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Developing an Effective Environmental Life Test Plan for Microelectronic Product Design

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DEVELOPING AN EFFECTIVE ENVIRONmental life test plan is one of the challenges seen in new microelectronic product design. Some customers may not “require” environmental testing, but many customers will and may want to see the corresponding test data and results. Regardless of customer obligations, almost all new product designers have an internal minimum requirement for demonstrated environmental test endurance. Each of these environmental life test plans should be viewed with a “top down” approach. Looking at the top-most assembly level environmental endurance requirements first then flowing that requirement down to the lowest component level.

Environmental testing strategy begins with determining what specific testing is required. It could be high intensity ultraviolet testing (to simulate exposure to sunlight), or it could be a humidity test, heat test, thermal shock test, thermal cycle test, etc. As an example, automotive applications undoubtedly require a thermal cycle test. This test is typically in the range of -40°C to +125°C with 30 minute dwell for 3000 cycles. It is important to establish these requirements up front. They will help determine the longest lead time requirements so that the test plan can be populated. This will also aid in the product development cycle if the “test early, test often” approach [1] is used.

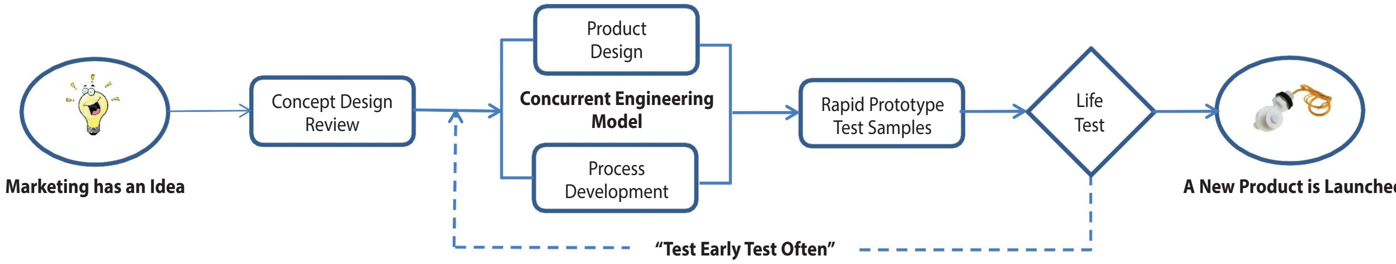
No environmental test is valid unless an established output from that test can be accurately and precisely measured. If the output of a test cannot be measured, or it is not quantified, it serves no value[2]. The output of an environmental test is typically a function test of the part or device. It can also be a physical measurement to determine if the part has changed dimension (which is often done after a humidity test), or it may require that the part be disassembled and examined for signs of damage after testing is complete. Sometimes it is necessary to continuously power and monitor the output of the part during test to determine if there is an output shift as a result of certain test conditions. In some cases it is necessary to derive more than one output from a test, like a dimension and electrical output. Regardless of the test parameters, all testing must have a measurable output.

The next step in creating an effective test plan is to determine how many parts to test, the sequence of the testing, and duration of each test. During this step, the test plan matrix is filled out. The quantity of parts to be tested is governed by the need for output data. (It is important to understand that this is not a statistical test. Since the results are pass/fail, it is not necessary to test a statistically significant

