



## What is Performance?

Pose that question to 10 people and you will get 20 different answers. For product testing, performance falls into a few categories. The one that is top-of-mind for most people is “How well does the product perform or function?” Once people know a product will do what it is intended to do (function), then several other questions arise, e.g. How long will it function?, How well will it function?, Under what conditions will it operate?, How easy is it to use?, How well is it put together? These areas fall into five basic categories:

- Functionality
- Life Cycle
- Durability
- Usability
- Workmanship

Performance testing is the process of exposing products to conditions that challenge the assumption or hypothesis that the product will meet a performance objective. For example, will a speaker reproduce a sound accurately in a given frequency range with minimal distortion, will the speaker still function after 10 years in an automobile, will it still function at -40° C and 80° C? Also how easy is it to install or use the speaker and what is the quality of the construction and aesthetic properties?

### Five Types of Performance:

- *Functionality: all features function under normal use*
- *Life Cycle: product lasts in normal operation*
- *Durability: range of conditions product can handle*
- *Usability: Ease of use*
- *Workmanship: physical characteristics for high quality fabrication*

All performance tests can be defined in the following way:

- Hypothesis-What is assumed to be true about the performance of the product
- Parameters-What factors impact the performance and what factors must be monitored to gauge performance
- Test-What exposure and functional check is necessary to check the hypothesis based on the parameters.

Many performance tests are embodied in nationally and internationally recognized standards, but some have to be custom-made for the unique attributes or goals of the product.

Performance tests generally fall into two types:

- Demonstrate a minimum
- Measure an actual value

For example, a product may have a goal of functioning for five years. The performance test is then designed to demonstrate that the product performs for more than five years. This is done by exposing the product to an equivalent five years of life, usually through accelerated cycles and exposures. Measuring the product's actual life requires a different test. To measure the life, a product has to be exposed to the accelerated conditions and periodically checked to see when it fails. This second type of performance test takes more time and resources. The same rule of "Demonstrate" or "Measure" applies equally to all five categories:

<b>Category</b>	<b>Demonstrate</b>	<b>Measure</b>
Function	Does a button close an electrical connection with a transition time of less than 10 ms?	How quickly does a button close the electrical connection?
Life Cycle	Does the button still function after 1,000,000 cycles?	For how many cycles will the button function?
Durability	Does the button work at -40° and 80° C?	How cold and hot can the button function at?
Usability	Can the button be actuated with less than 2N force?	How much force at what angle is necessary to press the button and how does this compare to the demographic dexterity?
Workmanship	Is the button solidly constructed with no flash or sharp edges?	What is the strength of the button insert?

Most national and international testing methods for performance focus on *demonstrating* a minimum performance.

## The Top Ten Reasons to Conduct Performance Testing

### 10. Independent Support of Marketing Claims

Every product has some value proposition. Using independent testing to verify the claim before an economic decision is made is a logical step. Would you buy a house with out an appraisal? That would be foolish.

Intertek's Quality & Performance Mark (QPM) proves product performance and gives your consumers peace of mind through independent, third party testing & validation. The QPM tests for up to 5 of the critical quality & performance tests noted above, revealing your product's strengths. Additionally, the Quality & Performance Mark offers the *CheckPlus* Performance option. *CheckPlus* allows for independent validation of your specific manufacturer's product claims, further differentiating your product in the marketplace.



### 9. New Technology Implementation

New technology presents several challenges and opportunities. Obviously the first concern with any new technology: Will it perform as well as or better than current technology? If the technology is replacing part of an existing product, then how does it change the product? Are there hidden problems? With new technology it is often good to conduct performance testing designed to measure what is happening rather than just demonstrating a minimum level. Tests like Highly Accelerated Life Testing (HALT) and Failure Mode Verification Testing (FMVT<sup>®</sup>) are very useful in identifying if a new technology is doing something unexpected. Also, tools like Design Failure Modes and Effect Analysis (DFMEA) and Hypothesis Matrix can help ensure that nothing is overlooked.

### 8. Optimizing Production

Driving production parameters to an optimal state usually requires measuring the

performance, not just demonstrating a minimal performance. If small changes in the overall performance of the product can be measured as production parameters are adjusted, then the production can be optimized for the best product. Accelerated testing techniques can help make this a practical task.

