Reliability Demonstration Testing

June 27, 2012

Amnon Ganot

orbotech. Be Sure™

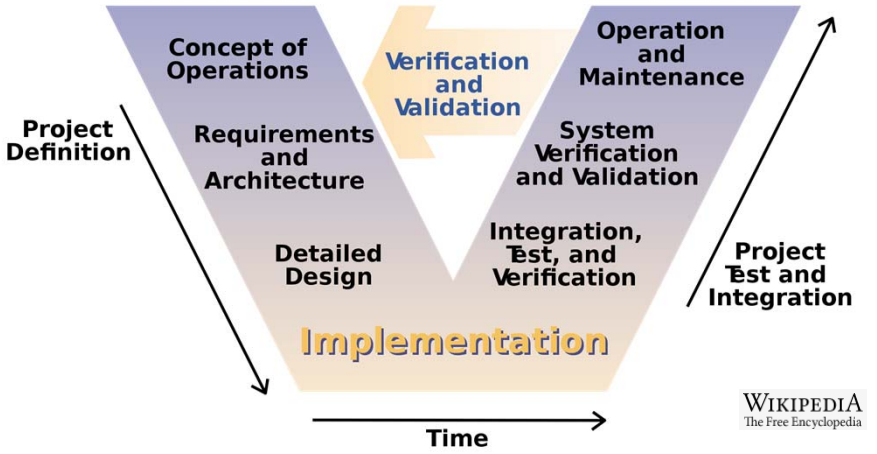
Outline

- The “V” Module
- Quality Definition
- Reliability Definition
- Reliability V&V
- Why Accelerating?
- Types of Accelerated Tests
  - ESS
  - Burn-In
  - Qualitative
  - Quantitative

2

orbotech. Be Sure™

The "V" Module



WIKIPEDIA
The Free Encyclopedia

orbotech. Be Sure™

3

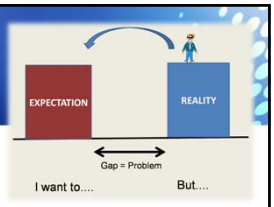
Quality Definition

- Manufacturer Point of View (Objective)
  - As per Taguchi, the quality of a product is the minimum **loss** imparted by the product to the society from the time the product is shipped.
  - *Defining quality as loss is equivalent to defining quality as the number of defective parts, or defining accuracy by way of inaccuracy (e.g., 100mm±1mm).*

orbotech. Be Sure™

4

Quality Definition



- Customer Point of View (Subjective)
  - Quality is conformance to customer **expectations**
  - E.g., we expect a cellular phone to continue working after falling (even though it is not within the spec.)

orbotech. Be Sure™

5

Reliability Definition

- The **probability** that equipment will perform its intended function (**mission**), within stated conditions, for a specified "period"
- Quality over "time"

orbotech. Be Sure™

6

Reliability Vs Quality

- Quality is a snapshot at the start of life and Reliability is a motion picture of the day-to-day operation

orbotech. Be Sure™

7

Reliability V&V

- Quality ⇒ Verification & Validation
- Reliability ⇒ Reliability Assurance Tests

orbotech. Be Sure™

8

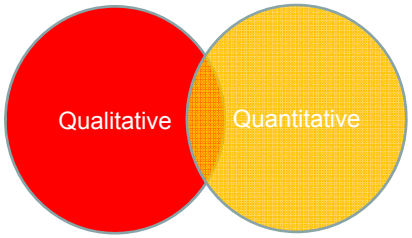
Why Accelerating?

- The amount of time available for testing is often considerably less than the expected lifetime of the component.
- This is certainly true for highly reliable components, for which testing under normal conditions would generate few if any failures within a reasonable time period.

orbotech. Be Sure™

Types of Accelerated Tests

- ESS and Burn-In
- Qualitative Tests
- Quantitative Tests



orbotech. Be Sure™

ESS (Environmental Stress Screening)

- A process involving the application of environmental stimuli to products
- The goal of ESS is to expose, identify and eliminate latent defects which cannot be detected by visual inspection or electrical testing but which will cause failures in the field.
- ESS is performed on the entire population and does not involve sampling

11

orbotech. Be Sure™

Burn-In

- Burn-In can be regarded as a special case of ESS.
- According to MIL-STD-883C, Burn-in is a test performed for the purpose of screening or eliminating marginal devices.
- Marginal devices are those with inherent defects or defects resulting from manufacturing aberrations which cause time- and stress-dependent failures
- As with ESS, Burn-in is performed on the entire population.

