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Trends Article

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Trends in Distribution Simulation Testing

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Abstract Packaged-product distribution simulation tests are most effective when the damage assessment made from actual supply chain and after laboratory testing achieves high correlation. In order to create effective distribution tests, clear understanding of the distribution environment must be developed and documented. This can be achieved by "*walking the system*"; making direct observations from within various distribution channels. Challenges associated with thorough and complete supply chain access limits the overall effectiveness of walking the system. One way to address those challenges is to use non-intrusive portable data recorders that can travel within the global supply chain, measuring critical distribution hazards such as shock, vibration, compression, temperature, humidity and other valuable information. This article details trends associated with the growth of advanced simulation testing based upon measured data from within the supply chain.
Keywords *Distribution; Simulation; Data Recorder; Packaged Products; Vibration Testing*

1. Introduction

Controlled packaged-product distribution testing has been taking place for more than sixty-five years. In the early 40's Westinghouse Electric's major appliance division began vibration and incline impact testing. Because of rising damage levels, the Porcelain Enamel Institute accepted an offer in 1948 from Westinghouse to publish their testing procedures under a banner called the National Safe Transit Committee. In 1958 that committee became known as the NSTC, Inc., and National Safe Transit Association (NSTA) in the mid-1970s, before adding two more test procedures to their offerings in 1984.

Those simple, but effective test procedures are still in use today, however over the past 20 years or so, distribution testing has progressed from what was more general and robust, to more focused and tailored simulation. In the mid-1990s, NSTA's board began to pursue a more global presence due to the changes in the global economy and supply chain. NSTA became the International Safe Transit

Association (ISTA) and since 1996, ISTA has expanded from 4 published US test procedures to 22, developed with global input and performed thousands of times annually around the world.

2. Current and Future Practices of Distribution Simulation Testing

All that new development has taken place in the areas of general and focused simulation, with test procedures for Small Parcel Simulation [1], Club Store Distribution Simulation [2], Fast Moving Consumer Goods [3] and ISTA's 4AB [4], which is a web-based application that allows users to build and select their testing procedures based upon their ability to map out their known distribution channels.

Global sustainability initiatives have demanded more responsible package design, focusing on material reduction, reuse, and recycling. Less packaging is typically considered "better", however reductions of protective packaging may cause more susceptibility to distribution hazards such as shock, vibration or compression. Thorough distribution testing becomes even more critical in qualifying proposed sustainable packaging solutions.

***Figure 1**: Damaged Corrugated Container Due to Reduction in Structural Material Used*

As a rule, distribution testing should be representative of the hazards your products will encounter when moving through the supply chain. The more you know and understand about the hazards in your environment(s), the more likely you'll succeed at protecting against them. Lack of knowledge causes one to err on the side of caution. In terms of distribution testing, that means using test procedures that are general in nature, and more robust in their intensity. That may be counterproductive to sustainable packaging initiatives. More robust testing probably requires more (*not less*) packaging materials to adequately protect the product.

***Figure 2**: The More You Know About the Supply Chain, the Better You Can Simulate it in the Lab*

Technological advances and a global thirst for knowledge have facilitated a growing repository of distribution hazard metrics and understanding. Portable data recorders can be configured to capture time-stamped, shock, drop, vibration, force, temperature, humidity and atmospheric pressure data, providing valuable record as to the hazards present within the supply chain. These data recorders are routinely mounted to transport vehicles and within transport packaging, some traveling on 60 day-plus international journeys, all in an effort to document the dynamic and climatic hazards present in any number of distribution channels.

***Figure 3**: Installing a Data Recorder on the Floor of a Truck Trailer for Distribution Measurement*

By developing this clear and concise understanding of ocean, air, truck and even intermodal transport distribution, testing can be developed to simulate those environments. Statistically valid summaries of the data are used to subsequently build handling, storage, transport and even climatic conditioning profiles. ISTA provides its members with documentation, such as their **ISTA Field Data Requirements** (published 2008, revised 2009), intended to give members guidance on how properly configure, record and analyze field data. Using these guidelines, ISTA has created their “Data Depot”, archiving transportation/distribution environment information that they use to develop or enhance their published standards. International research working groups continue to look at improved, consistent methods of capturing this distribution data such that capable instruments can be used globally to develop industry test methods.

