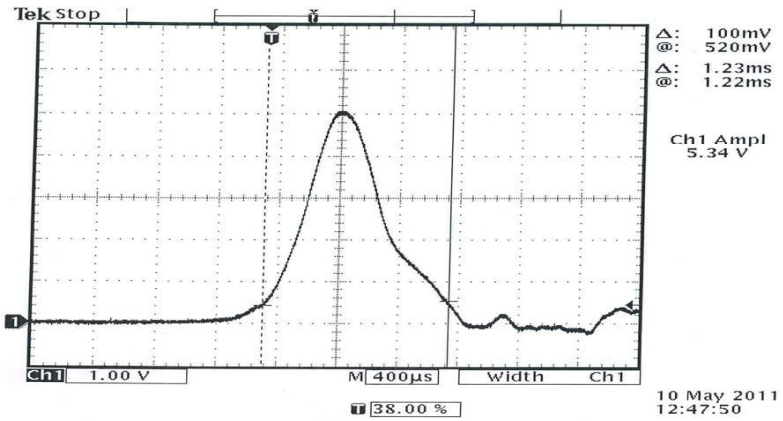
5.0 MIL-STD-883H Test Setup, and Profiles

5.1 Test # 2 Setup & Profile, 500G Shock

MIL-STD-883, Method 2002.5, Condition A. Thermopiles were fastened into 3 tooling plates, and attached to the Avco Drop Shock Machine as shown in the photos below. –Plates are rotated as needed to achieve all pulse orientations, and subjected to a total of 30 Half-sine/500G/1.0ms shock pulses, 5 in each of the three axes, in positive and negative direction. An accelerometer is mounted near the samples to measure the pulse profile (10 mV/G)







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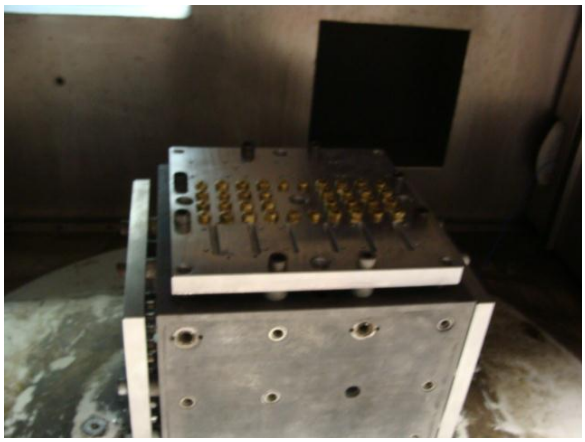
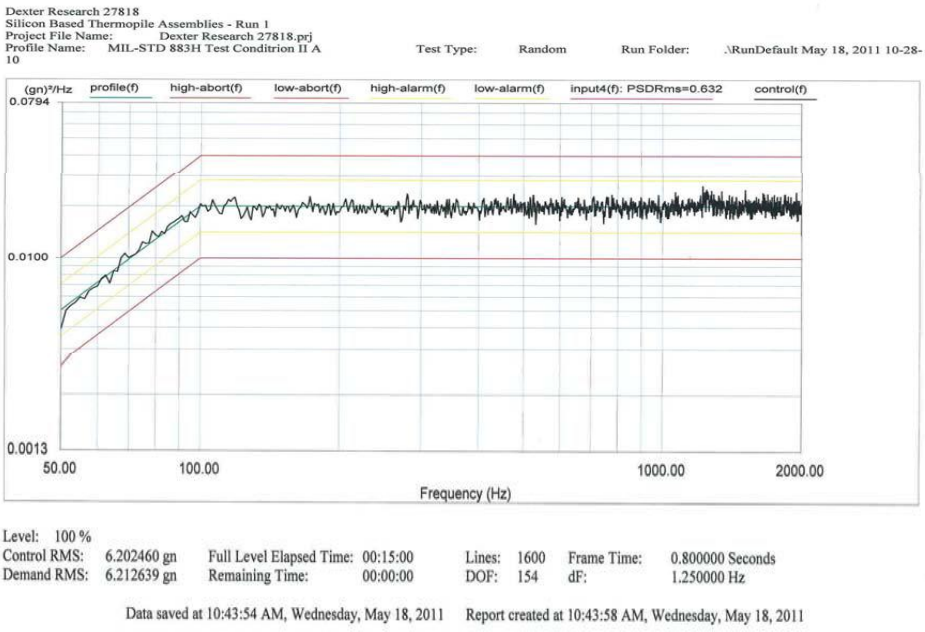
5.2 Test # 4 Setup & Profile, 6G Random Vibration

MIL-STD-883, 2026, Cond. II – A. Thermopiles were fastened into 3 tooling plates, attached to the LDS Vibration Table as shown in the photos below, and subjected to the following vibration profile for 15 minutes in each of 3 axes. An accelerometer is mounted near the samples to measure and control the vibration input listed below.