12

orbotech. Be Sure™

Accelerated Testing: Qualitative Tests

- An accelerated test that yield Failure Information (for Failure modes) only, is commonly called a Qualitative Test (or Shake & Bake Test, HALT, Elephant Test, etc.).

http://www.infiniteunknown.net/2009/06/25/panasonics-tiger-resistant-laptop/

orbotech. Be Sure™

13

Accelerated Testing: Qualitative Tests

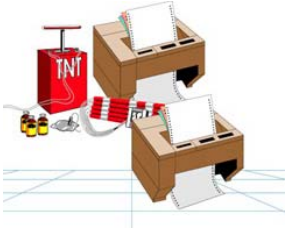
- Overstressing of products to “quickly” obtain failures is perhaps the oldest form of Reliability Testing
- No Life (Reliability) information is usually obtained!

orbotech. Be Sure™

14

What are Qualitative Tests?

- Torture tests are performed on small sizes and the specimens are subjected to a harsh environment (i.e. severe levels of stress).
  - If the specimen survives, it passes the test
  - Torque test data cannot usually be extrapolated to use condition.



15

orbotech. Be Sure™

Qualitative Tests

- Benefits
  - Increase Reliability by revealing probable failure modes
- Unanswered Questions
  - What is the Reliability of the Product?
  - Are the failures modes the same as the ones that will occur during the life of the product under normal use?

16

orbotech. Be Sure™

Why Quantitative ALT?

- To be able to quantify the life characteristics of a product in a shorter time
  - If you are warranting a product for 5 years and it has a 12 month development cycle, you can't afford the time to do life tests under usual conditions

17

orbotech. Be Sure™

Quantitative Accelerated Life Testing

- Quantitative Accelerated Life Testing, unlike the Qualitative Testing, is designed to provide Reliability information on the product, component or system

18

orbotech. Be Sure™

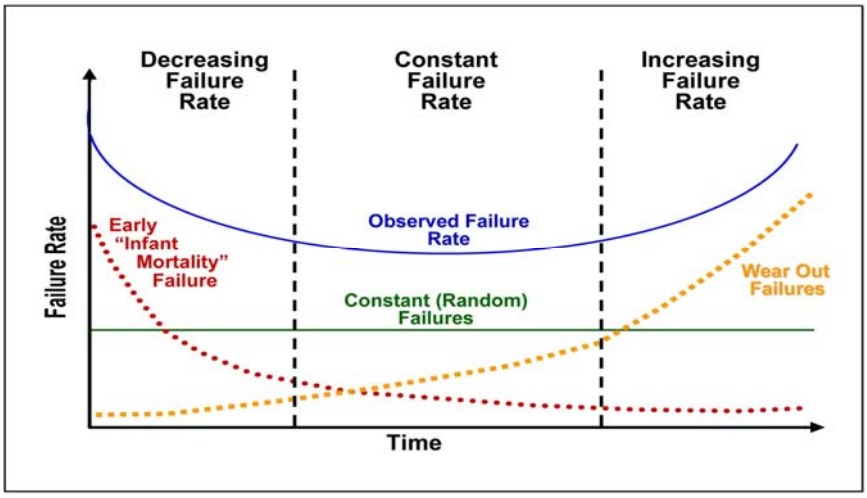
Data needed: Time-To-Failure Data

- Time-To-Failure can be in any quantitative measure, such as hours, days, cycles, miles, actuations, etc.

19

orbotech. Be Sure™

Product/System Failure Rate



20

orbotech. Be Sure™

Acceleration Means

- In order to accelerate the test, one or more of the following may be necessary:

Action	*MTBF*	*LE**
Increase the number of units on test	✓	✗
Accelerate the number of cycles per unit of time	✓	✓
Increase the stresses that generate failures (accelerated stress testing)	✓	✓

* Life Expectancy

21

orbotech. Be Sure™

"Usage Rate Acceleration" or "Continuous Use Acceleration"

- Easiest and most common form of Accelerated Life Testing is "Continuous Use Acceleration"

Average Use – 10 hours a week!

