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ASTM D4169: A Historical Perspective, Plus Review and Implications of D4169-16

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Agenda

1) ASTM D4169 - Historical Perspective
   - Review of Protective Package Testing Protocols, pre-ASTM D4169
   - Overview and Significance of D4169's Initial Release
   - Comments on Test Industry Acceptance of the Original Document

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Agenda (cont.)

2) ASTM D4169-16

- Overview and Significance of D4169-16
- Comparison of Test Inputs D4169-14 vs D4169-16
  - What Changed, What Didn't, and Why
- Commentary on the –16 Revision
- Steps To Take if Products or Packages Fail the –16 Revision

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Protective Packaging Test Protocols pre-ASTM D4169

1950's (and prior)

- NSTA 1 & 1A
  - Dated, often used but seldom validated, used unrealistic test methods & procedures….
- FED-STD-101: Test Procedures for Packaging Materials
  - Probably initiated in the '50s, widely used for military hardware, revised 3 times until the mid '80s, folded into MIL-STD-3010
- MIL-HDBK-304: Package Cushioning Design
  - Originally an Air Force doc, good information but not widely used

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Protective Packaging Test Protocols pre-ASTM D4169

1960's

- Advent of ***"Scientific Packaging"***
  - MSU's School of Packaging - Dr. Jim Goff
  - Application of military methods & procedures to commercial products
  - Damage Boundary shock testing: ASTM D3332
  - Vibration test methods & design procedures: ASTM D3580 & similar

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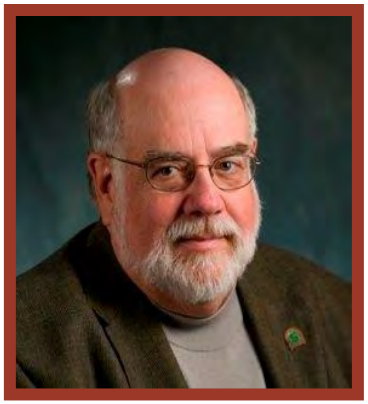
THE SCHOOL OF PACKAGING
MICHIGAN STATE UNIVERSITY

Protective Packaging Test Protocols pre-ASTM D4169

1970's

- Work begins on the 1st "Pre-Shipment Package Performance Test Protocol"
  - ASTM D10.21 Subcommittee known as "The Ostrem Group"
  - Core members: Fred Ostrem, Dunc Godshall, Sergei Guins, Dennis Young, Bob Fiedler
  - Lots of give & take, "fervent" exchange of ideas
  - Ten years of investigation & negotiations
  - Breakthrough was the 2+ hour phone call: Godshall & Young
  - Draft document survived the scrutiny of the entire D10 Committee, required for a "consensus" document



D. E. Young

Bob Fiedler

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Significance of D4169's Initial Release

1980's

Here is what this document meant to the Package Testing community:

- A good understanding of how a packaged product will arrive at a customer's location ***prior to shipment***
- A scientifically valid method of *bringing the distribution environment into the test laboratory*
- A test protocol based on other existing documents that didn't require any new or non-existing equipment, documents, or procedures

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Significance of D4169's Initial Release

1980's (cont.)

- A method of handling the wide variations in product sensitivities, distribution environment variables, identification of "hazards", proper sequencing of hazards
- Procedures for dealing with vastly different transportation vehicles and lading on those vehicles
- A true consensus document satisfactory to (fussy) gov agencies (FDA, etc.)

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Industry Acceptance of D4169

1982

- Acceptance was immediate and almost overwhelming (!)

- Huge affect on packaging materials, designs, etc.
- Opened new doors to marketers using the package as the primary product selling agent

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D4169 Brief Change History

ASTM D4169-82

- Early history & revisions:
  - First printing: 1982
  - First revision: 1984
  - Second revision: 1986

7 pages, 17 DCs, 11 ref Docs, 9 Hazard Elements, 3 ALs, sine sweep vibration

D4169: Brief Change History

Rev	Pgs	DCs	Ref Docs	Hazard Elements	ALs	Vibration	Significant Changes
-86	7	17	11	9	3	Sine Sweep, 3 ALs, 180 min	Editorial
-88	8	18	11	8	3	Random, 3 veh, 3 AL's 180 min	Added Random, DC 18 (Gov proc)
-99	11	18	14	8	3	Random, 3 veh, 3 ALs, 180 min	
-01	11	18	14	8	3	same	Editorial…
-04a	12	18	15	9	3	same	Add Alt. test, DC2 test plan exam in Appendix
-05	12	18	16	9	3	same	Fork lift handling