Frequency (Hz)	Power Spectral Density -PSD (G^2/Hz)
5	0.000051
100	0.02
2000	0.02
Overall Grms Level = 6.21	



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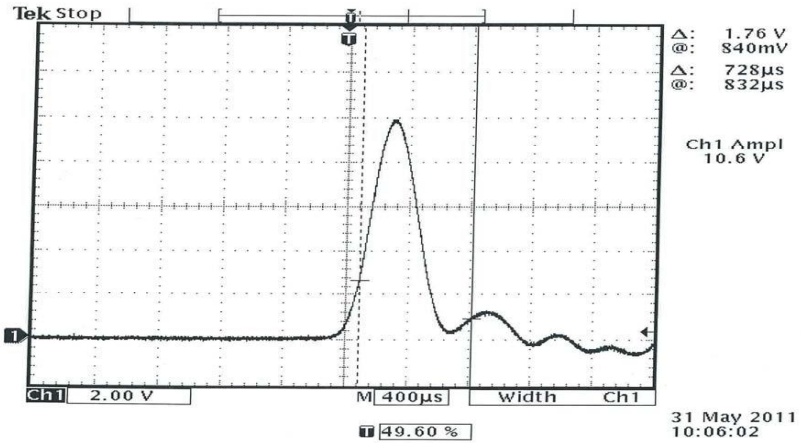
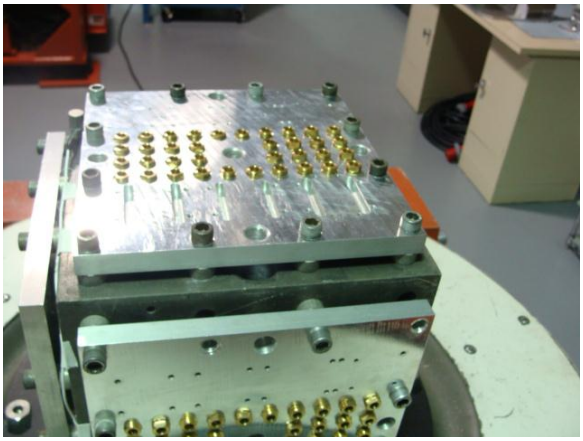
5.3 Test # 6 Profile, 1,000G Shock

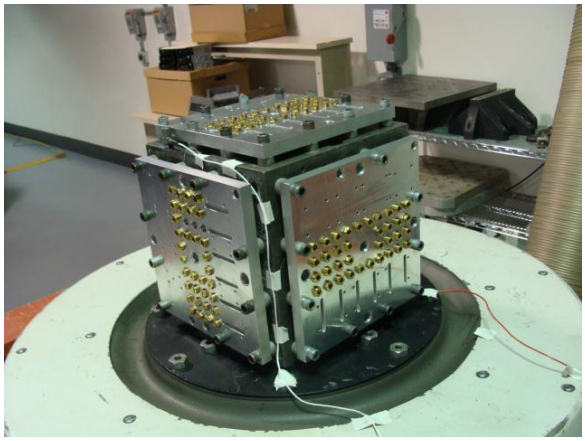
MIL-STD-883, Method 2002.5, Condition B (modified from 1,500G down to 1,000G). Thermopiles plates were mounted to the Drop Shock Machine as shown 5.1 above, and subjected to a total of 30 Half-sine/1,000G/0.5ms shock pulses, 5 in each of the three axes, in positive and negative directions. An accelerometer is mounted near the samples to measure the pulse profile. (10 mV/G)



5.4 Test # 8 Setup & Profile, 30G Random Vibration

MIL-STD-883H, 2026, Cond. II – J. Thermopiles were fastened into 3 tooling plates, attached to the LDS Vibration Table as shown in the photos below, and subjected to the following vibration profile for 3 hours in each of 3 axes. An accelerometer is mounted near the samples to measure and control the vibration input below.