As our collective understanding of the distribution environment continues to grow, our ability to simulate those characteristics has improved as well. Measurements made during truck accelerating, braking and turning maneuvers has resulted in both test procedures and laboratory equipment that are used to specifically predict unit load stability. In 2012, The Fraunhofer Institute, located in Dortmund, Germany commissioned Lansmont Corporation to build the first ever, Load Stability test system. The Dortmund based Fraunhofer Institute specializes in research and expertise associated with load securement solutions. It was imperative that their test system possessed the exact time-history characteristics associated with emergency truck maneuvers such as braking, accelerating and turning.

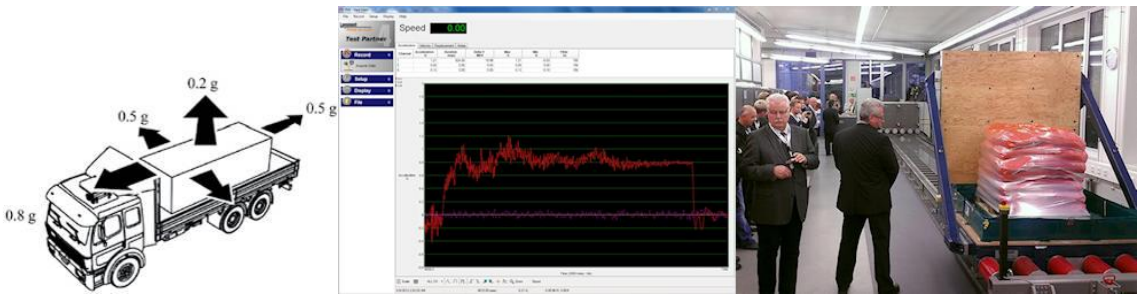

***Figure 4**: (a) Typical Forces Experienced Due to Braking, Accelerating and Turning, (b) Load Stability Test System Installed at Fraunhofer Institute in Dortmund, Germany*

ISTA currently has a Load Stability Workgroup that has been tasked to develop and incorporate the first-ever, specifically targeted load stability tests into their general simulation test series. ISTA members can inquire about opportunities to participate in this Working Group by contacting A.J. Gruber, ISTA's Vice President of Technical, at ajgruber@ista.org.

Concurrently, efforts within ASTM D10 are in process to update the random vibration profiles in D4169 [5]. It's widely accepted that the existing profiles are overly severe and not representative of today's over-the-road, rail or air transport environments. Representative transport data is being analyzed to determine the most relevant spectral shapes, intensities while also addressing overall test duration.