19 years

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D4169: Brief Change History (cont'd)

Rev	Pgs	DCs	Ref Docs	Hazard Elements	ALs	Vibration	Significant Changes
-08	14	18	20	10	3	Same - Random	Added Conc. Impact D6344, mod FL Handling, editorial
-09	15	18	20	10	3	same	Mod to DC 18, other edit changes
…	…	…	…	…	…	…	…
-14	16	18	21	10	3	same	# of impacts, 3 axis vibe, other editorial
-16	17	18	21	10	Vibe portion changed	All truck profiles changed	Added summary of changes from previous version

8 years

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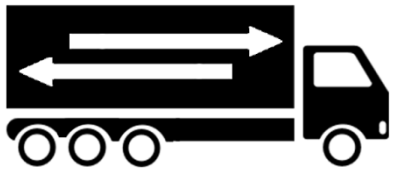

QUESTIONS

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ASTM D4169-16: Why the Change?

- The 2016 version is the latest step in the ongoing evolution of laboratory simulation testing of products and their protective package systems.

Hydraulic Vibration Machines – WESTPAK, San Jose, CA

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ASTM D4169-16: Why the Change?

- With the increased availability and lower costs of data recorder equipment, we have a much better understanding of the stresses products and packages are exposed to in the distribution environment.
  - This increased understanding has been reflected in past revisions of various package and product test protocols.
- ASTM D4169 had not changed their vibration profiles in so long that many considered them to be “settled science” when in fact, they weren’t.

ASTM D4169-16: Why the Change?

Bill Kipp, speaking in 2008 ……

"Too many times we hear, 'I don't understand it - we passed all the lab tests, but we're still having problems in the field.'

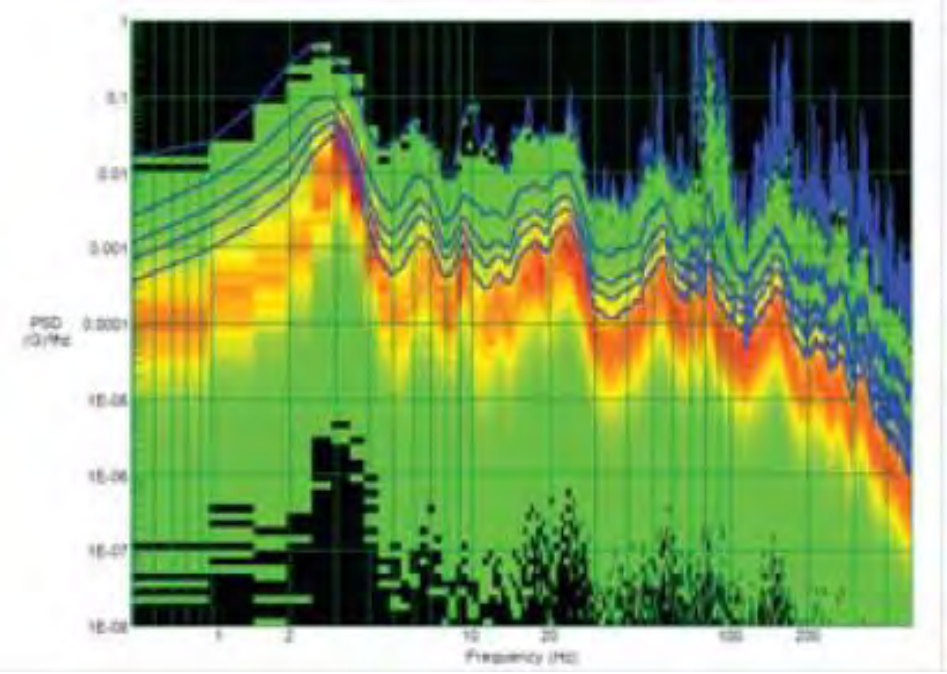
Then the tests are wrong!