1 Week = 168 hours

Possible Acceleration Factor = 16

22

orbotech. Be Sure™

The Problem with "Continuous Use Acceleration"

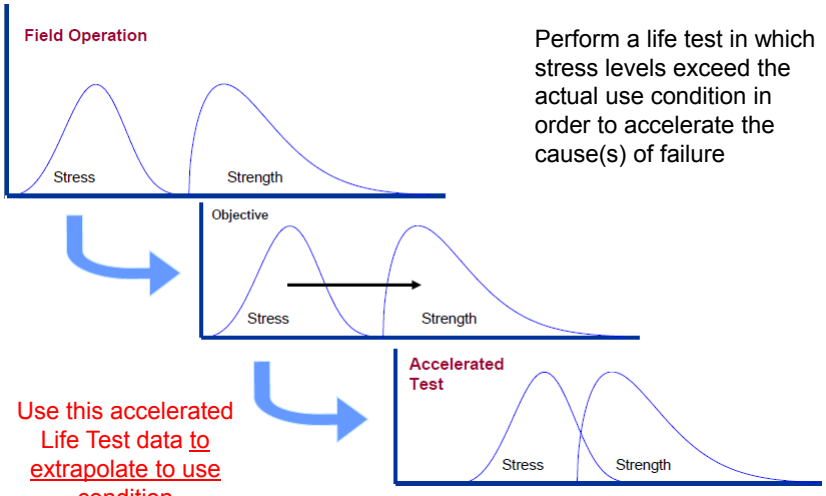
- How do you accelerate "High Usage" product?
  - Many product have a very high (even continuous) usage rate such as TV's, computers, alarm systems, etc.




23

orbotech. Be Sure™

Objective of Increasing Stress in an ALT



Perform a life test in which stress levels exceed the actual use condition in order to accelerate the cause(s) of failure

Use this accelerated Life Test data to extrapolate to use condition

24

orbotech. Be Sure™

Typical Test Acceleration Parameters

- Temperature
- Humidity
- Voltage, Current
- Vibration
- Temperature Cycling
- Power Cycling
- Contamination Level
- Force, Load, Pressure
- Combination of the above

25

orbotech. Be Sure™

Stress Levels

- The test stresses should be chosen so that they accelerate the failure modes under consideration.
- Test Stress levels should be chosen so that do not introduce failure modes that would never occur under use condition (i.e. material phase change).

26

orbotech. Be Sure™

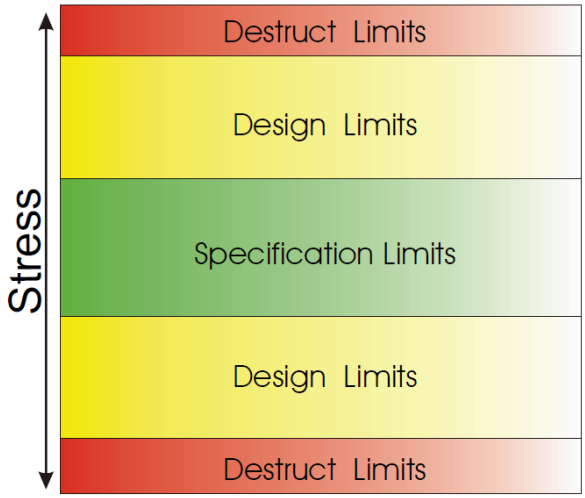
No Free Lunch

- Stress levels must be high “enough” so that enough failures are observed within the allowable testing time.
- The higher the accelerated stress from the operating stress, the greater the uncertainty of the extrapolation.