Product Validation Test Plan

Section	Test	Results Pass	Results Fail	Dur. Days*	Pre Function	Post function	Visual Insp.	# of Parts	Weeks 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Test	**Functional tests**																									
1	Function test (Leak, Characterize, Insulation Resistance)			1	Yes	Yes	No																			
2	Function test			1	Yes	Yes	No																			
3	Characterization			1	Yes	Yes	No																			
4	Presure cycle test			1	Yes	Yes	No																			
	Environmental test requirements for product verification																									
5	Humidity Cycling			30	Yes	Yes	No																			
6	Salt spray fog (144h @ DIN 50 021 SS)			8	Yes	Yes	Yes																			
7	Heat Soak			91	Yes	Yes	No																			
8	Cold Soak			91	Yes	Yes	Yes																			
	Thermal Loading and Endurance																									
9	Thermal shock test (200 cycles)			10	Yes	Yes	No				SEQUENTIAL TEST															
10	Extended Thermal Shock (1000 cycles)			50	Yes	Yes	No				SEQUENTIAL TEST															
11	Endurance test			40	Yes	Yes	No																			
12	Stepped temperature test			2	Yes	Yes	No				SEQUENTIAL TEST															
13	Ice water shock test (100 cycles)			4	Yes	Yes	Yes				SEQUENTIAL TEST															
	Misc																									
14	UV testing			5	No	No	Yes																			
15	HAST testing			1	No	No	Yes																			

Environmental Life Test



The Test Early, Test Often Strategy Applied to the Product Development Cycle

sample size - like 32 parts.) In most cases 5 parts will be more than adequate to collect meaningful data.

If it is not called out in a customer requirement, the testing sequence will require some planning. Depending on the application, some of the tests may need to be placed in sequence. The same group of 5 parts may go from one test directly to another to simulate a specific environmental condition. For example, a single group of parts may go from UV test directly to humidity or heat soak to simulate a humid island environment.

Once the sequence of tests is known, the duration of each test must be determined. In most cases the test is complete at a predetermined time or interval. However, in some cases, the customer may request one interval, but the design group holds the product to a higher standard and may decide to extend the test length. In other cases, it may be necessary to run a test, collect the data at the determined "end of test" point, and then continue to run the test until the product fails. This can help determine the theoretical end of life under a given condition. In any case, it is important to have a well thought out test plan at the beginning of the new product development cycle.

Once the specific tests, duration, quantity, sequence, and outputs are determined, the test plan can begin to take shape. The table shown on the previous page is an example of a typical test plan that includes some of the variables discussed. It is easy to see that the heat soak and cold soak tests become gating items due to the extended time requirements. The test plan must meet all of the product durability requirements while considering the time constraints. When creating the test plan it is also wise to consider a contingency plan in the event that there is a failure during test.

In addition to a well thought out and properly documented test plan there are some other things to consider during product development. The "test early, test often" strategy can be used to check basic design and process assumptions. This is the strategy of conducting specifically targeted early environmental testing on selected subassemblies, components, or complete devices as early as possible in the design cycle. This allows the design team to gain an understanding of the design strengths and weaknesses before the design is frozen and the final test plan is executed.

An environmental test strategy for new product development of microelectronic assemblies should be considered carefully. A well thought out test plan that includes a top-down approach, lead times and contingencies, measurable outputs, and a defined quantity of parts for analysis can be very cost effective. Integrating this test plan into a "test early, test often" strategy can further streamline early learning and ensure that objectives are met. New product development for microelectronic assemblies is very challenging and the proper strategy for environmental testing can get your product to market with the lowest overall development time and cost. ◆

Mr. Boyce is the Engineering Manager at SMART Microsystems. He is detail-oriented and is a hands-on engineering leader with a wide range of diverse skills from his background in automotive sensing.
He has served in senior engineering roles over the last 19 years with accomplishments that include manufactured automotive sensors. He also led new product development teams that created over $25 million in new revenue per year. He is certified in EIT and Six Sigma Green Belt and is an industry recognized expert in Al wire bonding. Additionally, he designed and led the metrology lab and machine shop at Sensata.

Mr. Boyce earned a Bachelor of Science in Engineering degree from the University of Rhode Island and has been a member of the IMAPS New England Chapter for over 10 years.

References

[1] "Engineering that Begins with the End in Mind", MEPTEC Report, Spring 2016, Volume 20, Number 1.

[2] William Boyce, "Precision Measurement for MEMS Sensor Applications", Tap Times, February 2017, Volume 8, Number 2.