Frequency (Hz)	Power Spectral Density -PSD (G^2/Hz)
5	.00118673
100	0.465386
2000	0.465386
Overall Grms Level = 30.0	

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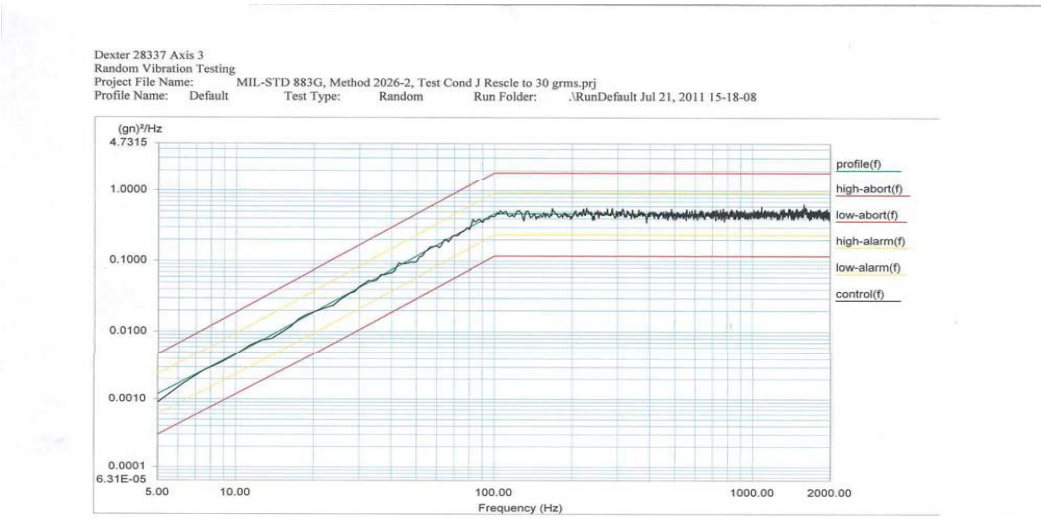

6.0 Detector Test Data

All circuit integrity test data defined in the table below. The resistance of DX-0409-0830 units (kohm), and the sensitivity (uV) of the DX-0017 & DX-0018 units are reflected. Delta from Baseline columns illustrate the percent of change from the baseline reading.

Detector test data: kohm for 'DX', uV for '4211XX'

D = detector, R = On-Chip Resistor, T = Chip Thermistor

Δ from Baseline columns formatted to show any change > +/- 10% as

			Tested after:							
Detector	**#**	**Pre-MIL Baseline (5/6/11)**	**500G Shock (5/12/11)**	**Δ from Baseline**	**6G Vibe (5/20/11)**	**Δ from Baseline**	**1000G Shock (6/13/11)**	**Δ from Baseline**	**30G Vibe (8/1/11)**	**Δ from Baseline**
DX-0830	1 D	54.2	54.31	0.2%	54.46	0.5%	54.26	1.8%	54.34	0.3%
DX-0830	1 R	28.6	28.65	0.2%	28.68	0.3%	28.63	3.5%	28.66	0.2%
DX-0830	2 D	54.8	54.9	0.2%	55.06	0.5%	54.84	1.8%	54.95	0.3%
DX-0830	2 R	30.39	30.43	0.1%	30.46	0.2%	30.41	3.3%	30.43	0.1%
DX-0830	3 D	54.83	54.94	0.2%	55.04	0.4%	54.9	1.8%	54.9	0.1%
DX-0830	3 R	29.23	29.28	0.2%	29.3	0.2%	29.25	3.4%	29.26	0.1%
DX-0830	4 D	55.54	55.69	0.3%	55.75	0.4%	55.61	1.8%	55.68	0.3%
DX-0830	4 R	30.36	30.42	0.2%	30.45	0.3%	30.4	3.3%	30.41	0.2%
DX-0830	5 D	55.35	55.51	0.3%	55.63	0.5%	55.44	1.8%	55.48	0.2%
DX-0830	5 R	29.84	29.91	0.2%	29.94	0.3%	29.89	3.4%	29.92	0.3%
DX-0830	6 D	55.17	55.34	0.3%	55.42	0.5%	55.26	1.8%	55.28	0.2%
DX-0830	6 R	29.29	29.36	0.2%	29.38	0.3%	29.33	3.4%	29.33	0.1%
DX-0830	7 D	53.95	54.09	0.3%	54.15	0.4%	53.96	1.9%	54.03	0.1%
DX-0830	7 R	28.46	28.54	0.3%	28.53	0.2%	28.48	3.5%	28.48	0.1%
DX-0830	8 D	54.95	55.08	0.2%	55.18	0.4%	54.99	1.8%	55.05	0.2%
DX-0830	8 R	30.99	31.07	0.3%	31.08	0.3%	31.02	3.2%	31.04	0.2%
DX-0830	9 D	55.4	55.55	0.3%	55.66	0.5%	55.44	1.8%	55.49	0.2%
DX-0830	9 R	30.28	30.34	0.2%	30.36	0.3%	30.31	3.3%	30.31	0.1%
DX-0830	10 D	53.81	53.95	0.3%	54.02	0.4%	53.86	1.9%	53.9	0.2%
DX-0830	10 R	29.87	29.93	0.2%	29.93	0.2%	29.88	3.3%	29.91	0.1%
DX-0830	11 D	55.66	55.78	0.2%	55.89	0.4%	55.65	1.8%	55.74	0.1%
DX-0830	11 R	30.01	30.1	0.3%	30.11	0.3%	30.04	3.3%	30.05	0.1%
DX-0830	12 D	55.87	56.01	0.3%	56.14	0.5%	55.93	1.8%	55.96	0.2%
DX-0830	12 R	30.26	30.33	0.2%	30.33	0.2%	30.28	3.3%	30.3	0.1%
DX-0830	13 D	55.74	55.88	0.3%	56.01	0.5%	55.79	1.8%	55.84	0.2%
DX-0830	13 R	29.95	30.02	0.2%	30.02	0.2%	29.97	3.3%	29.98	0.1%
DX-0830	14 D	55.31	55.41	0.2%	55.55	0.4%	55.34	1.8%	55.4	0.2%
DX-0830	14 R	31.38	31.46	0.3%	31.47	0.3%	31.41	3.2%	31.44	0.2%
DX-0830	15 D	55.23	55.34	0.2%	55.51	0.5%	55.27	1.8%	55.36	0.2%