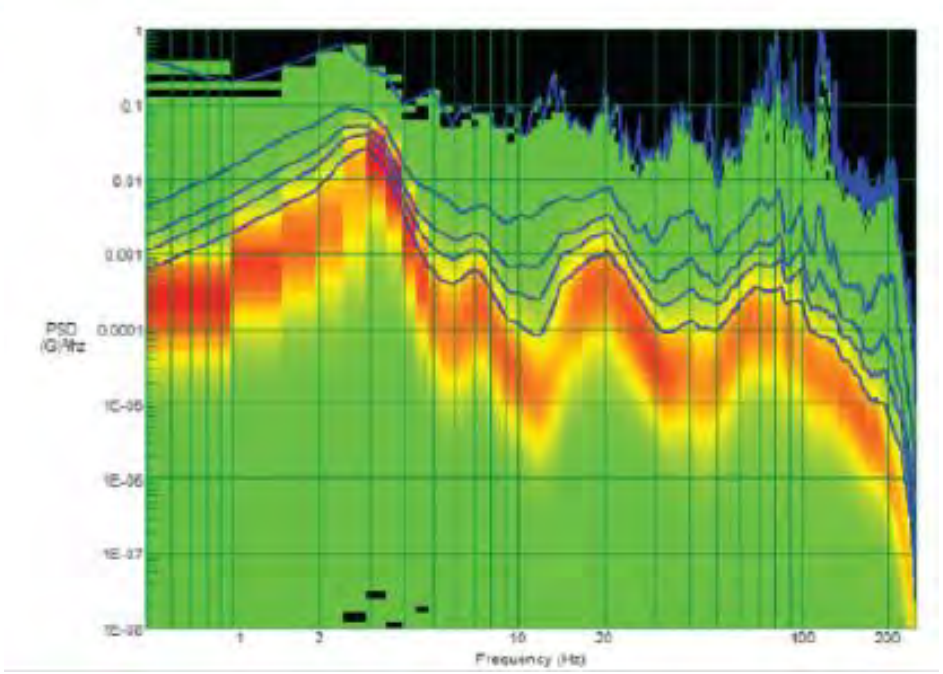
The opposite can also happen, 'We don't have any damage in shipment, but we can't pass the laboratory tests.'

Then the tests are wrong!"

Bill Kipp

ASTM D4169-16: Why the Change?





Here are just two examples of what real-life vibration looks like on American roads:

- These plots are compilations of multiple recordings of shock and vibration in transit.
- Green signifies that a particular event occurred at that frequency/severity.
- Yellow indicates more events occurred at those frequencies/severities.
- Orange/red shows where the majority of events occurred. Note similar waveforms.

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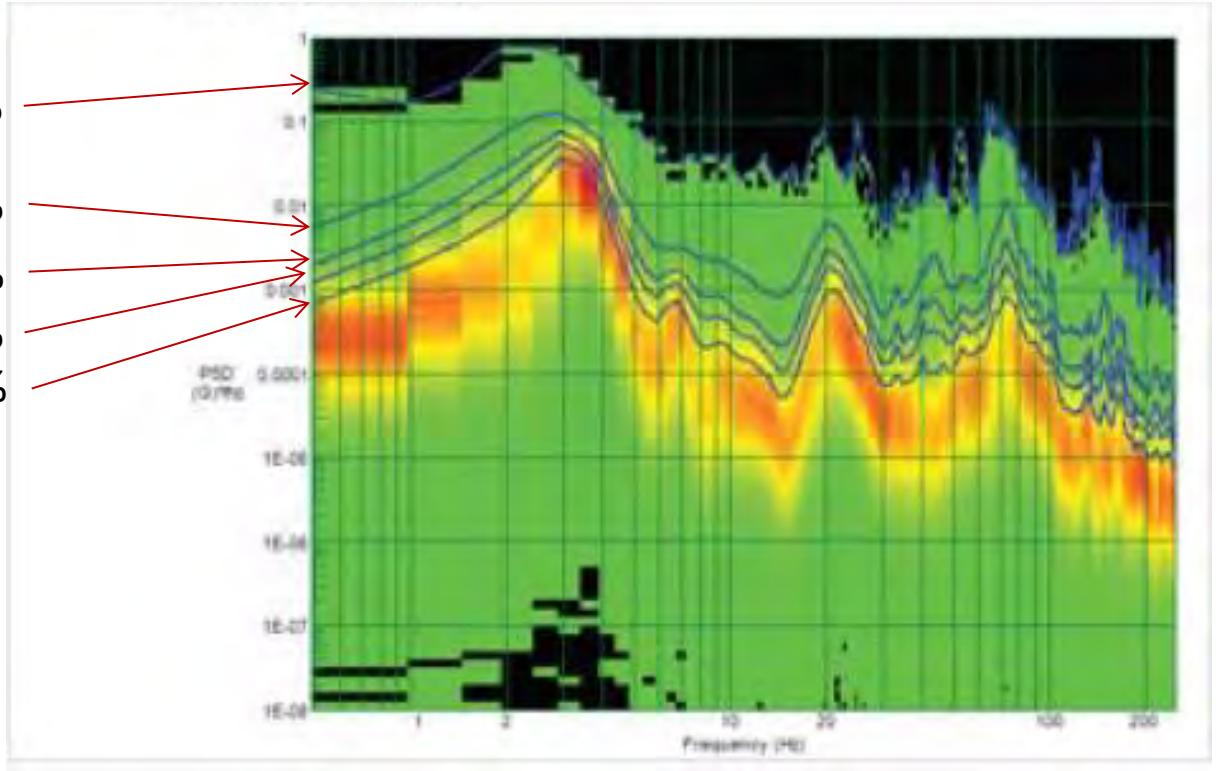
ASTM D4169-16: Why the Change?