27

orbotech. Be Sure™

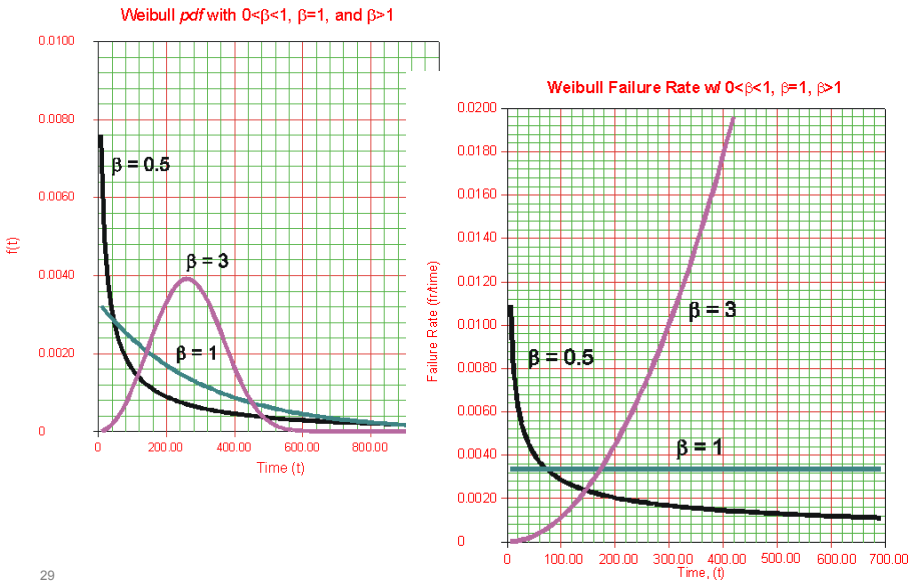
Stress Levels



28

orbotech. Be Sure™

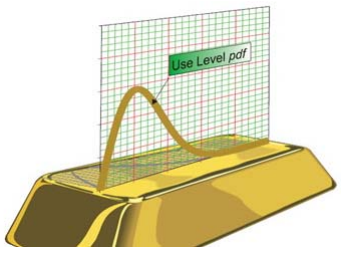
The Weibull Distribution



29

Understanding Accelerated Life Test Analysis

- Estimate life distribution of the product in a shorter time.

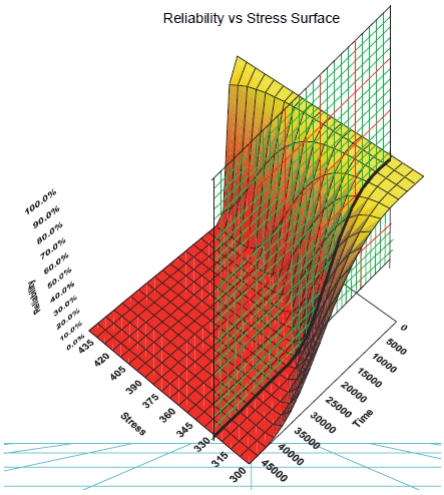


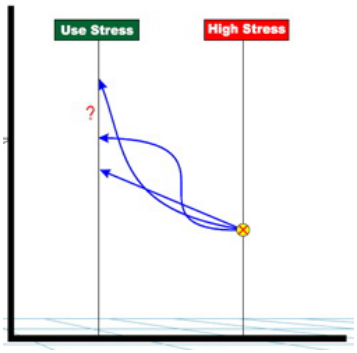
- ✓ Percent falling under warranty
- ✓ Assess risk
- ✓ Compare designs
- ✓ Determine wear-out period (product performance degradation

30

orbotech. Be Sure™

Understanding ALT – Looking at a Single Constant Stress ALT



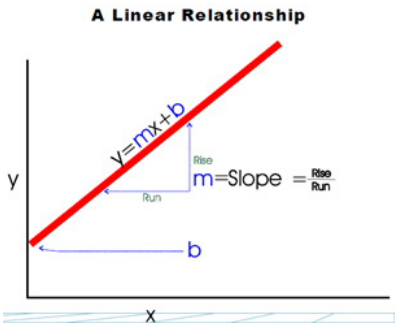


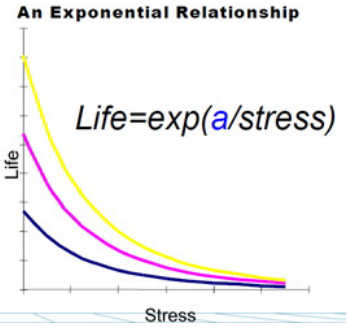
31

orbotech. Be Sure™

Determine a Relationship between "Test Stresses" and the "Use Stresses"

- Use a Mathematical Model to describe the relationship ($y = mx + b$ is a simple Linear Model).





32

orbotech. Be Sure™

Determine a Relationship between "Test Stresses" and the "Use Stresses"

- The more points we have, the better off we are in correctly determining the Life-Stress relationship (fitting the model to our data).

33

orbotech. Be Sure™

Reliability Information

- Once the parameters of the underlying life distribution and stress-life relationship have been estimated, a variety of reliability information about he product can be derived such as:
  - Warranty time
  - The instantaneous failure rate which indicates the number of failures occurring per unit time.
  - The mean life which provides a measure of the average time of operation to failure.

34

orbotech. Be Sure™

Acceleration Models

"All models are wrong, but some are useful…"

George Box

orbotech. Be Sure™

35

Questions?

orbotech. Be Sure™

36


Thanks for your attention
37
orbotech.
Be Sure™