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DX-0830	15 R	29.56	29.63	0.2%	29.66	0.3%	29.6	3.4%	29.61	0.2%
DX-0783	1 D	92.32	92.75	0.5%	92.97	0.7%	92.7	1.1%	93.02	0.8%
DX-0783	1 T	32.44	32.2	-0.7%	32.12	-1.0%	33.45	3.2%	34.97	7.8%
DX-0783	2 D	92.64	93.01	0.4%	93.12	0.5%	92.78	1.1%	93.2	0.6%
DX-0783	2 T	32.02	29.65	-7.4%	31.85	-0.5%	33.02	3.2%	34.8	8.7%
DX-0783	3 D	92.63	92.98	0.4%	93.18	0.6%	92.75	1.1%	93.26	0.7%
DX-0783	3 T	31.47	31.03	-1.4%	31.37	-0.3%	32.66	3.3%	34.26	8.9%
DX-0783	4 D	92.71	93.13	0.5%	93.13	0.5%	92.98	1.1%	93.46	0.8%
DX-0783	4 T	31.93	31.37	-1.8%	31.97	0.1%	33.13	3.2%	34.79	9.0%
DX-0783	5 D	92.29	92.66	0.4%	92.75	0.5%	92.57	1.1%	93.05	0.8%
DX-0783	5 T	31.12	30.49	-2.0%	30.96	-0.5%	32.24	3.3%	33.67	8.2%
DX-0783	6 D	92.61	93.03	0.5%	93.14	0.6%	92.77	1.1%	93.26	0.7%
DX-0783	6 T	31.71	31.1	-1.9%	31.44	-0.9%	32.85	3.3%	34.23	7.9%
DX-0783	7 D	92.4	92.94	0.6%	93.03	0.7%	92.77	1.1%	93.11	0.8%
DX-0783	7 T	30.94	29.92	-3.3%	30.49	-1.5%	32.07	3.4%	33.67	8.8%
DX-0783	8 D	92.44	92.78	0.4%	92.91	0.5%	92.67	1.1%	93.08	0.7%
DX-0783	8 T	31.94	31.01	-2.9%	31.58	-1.1%	33.05	3.2%	34.71	8.7%
DX-0783	9 D	92.58	92.95	0.4%	93.05	0.5%	92.78	1.1%	93.23	0.7%
DX-0783	9 T	31.04	30.19	-2.7%	30.54	-1.6%	32.16	3.3%	33.54	8.1%
DX-0783	10 D	92.37	92.73	0.4%	92.76	0.4%	92.59	1.1%	93.13	0.8%
DX-0783	10 T	31.8	31	-2.5%	31.35	-1.4%	32.99	3.3%	34.41	8.2%
DX-0783	11 D	92.64	92.9	0.3%	92.98	0.4%	92.77	1.1%	93.24	0.6%
DX-0783	11 T	31.1	30.1	-3.2%	30.55	-1.8%	32.19	3.3%	33.73	8.5%
DX-0783	12 D	92.33	92.765	0.5%	92.76	0.5%	92.59	1.1%	93.07	0.8%
DX-0783	12 T	31.98	31.42	-1.8%	31.97	0.0%	33.31	3.3%	34.79	8.8%
DX-0783	13 D	92.48	92.93	0.5%	93	0.6%	92.74	1.1%	93.36	1.0%
DX-0783	13 T	31.65	30.59	-3.3%	31.36	-0.9%	32.9	3.3%	34.36	8.6%
DX-0783	14 D	92.22	92.61	0.4%	92.7	0.5%	92.58	1.1%	92.98	0.8%
DX-0783	14 T	31.42	29.64	-5.7%	31.21	-0.7%	32.62	3.3%	34.13	8.6%
DX-0783	15 D	92.4	92.74	0.4%	92.95	0.6%	92.57	1.1%	93.14	0.8%
DX-0783	15 T	31.87	30.93	-2.9%	31.36	-1.6%	33.22	3.3%	34.58	8.5%
DX-0425	1	81.51	81.89	0.5%	81.94	0.5%	81.72	1.2%	82.01	0.6%
DX-0425	2	80.98	81.37	0.5%	81.51	0.7%	81.15	1.2%	81.5	0.6%
DX-0425	3	81.56	81.82	0.3%	82.01	0.6%	81.81	1.2%	82.12	0.7%
DX-0425	4	81.12	81.53	0.5%	81.57	0.6%	81.27	1.2%	81.59	0.6%