- The blue lines on these graphs indicate the probability of a particular vibration event. The top blue line represents that 100% of all events occurred below that level.
- Working down, the blue lines below it indicate 99%, 95%, 90% and 80% probabilities of occurrence.

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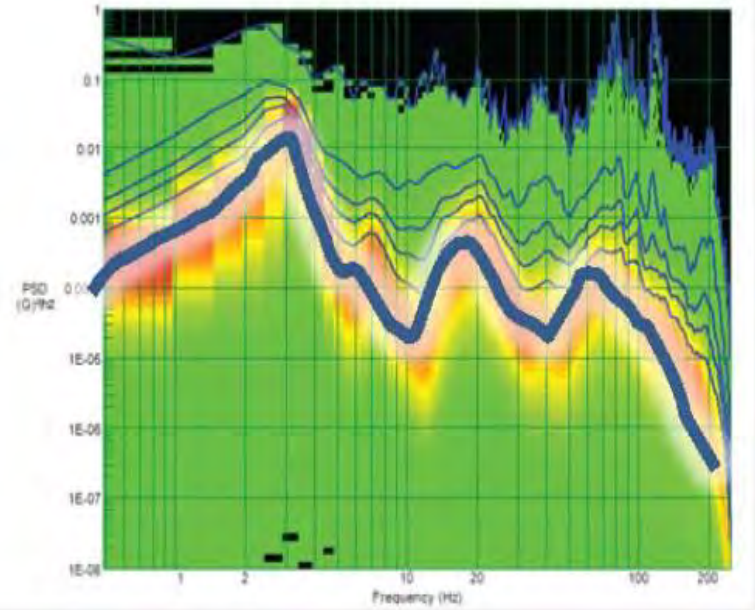
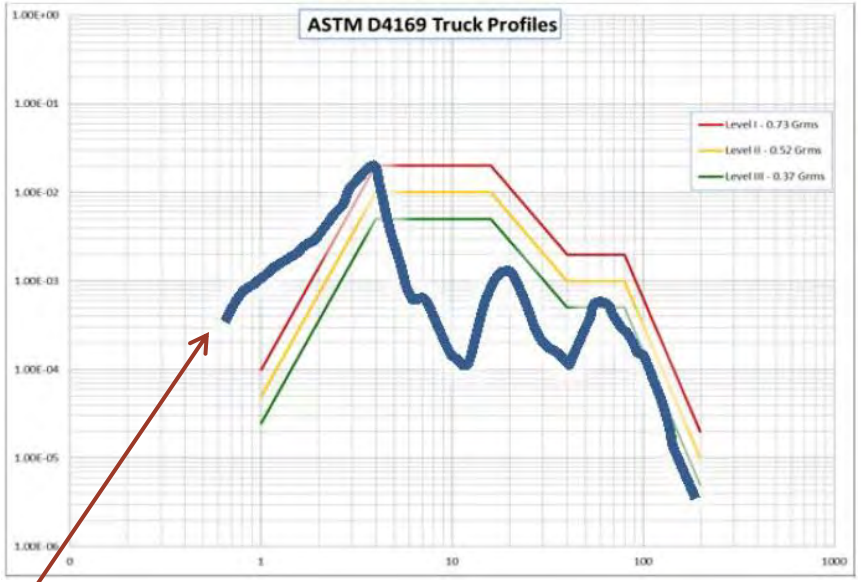
ASTM D4169-16: Why the Change?