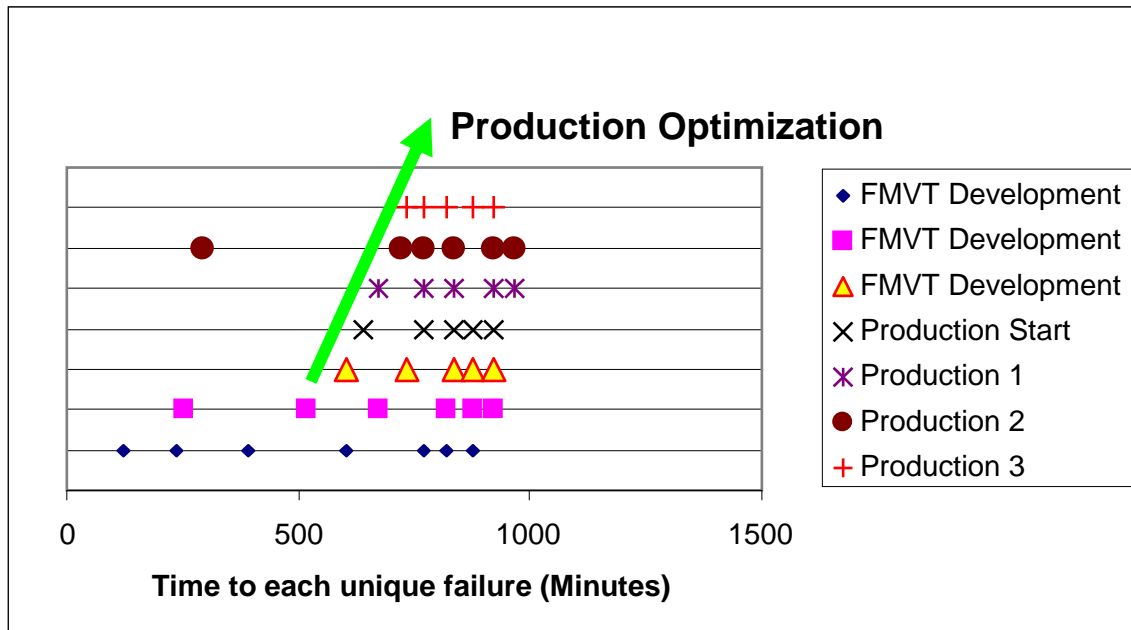


Figure 1. Iterative optimization of a product's time and number of failures through accelerated testing.

## 7. Solving Warranty Problems

There are two ways to address warranty. The first is to wait for it to happen and then *respond*. The challenge with this approach is being able to re-produce the failure from the field so that the problem can be solved. A combination of forensic failure analysis and performance testing can help identify the root cause of the failure.

Failure analysis is using physical, chemical and mechanical testing to determine the root cause of a failure. Failures may involve fractures, malfunction of a component, subsystem or system, visual defect or unexpected behavior of a material. The typical procedure in failure analysis involves inspection (visual, optical microscope, electronic microscope. e.g. fractography), material identification (atomic/molecule, chemical composition, microstructure, contamination, e.g. infrared spectroscopy), property evaluation (chemical, physical, mechanical, thermal, electrical, e.g. tensile test) and cognition.

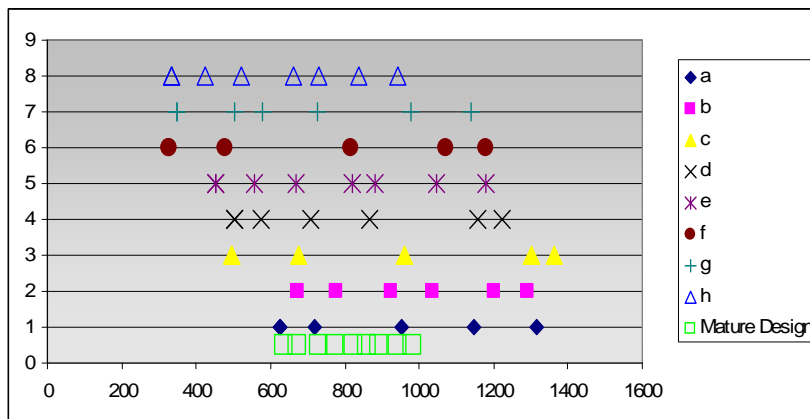
The other way to address warranty is to *prevent* the warranty from happening in the first place. In recent years performance testing and validation planning tools have been able to achieve zero or near zero field incidents on products. Using good performance validation planning tools like DFMEA and Hypothesis Matrix (HM) can insure that no design flaws cause warranty issues and make the product easier to manufacture, reducing warranties due to the manufacturing process.