DX-0425	5	81.57	82.09	0.6%	82.06	0.6%	81.71	1.2%	81.94	0.5%
DX-0425	6	81.66	82.33	0.8%	82.41	0.9%	82.24	1.2%	82.41	0.9%
DX-0425	7	81.96	82.43	0.6%	82.44	0.6%	82.17	1.2%	82.57	0.7%
DX-0425	8	82.09	82.59	0.6%	82.59	0.6%	82.4	1.2%	82.59	0.6%
DX-0425	9	82.14	82.66	0.6%	82.7	0.7%	82.38	1.2%	82.74	0.7%
DX-0425	10	82.11	82.61	0.6%	82.65	0.7%	82.34	1.2%	82.72	0.7%
DX-0425	11	81.5	82.06	0.7%	82.12	0.8%	81.95	1.2%	82.15	0.8%
DX-0425	12	81.4	81.74	0.4%	81.8	0.5%	81.55	1.2%	81.84	0.5%
DX-0425	13	81.25	81.58	0.4%	82.46	1.5%	82.12	1.2%	79.1	-2.6%
DX-0425	14	81.29	81.76	0.6%	81.81	0.6%	81.64	1.2%	81.97	0.8%
DX-0425	15	81.96	82.33	0.5%	81.62	-0.4%	81.51	1.2%	81.74	-0.3%
DX-0875	1 D	58.82	58.59	-0.4%	58.7	-0.2%	58.54	1.7%	58.67	-0.3%
DX-0875	1 R	28.62	28.74	0.4%	28.66	0.1%	28.62	3.5%	28.69	0.2%
DX-0875	2 D	59.72	59.62	-0.2%	59.7	0.0%	59.52	1.7%	59.65	-0.1%
DX-0875	2 R	29.78	29.83	0.2%	29.77	0.0%	29.72	3.4%	29.97	0.6%
DX-0875	3 D	57.7	57.55	-0.3%	57.66	-0.1%	57.45	1.7%	57.67	-0.1%
DX-0875	3 R	26.71	26.75	0.1%	26.71	0.0%	26.7	3.7%	26.77	0.2%
DX-0875	4 D	58.06	57.8	-0.4%	57.89	-0.3%	57.81	1.7%	57.95	-0.2%
DX-0875	4 R	28.11	28.21	0.4%	28.13	0.1%	28.1	3.6%	28.17	0.2%
DX-0875	5 D	58.6	58.39	-0.4%	58.46	-0.2%	58.29	1.7%	58.47	-0.2%
DX-0875	5 R	28	28.05	0.2%	27.97	-0.1%	27.97	3.6%	28.03	0.1%
DX-0875	6 D	59.06	58.9	-0.3%	59.02	-0.1%	58.83	1.7%	58.95	-0.2%
DX-0875	6 R	28.14	28.25	0.4%	28.19	0.2%	28.13	3.6%	28.19	0.2%
DX-0875	7 D	58.65	58.41	-0.4%	58.51	-0.2%	58.33	1.7%	58.48	-0.3%
DX-0875	7 R	28.93	29.03	0.3%	28.97	0.1%	28.93	3.5%	29.01	0.3%
DX-0875	8 D	59.62	59.53	-0.2%	59.59	-0.1%	59.43	1.7%	59.58	-0.1%
DX-0875	8 R	29.34	29.46	0.4%	29.36	0.1%	29.34	3.4%	29.37	0.1%
DX-0875	9 D	59.69	59.63	-0.1%	59.68	0.0%	56.56	1.6%	59.59	-0.2%
DX-0875	9 R	29.36	29.55	0.6%	29.43	0.2%	29.41	3.4%	29.45	0.3%
DX-0875	10 D	57.98	57.74	-0.4%	57.83	-0.3%	57.71	1.7%	57.85	-0.2%
DX-0875	10 R	28.43	28.55	0.4%	28.48	0.2%	28.42	3.5%	28.46	0.1%
DX-0875	11 D	59.54	59.38	-0.3%	59.47	-0.1%	59.35	1.7%	59.46	-0.1%
DX-0875	11 R	30.28	30.37	0.3%	30.29	0.0%	30.23	3.3%	30.31	0.1%
DX-0875	12 D	58.42	58.13	-0.5%	58.19	-0.4%	58.09	1.7%	58.19	-0.4%
DX-0875	12 R	28.23	28.27	0.1%	28.23	0.0%	28.21	3.5%	28.25	0.1%
DX-0875	13 D	58.64	58.32	-0.5%	58.49	-0.3%	58.37	1.7%	58.47	-0.3%