In a nutshell, this is why the change was made:

- When comparing the average intensity of real-world truck transportation (the thick blue line) against the “classic” ASTM truck profiles (red, yellow and green lines), the mis-match is quite obvious.

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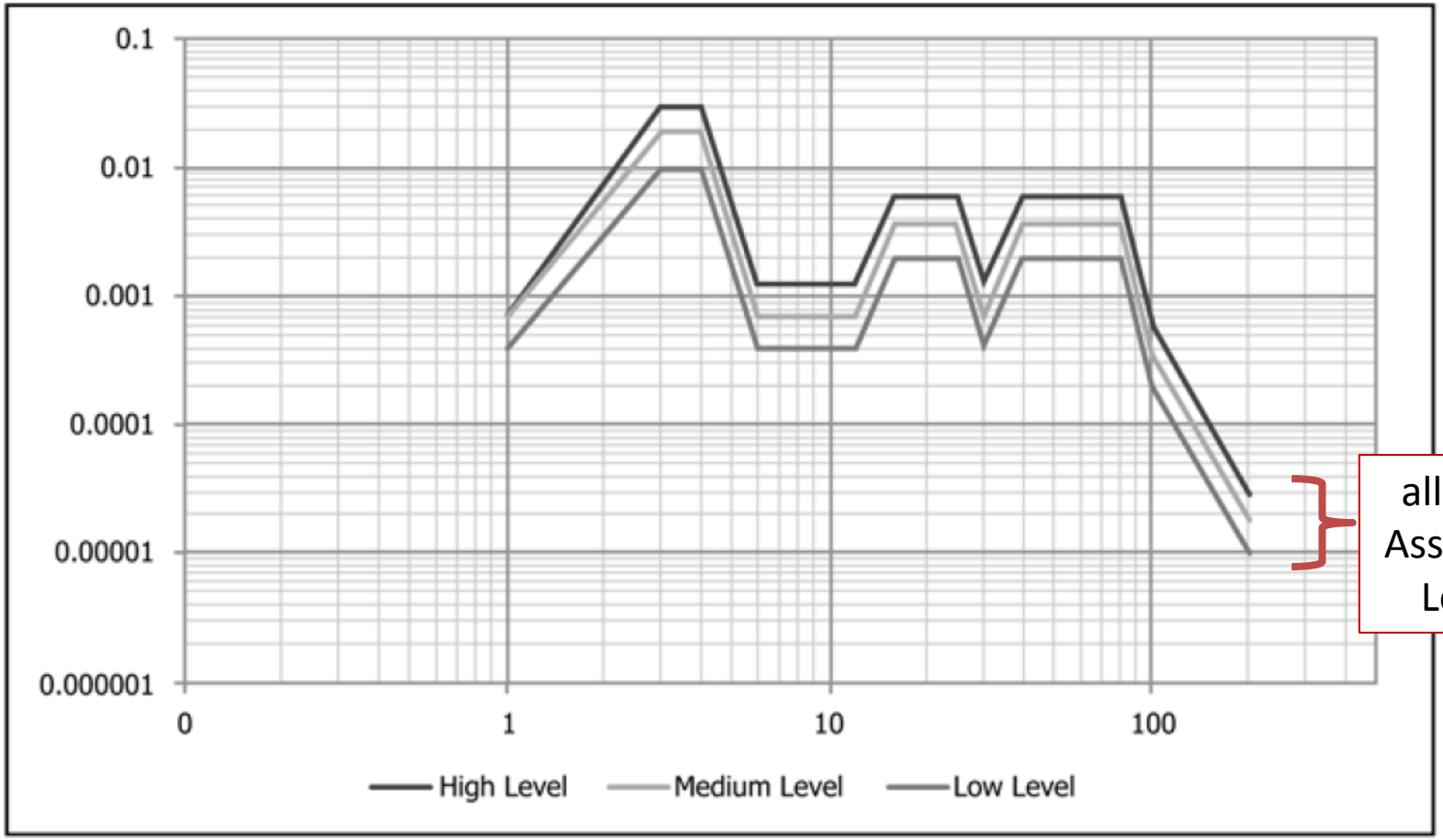
What Is the Change?