A Hypothesis Matrix provides:

- 1) A double-check on the brainstorming in the DFMEA – DFMEA is a left-to-right thought process while the HM cross references all potential mechanisms with all potential failures.
- 2) A cross-check of current validation plan and research with the complete hypothesis – exposing duplicate tests and holes in the test plan.
- 3) Identification of the most concise set of tests that satisfies all of the hypothesis.

## 6. Identifying Optimal Design

Reducing cost and increasing margins while preserving a robust design requires optimizing the design. Performance testing can prove if a design change is moving in the correct direction.



Here multiple designs are tested to failure using FMVT. As the design matures the time to failure increases and the spread between different failure modes shrinks.

## 5. Comparing Products - Competing designs within an organization or product line to figure out which is good, better and which is best

These type of performance tests are usually run as a comparison between two or

more products. They can be objective (what is stronger, faster, more efficient) or subjective (“9 out of 10 contractors preferred...”)

#### 4. Comparing Products - Competitive products and supply chain

Just like comparing products with in the company or comparing products to competitors, performance testing can be used to determine which of several competitors will be chosen. Which one is more durable? Which one is more cost effective?



*Night Light comparison testing – which night light is more durable?*

#### 3. Proving Life Estimate

Many performance tests are life tests. These are tests designed to either measure or demonstrate a life. Most life tests to a recognized standard are demonstrating a minimum life of the product under assumed conditions. Some life testing is inferred through comparison testing.

To demonstrate a minimum life, an equivalent life must be determined. For example a button for a cell phone used for texting could be assumed to be pushed 2 times a second for an average of 8 hrs a day for two years (if this seems high its because you don't have teenagers). This represents over 10 million button pushes. Two options: 1) Demonstrate that the button meets a minimum life by pushing 12 buttons for 10M cycles (90 % Reliability with a 70% confidence) or 2) Measure the life of the button by pushing the 12 buttons until at least 3 fail – determining an actual mean time to failure. The buttons could be pressed several times a second reducing the testing time to 90-100 days.

Another method for estimating the life of a product is an accelerated reliability test. In this test, a key stress is raised to accelerate the rate of damage on a key failure mode. For example, temperature on a solenoid may be raised in order to shorten its life. If the acceleration factor is known, the life can be estimated by a single set of samples at a single temperature. If the acceleration factor is not known, then several different elevated temperatures must be used in order to determine the time to failure and the acceleration factor.

## 2. Meeting trade organization marketing requirements/meeting purchasing contract requirements

This is one of the most common reasons for conducting performance testing. Intertek runs over 130 programs for evaluating product to trade organization and government requirements. Independent laboratories are often called “3<sup>rd</sup> party testers.” This is because there is the test laboratory conducting the test, the company or organization setting the requirements and auditing the results and then the manufacturer who actually submits the parts for testing. The business relationship is usually between the manufacturer and the company or organization that is setting the standards. Both parties in the business relationship have a vested, but sometimes competing interest in the testing outcome. The 3<sup>rd</sup> party (the laboratory) is independent and objective. A good 3<sup>rd</sup> party laboratory has only one vested interest – producing accurate results.

## 1. Cost

Cost is the #1 reason for conducting performance testing. Whatever performance testing is conducted, it should be focused on reducing cost. Warranty, Design Optimization, Life Cycle, Weight, Production Cost, Identify Weaknesses and Strengths, New Technology or any other performance test should be used to control costs and improve the full life cycle cost of the product.



*Intertek offers a wide variety of Performance Testing services, including accelerated stress testing, materials testing and failure analysis. For more information on how your organization can implement the Quality & Performance Mark, or for a quote on other Performance Testing services, please contact [icenter@intertek.com](mailto:icenter@intertek.com) or call 1-800-WORLDFAB.*