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DX-0875	13 R	28.33	28.4	0.2%	28.31	-0.1%	28.28	3.5%	28.32	0.0%
DX-0875	14 D	58.14	57.82	-0.6%	57.95	-0.3%	57.83	1.7%	57.89	-0.4%
DX-0875	14 R	27.37	27.4	0.1%	27.39	0.1%	27.37	3.7%	27.45	0.3%
DX-0875	15 D	58.04	57.79	-0.4%	57.87	-0.3%	57.78	1.7%	57.88	-0.3%
DX-0875	15 R	28.03	28.05	0.1%	27.99	-0.1%	27.99	3.6%	28.06	0.1%
DX-0875	16 D	58.91	58.76	-0.3%	58.83	-0.1%	58.72	1.7%	58.84	-0.1%
DX-0875	16 R	29.09	29.18	0.3%	29.12	0.1%	29.09	3.4%	29.13	0.1%
DX-0875	17 D	57.55	58.21	1.1%	9999	17274.5%		n/a		n/a
DX-0875	17 R	27.7	28.13	1.6%	9999	35997.5%		n/a		n/a
DX-0875	18 D	58.44	57.45	-1.7%	57.49	-1.6%	57.37	1.7%	57.51	-1.6%
DX-0875	18 R	28.07	27.75	-1.1%	27.7	-1.3%	27.68	3.5%	27.73	-1.2%
DX-0875	19 D	59.05	58.9	-0.3%	58.97	-0.1%	58.83	1.7%	58.97	-0.1%
DX-0875	19 R	28.6	28.67	0.2%	28.64	0.1%	28.57	3.5%	28.65	0.2%
DX-0875	20 D	59.08	59.01	-0.1%	59.04	-0.1%	58.89	1.7%	59	-0.1%
DX-0875	20 R	28.64	28.82	0.6%	28.66	0.1%	28.62	3.5%	28.61	-0.1%
DX-0409	1	84.57	84.75	0.2%	84.81	0.3%	84.45	1.2%	84.83	0.3%
DX-0409	2	85.75	85.83	0.1%	85.78	0.0%	85.45	1.2%	85.89	0.2%
DX-0409	3	97.99	98.05	0.1%	98.16	0.2%	97.91	1.0%	98.46	0.5%
DX-0409	4	98.49	98.57	0.1%	98.71	0.2%	98.31	1.0%	98.84	0.4%
DX-0409	5	86.92	87.08	0.2%	87.14	0.3%	86.62	1.1%	87.12	0.2%
DX-0409	6	73.29	73.36	0.1%	73.36	0.1%	73.06	1.4%	73.35	0.1%
DX-0409	7	84.01	84.06	0.1%	84.13	0.1%	83.76	1.2%	84.11	0.1%
DX-0409	8	85.19	85.32	0.2%	85.41	0.3%	85.13	1.2%	85.41	0.3%
DX-0409	9	89.86	89.88	0.0%	90.05	0.2%	89.71	1.1%	90.03	0.2%
DX-0409	10	47.3	47.29	0.0%	47.32	0.0%	47.17	2.1%	47.26	-0.1%
DX-0409	11	70.04	70.01	0.0%	70.05	0.0%	69.85	1.4%	70	-0.1%
DX-0409	12	96.44	96.43	0.0%	96.6	0.2%	96.21	1.0%	96.62	0.2%