New Combined Truck Spectrum Vibration: Does it look a bit more familiar now?



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Where Are My Assurance Levels?

- The new spectrum combines all three Assurance Levels
  - Based on the spectrum found in existing test procedures ASTM D7386-16 & ISTA 3A.

- The goal is to more closely model “real-world” vibration actually encountered and measured on US and European roads.
  - Builds on the work of Bill Kipp, ASTM Committee D10, & ISTA.

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ASTM D4169-16 Truck Vibration Changes *

ASTM D4169-**14** DC3

- 180 minutes divided amongst all possible shipping orientations
  - 60 minutes per axis
- Profile based on Assurance Level I, II, or III

Truck:

	Power Spectral Density Level, g^2/Hz		
	Assurance Level	Assurance Level	Assurance Level
Frequency, Hz	I	II	III
1	0.0001	0.00005	0.000025
4	0.02	0.01	0.005
16	0.02	0.01	0.005
40	0.002	0.001	0.0005
80	0.002	0.001	0.0005
200	0.00002	0.00001	0.000005
Overall, g rms	0.73	0.52	0.37
Duration, min[B]	180	180	180

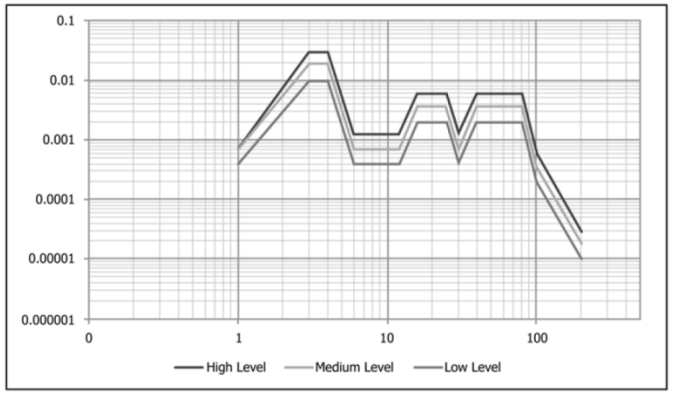
ASTM D4169-**16** DC3

- 180 minutes divided amongst all possible shipping orientations
  - Up to 3 axes
- All the following High, Medium, and Low level Truck profiles tested (no assurance levels)
  - Low Level: 120 minutes (40 minutes per axis)
  - Medium Level: 45 minutes (15 minutes per axis)
  - High level: 15 minutes (5 minutes per axis)

TABLE 2 TRUCK—Power Spectral Density Levels

Frequency	Power Spectral Density Level, G^2/Hz		
	High Level	Medium Level	Low Level
1	0.00072	0.00072	0.0004
3	0.030	0.018	0.010
4	0.030	0.018	0.010
6	0.0012	0.00072	0.00040
12	0.0012	0.00072	0.00040
16	0.0060	0.0036	0.0020
25	0.0060	0.0036	0.0020
30	0.0012	0.00072	0.00040
40	0.0060	0.0036	0.0020
80	0.0060	0.0036	0.0020
100	0.00060	0.00036	0.00020
200	0.000030	0.000018	0.000010
Overall G_{rms}	0.70	0.54	0.40

-16 Version



* NOTE: Only the TRUCK profile is affected; there are no changes to any other testing schedules.

