Package Integrity Testing: Common Tests and Applications

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- What is Package Integrity Testing
- What are the Functions of a Package
- Review of Common Test Specs
- The Distribution Environment
- Package Design vs. Distribution Environment
- Critical Elements of Package Integrity Testing
- Package Integrity vs. Package Performance Testing
- Interpretation of Results
- Benefits of Package Integrity Testing
During the early years, the most typical type of “package testing” was to ship the package via UPS through the Chicago hub.

By the mid-1950’s considerable effort was directed towards what the actual shipping environment consisted of.

Studies were initially conducted by the military.

In the late 1970’s, General Technical Report FPL-22 was published by the Forest Products Laboratory at the University of Wisconsin.
  – These studies looked at drop height, vibration, temperature, humidity and pressure hazards in the shipping environment.

Later studies were then conducted by NSTA (now ISTA) and ASTM
  – These organizations are actively reviewing data on the environment.
Before we continue, let’s look at the basic functions of a package:

• Containment
  – Contain and brace product in order to get it to its destination

• Protection
  – Protect the product from the environment
  – In some cases, protect the environment from the product

• Communication
  – Product description, marketing, nutritional information, etc.

• Convenience / Utility
  – Easy access to the product such as a cereal box, soda bottle, and so forth
Package design is a function of the quantified distribution environment:

- Protective packaging is designed to attenuate transmitted deceleration levels during impacts.
- Protective packaging is engineered to attenuate the product resonance as associated with various modes of transportation.
- Protective packaging can be designed to keep tight temperature control of its contents.
- Protective packaging can be designed to protect against spills from possible hazardous materials contained within.
- Protective packaging can be designed with optimal headspace to protect against short-term and long-term stacking.
The distribution environment has already been defined

- During the initial qualifications, ride-recorders using tape were utilized to measure the vibration
- Mapping the distribution environment has come a long way since those days.
- Environmental data recorders these days can:
  - Measure shock
  - Calculate drop height
  - Calculate the Shock Response Spectrum (SRS)
  - Measure vibration
  - Calculate the Power Spectral Density (PSD)
  - Measure temperature
  - Measure humidity
  - Measure Altitude
  - Have GPS capabilities
These systems are:

- Self-contained
- Utilize a tri-axial accelerometers
- Have internal temperature/humidity and altitude sensors
- Can record and store data for up to 90 days at a time

Current EDRs *

* SAVER 3X90, 9X30 and 3M by Lansmont Corporation
• Data gathered using such ride recorders is then compiled and time-compressed.

• Time compression: The test intensity is increased in order to shorten test time

• A formula that has been used in the past for time-compression of vibration is:

\[ \text{Test Level} = \text{Field Level} \times (\text{Field Time}/\text{Test Time})^{1/2} \]

Where:
- **Test level** is the G rms intensity level of the laboratory test
- **Field level** is the G rms intensity of the recorded data from the vehicle
- **Field time** is the time of the trip anticipated from source to destination
- **Test time** is the duration of the laboratory simulation required to duplicate the field test at the laboratory test level

* Reference: Dennis Young, ISTA
Once the data has been gathered and analyzed, it is put in a sequence of test inputs similar to what is encountered during the distribution environment. This document is referred to as a test standard.

**Common used test standards in the industry:**

- **ASTM D4169**
  - Recognized by the FDA, based on data initially gathered from the environment, long standing history
- **ASTM D7386**
  - Recognized by the FDA, based on more recent studies gathered by UPS
- **ISTA 2A**
  - Partial simulation test, as with ASTM D4169 it is based on older environmental data
- **ISTA 3A**
  - General simulation and based on more recent data, very similar to ASTM D7386
- **ISTA 2B/3B/3E**
  - Used for large packages, pallets, unitized loads and crates
- **TelCordia**
  - Used for the telecommunications industry
- **Mil-STD**
  - Old data gathered by military, the package testing portion of this standard is very simple as a lot of over-design goes into the actual product design.
Critical Elements of a Package Integrity Testing are:

- Climatic Conditioning
- Temperature and humidity extremes that may be encountered during severe climates

- Typical test standards that apply
  - ASTM D4332
  - ASTM F2825
  - ISTA 2 and 3 series
  - ISTA 7D

Environmental Test Chambers
Critical Elements of a Package Integrity Testing are:

- Impacts – caused by drops, kicks, conveyor diverter arms, and other packages falling on top
- Common test standards that apply:
  - ASTM D5276 (general test method)
  - ISTA 1 series
  - ISTA 2 series
  - ISTA 3 series

Impact / Drop Test
Critical Elements of a Package Integrity Testing are:

- Vibration – caused by shipment via truck, rail or aircraft. Unlike other elements, vibration is guaranteed to occur 100% of the time packages are transported.

- Common test standards that apply:
  - ASTM D4728 (general test method)
  - ISTA 1 series
  - ISTA 2 series
  - ISTA 3 series
Critical Elements of a Package Integrity Testing are:

- Stacking (Compression) – Static or dynamic.
  - Can occur in a moving vehicle or in a warehouse

- Common test standards that apply are:
  - ASTM D642 (general test method)
  - ISTA 1 series
  - ISTA 2 series
  - ISTA 3 series
Critical Elements of a package integrity testing are:

- Altitude – Aircraft (most aircraft are pressurized to 8,000 feet) and truck routes along high-mountain roads (over 9,000 feet)

- Common test standards that apply are:
  - ASTM D6653
  - ISTA 3 series

Temperature / Altitude Test Chambers
Package Performance vs. Package Integrity Testing

Package Performance Testing

- Quantitative
- Measures actual performance of a package with the aid of accelerometers
- Used to optimize a package design
- Sample size is typically 1
- [www.westpak.com/page/Packaging](http://www.westpak.com/page/Packaging)

Package Integrity Testing

- Qualitative
- Pass/Fail Test
- Used to validate a package system
- Usually larger sample sizes are utilized

“West Lab” at Westpak, San Jose, CA
Sample Size

Determining sample size for Package Integrity Testing

• Attribute vs. Variable

• Attribute sampling
  • This strictly a acceptable/non-acceptable (or pass/fail) evaluation
  • Much larger sample sizes
    • Sample size = \[\frac{\ln (1 - \text{desired confidence})}{\ln \text{desired reliability}}\]
      • i.e. for a 95% confidence / 95% reliability, sample size = 59

• Variable sampling
  • A quality characteristic or point of interest of a package system is measured and averaged
  • Smaller sample sizes are generally used
  • Sample sizes can be whatever is needed to give a “good average”
Advantages

- Replicate mean and extreme values in regards to quantified hazards in the distribution environment (bring the environment into the lab)

- Repeatable

- Time savings – speed at which tests can be conducted

- Cost savings – product damage, lost business, negative consumer image
So how do we know when we’ve done it right?

• Set acceptance criterion prior to testing
  – Product functionality
  – Cosmetic damage
  – Excessive package wear (structural integrity, graphics, etc)

• Evaluate results based on that criterion
Questions?
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Thank you!

Please feel free to Contact Us with any questions or assistance with your testing needs.

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