DX-0409	13	94.98	94.89	-0.1%	94.98	0.0%	94.62	1.0%	95.13	0.2%
DX-0409	14	85.83	83.52	-2.7%	83.62	-2.6%	83.26	1.1%	83.62	-2.6%
DX-0409	15	85.48	85.47	0.0%	85.56	0.1%	85.4	1.2%	85.66	0.2%
DX-0409	16	85.3	85.35	0.1%	85.44	0.2%	85.1	1.2%	85.51	0.2%
DX-0409	17	89.76	89.87	0.1%	90.04	0.3%	89.65	1.1%	89.98	0.2%
DX-0409	18	84.13	84.05	-0.1%	84.28	0.2%	83.87	1.2%	84.28	0.2%
DX-0409	19	83.41	83.38	0.0%	83.48	0.1%	83.2	1.2%	83.53	0.1%
DX-0409	20	94.77	94.87	0.1%	95.03	0.3%	94.76	1.1%	85.26	-10.0%
DX-0017	1	380.6	379.1	-0.4%	379.6	-0.3%	390.3	0.3%	388.1	2.0%
DX-0017	2	399.2	395.8	-0.9%	404.9	1.4%	411	0.3%	396.4	-0.7%
DX-0017	3	376.1	375	-0.3%	376.1	0.0%	383.3	0.3%	379.3	0.9%
DX-0017	4	381.9	382.2	0.1%	383.3	0.4%	388.2	0.3%	9999	2518.2%
DX-0017	5	388.5	392.5	1.0%	392.7	1.1%	398.2	0.3%	395.2	1.7%
DX-0017	6	348.1	358.1	2.9%	357.9	2.8%	366.6	0.3%	371.3	6.7%
DX-0017	7	375.3	365.9	-2.5%	369	-1.7%	375.5	0.3%	375.8	0.1%
DX-0017	8	392.2	389.5	-0.7%	387.2	-1.3%	393.4	0.3%	388.9	-0.8%
DX-0017	9	391	383.2	-2.0%	380.6	-2.7%	389	0.3%	388.1	-0.7%
DX-0017	10	394.6	367.6	-6.8%	390.9	-0.9%	394.7	0.3%	387.1	-1.9%
DX-0018	1	234.1	224.7	-4.0%	225.3	-3.8%	231.8	0.4%	231.2	-1.2%
DX-0018	2	236.5	228.7	-3.3%	228.6	-3.3%	235	0.4%	233.7	-1.2%
DX-0018	3	228.1	223.2	-2.1%	220.9	-3.2%	227.6	0.4%	226.1	-0.9%
DX-0018	4	245.9	244.6	-0.5%	249.7	1.5%	251.7	0.4%	249.7	1.5%
DX-0018	5	252.2	235.1	-6.8%	235	-6.8%	243.1	0.4%	241.6	-4.2%
DX-0018	6	251.8	245.3	-2.6%	243.3	-3.4%	249.7	0.4%	247.5	-1.7%
DX-0018	7	232.4	210.4	-9.5%	233	0.3%	238.6	0.4%	233.9	0.6%
DX-0018	8	227.1	227.1	0.0%	226.7	-0.2%	239.9	0.5%	244.7	7.7%
DX-0018	9	238.3	230.6	-3.2%	229.3	-3.8%	235.4	0.4%	233.1	-2.2%
DX-0018	10	233.1	226.8	-2.7%	226.6	-2.8%	229.5	0.4%	227.5	-2.4%