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ASTM D4169-16 Truck Vibration Changes *

ASTM D4169-**14** DC13

- 180 total minutes
  - 60 minutes truck
  - 120 minutes air
  - Divided amongst all possible shipping orientations
    - Truck: 20 min each base, side, end
    - Air: 40 min each base, side, end
- Profiles based on Assurance Level I, II, or III

Truck:

	Power Spectral Density Level, g^2/Hz		
	Assurance Level	Assurance Level	Assurance Level
Frequency, Hz	I	II	III
1	0.0001	0.00005	0.000025
4	0.02	0.01	0.005
16	0.02	0.01	0.005
40	0.002	0.001	0.0005
80	0.002	0.001	0.0005
200	0.00002	0.00001	0.000005
Overall, g rms	0.73	0.52	0.37
Duration, min[B]	180	180	180

Air:

	Power Spectral Density Level, g^2/Hz		
	Assurance Level	Assurance Level	Assurance Level
Frequency, Hz	I	II	III
2	0.0004	0.0002	0.0001
12	0.02	0.01	0.005
100	0.02	0.01	0.005
300	0.00002	0.00001	0.000005
Overall, g rms	1.49	1.05	0.74
Duration, min[B]	180	180	180

ASTM D4169-**16** DC 13

- 180 minutes divided amongst all possible shipping orientations
  - Up to 3 axes
    - 60 minutes truck
    - 120 minutes air
- All the following High, Medium, and Low level Truck profiles tested (No assurance levels)
  - Truck Low Level: 40 minutes (13 min, 20 sec per axis)
  - Truck Medium Level: 15 minutes (5 min per axis)
  - Truck High level: 5 minutes (1 min, 40 sec per axis)
- Air profile based on Assurance Level I, II, or III
  - 40 minutes per axis

TABLE 2 TRUCK—Power Spectral Density Levels

Frequency	Power Spectral Density Level, G^2/Hz		
	High Level	Medium Level	Low Level
1	0.00072	0.00072	0.0004
3	0.030	0.018	0.010
4	0.030	0.018	0.010
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12	0.0012	0.00072	0.00040
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25	0.0060	0.0036	0.0020
30	0.0012	0.00072	0.00040
40	0.0060	0.0036	0.0020
80	0.0060	0.0036	0.0020
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200	0.000030	0.000018	0.000010
Overall G_{rms}	0.70	0.54	0.40

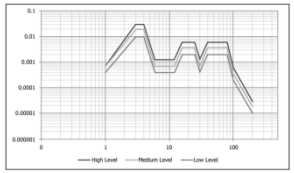

TABLE 4 AIR—Power Spectral Density Levels

Frequency	Power Spectral Density Level G^2/Hz		
	Assurance Level		
	I	II	III
2	0.0004	0.0002	0.0001
12	0.02	0.01	0.005
100	0.02	0.01	0.005
300	0.00002	0.00001	0.000005
Overall G_{rms}	1.49	1.05	0.74

* NOTE: Only the TRUCK profile is affected; there are no changes to any other testing schedules.

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What Did Not Change?

There are no changes to the other test inputs.

- **D10 Committee did clarify some wording and fix a few typos.**

WESTPAK's Commentary on D4169-16

- The science of transport vibration measurement and replication is alive and on-going. This change more closely aligns the truck vibration simulation with real-world data and with real customer experiences.
- We've seen many of our 4169 clients (especially in the medical device arena) cutting back their truck vibration test level from AL I to AL II due to concerns over getting test results more severe than real-world results.
- The majority of this new multi-level G_{rms} test occurs below the old AL II G_{rms} levels.

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Steps To Take If Products or Packages Fail D4169-16

From ASTM D4169-16, page 8:

12.4.2 "**If** more detailed information is available on the transport vibration environment or the shipping unit damage history, it is recommended that the procedure **be modified** to use such information. … A 3 h (180 min) duration is reasonable to use **in the absence of specific shipping or testing experience**."

Comment: So **if** you have "more detailed information" it is certainly possible to write a justification for doing your vibration testing differently (like altering the duration, or staying with D4169-14 spectra).

OR…

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Steps To Take If Products or Packages Fail D4169-16

- ✓ Use a different Distribution Cycle – DC2 allows you to select the testing most like your distribution cycle.
- ✓ Use ASTM D7386 if you are shipping single parcels.
- ✓ Use ISTA 2A or 3A (or similar ISTA test matching your distribution environment).

Note: Now that ISTA has partnered with ANSI, ISTA testing is more widely accepted by regulatory agencies than in the past.

http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfStandards/search.cfm

QUESTIONS

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More Questions Later?

Submit webinar and test questions to WESTPAK via our website at www.westpak.com/contactus

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