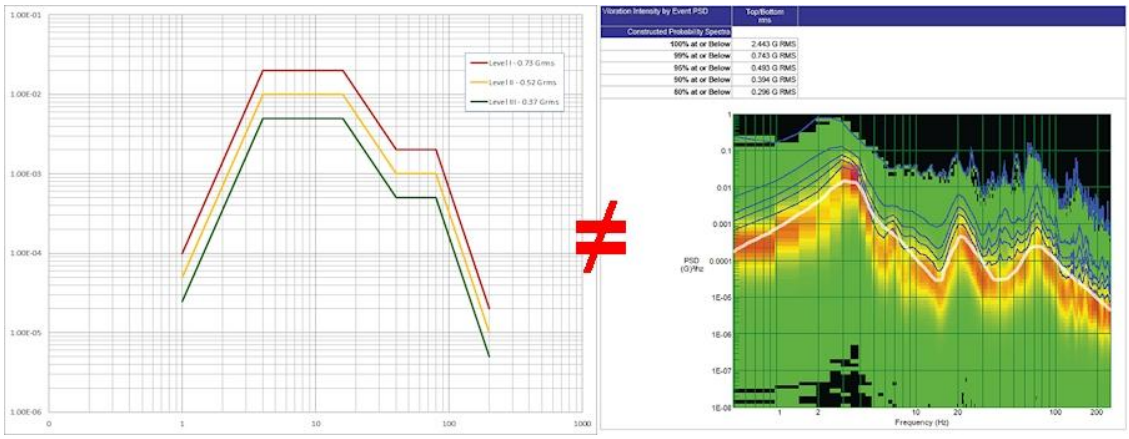

Figure 5: *Comparison of ASTM Truck Spectra (Levels 1-3) and Recently Measured Vibration Spectra from Multiple Over-The-Road Truck Trailer Shipments*

Other groups such as the Distribution Working Group within the International Association of Packaging Research Institutes (IAPRI) [6] continue with their efforts to document advanced vibration testing methodologies, such as time-history replication and multi-axis testing. Trucks and trains shake not only up-and-down, but also side-to-side, while rolling back and forth and pitching forward and backward. If packaged products are susceptible to those dynamics, it might make sense to selectively use that field measured data to drive that appropriate method of testing in the laboratory.

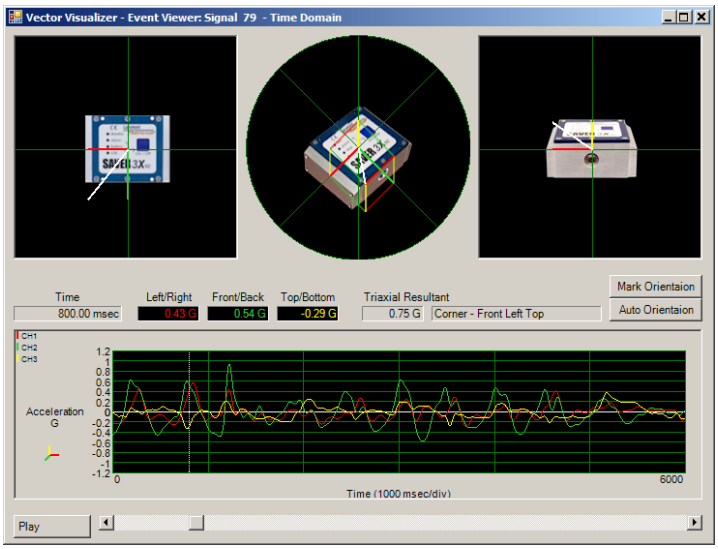

Figure 6: *Measured Time-History Event, Showing the Multi-Axis Energy Characteristics of the Event Itself*

Medical and pharmaceutical packaged products must comply with regulatory requirements that provide general, but stringent guidance, dictating “Each manufacturer shall ensure that device packaging and shipping containers are designed and constructed to protect the device from alteration or damage during the customary conditions of processing, storage, handling, and distribution” [7]. Many medical device and pharmaceutical manufacturers have consequently found it in their best interest to prove that their packaged-product testing practices are representative of the real world, by establishing measured, defendable evidence of their test procedure development process.

3. Conclusion

A documented, comprehensive understanding of specific distribution channels can provide the ability to tailor packaged-product distribution simulation such that any damage assessment performed after laboratory testing will achieve better correlation with results as measured from within the supply chain. Global, relevant testing organizations such as ISTA and ASTM are focusing their development efforts on advanced simulation tests, reducing the levels of over-testing that is generally accepted to be prevalent in many current, common test procedures.

References

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[2] ISTA Project 6-SAMSCLUB, 2010: Packaged-Products for Sam’s Club® Distribution System Shipment, International Safe Transit Association, East Lansing, MI.

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[5] ASTM Standard D4169, 2008: Standard Practice for Performance Testing of Shipping Containers and Systems. ASTM International, West Conshohocken, PA.

[6] International Association of Packaging Research Institutes (IAPRI), www.iapri.org, as of January 13, 2014.

[7] Code of Federal Regulations (CFR) Part 820, Section 130 – Device Packaging, as of January 13, 2014.