7.0 INTERPRETATION OF DATA

7.1 The DX-0875 indicated failure after being subjected to the 6G Random Vibration (15 minutes in each of 3 axes):

With the cap cut open on this unit, the photo below shows that the ST60 die membrane fracture/crack.

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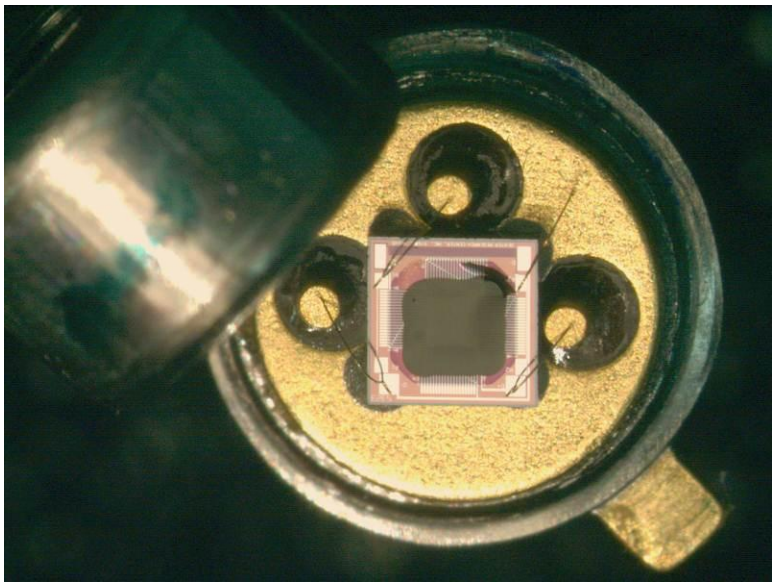
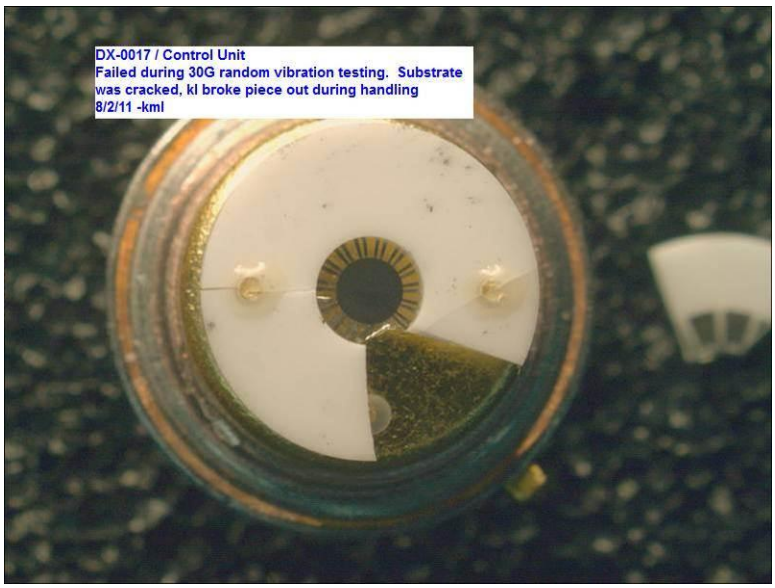


Dexter Research Centers' two highest volume ST60 configurations (TO18 & TO5 Quad) had thirty two broken membranes from over 317,975 dies shipped in 2009 and 2010, this represents 0.01% field loss for this failure mode. These two models were summarized because of the high volume and customer's willingness to return failed units for evaluation

7.2 The DX-0017 unit that indicated failure after the 30G Random Vibration (3hrs each axis)

With the cap cut open on this unit, the photo below shows that the 1M substrate had cracked, flexing the thin-film pattern creating an open circuit. As an observation; inspection before the substrate piece was broken out during handling for the photo, revealed that the substrate was unsecured from the support post (seen here with gray epoxy on it). It is unclear whether the crack allowed it to become unsecure, or whether it became unsecured allowing the stresses to crack the substrate.



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8.0 CONCLUSION

Test results support that our present silicon based volume thermopile detector dies, and the assembly techniques used in these configurations, are capable of withstanding MIL-STD-883H Physical Shock of 1,000G/0.5 ms pulses, 10x each axis, and Random Vibration of 30Grms/3hrs each axis as determined by the series of tests performed, and understanding of the known field failure mode and rate of the ST60 membrane fracture

Further, with respect to the military application inquiry regarding comparison to the 1M model; these same silicon based thermopiles and their assembly techniques are comparable in durability under these test conditions to the present 1M model