High Kurtosis Road Data

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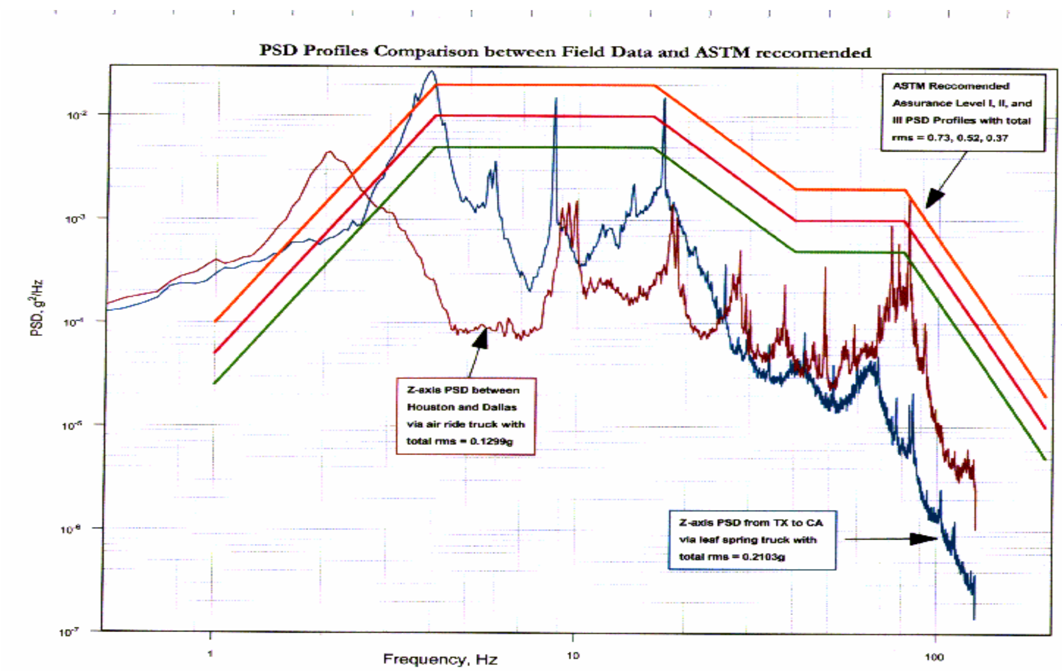
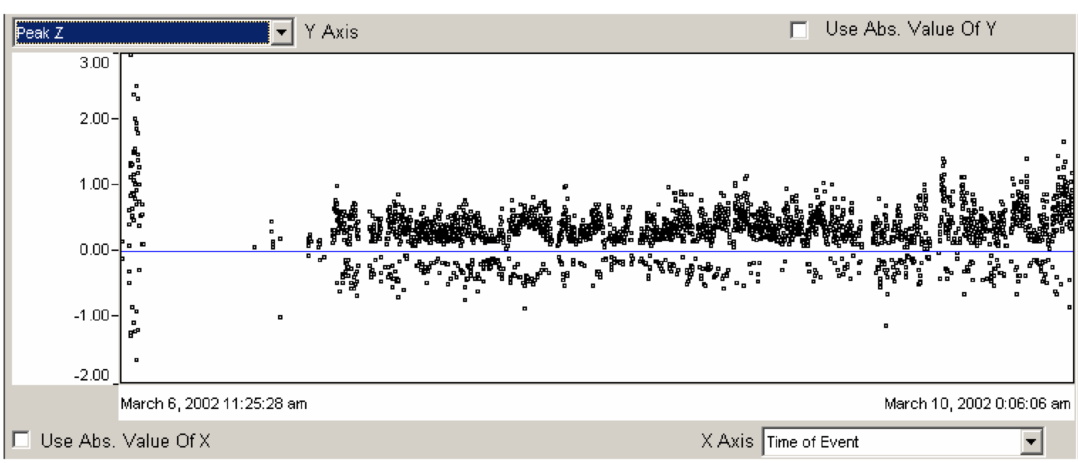
It is important to know the peak probability distribution (PPDF) of the end-use-environment to assess its severity against the test levels being employed. Kurtosis (the statistical 4th moment about the mean) does not show up as a test level, traditionally defined by a PSD shape and a G_{RMS}.

The displayed data represent two truck-rail-truck runs. In total, there were 4 shipments from California to Chicago (truck-rail-truck) and an additional 4 shipments from California to Dallas.

The PSDs show the statistical estimate of the average intensity vs. frequency for a California to Chicago run representing almost 54 hours of actual "on-road time". Note the RMS accelerations and especially the frequency bands where even the average actual road data exceeds the accepted test specifications.



Because the PSD is a statistical average intensity, we suspected that the actual road peak accelerations would differ greatly from the average, specifically in those frequency bands where the average is high and represents typical fundamental frequency of truck transport.



From the above scatter plot covering the entire transport exposure, the initial hour contained peak events, some exceeding 1.5 Gs and number reaching 2 to 3 Gs. This represents severe road sections of speed bumps, potholes, railroad tracks or curbs. Loading and handling shocks could contribute It should not be ignored in the test protocols for the packaged product. Truck suspension and driver behavior are also variables to be investigated.

Vibration Research reviewed the vertical axis acceleration time histories from the CA to Dallas truck data recorded with an IST EDR-4 recorder and imported the time histories into their Kurtosion^{TM} control module for a VR 8500 vibration controller and offered the following analysis.

The first segment of that truck data (possible handling shocks) shows:

length: 51 minutes
RMS: 0.23 G_{RMS}
kurtosis: 6.4

The second segment of that rail (plus truck) data shows:

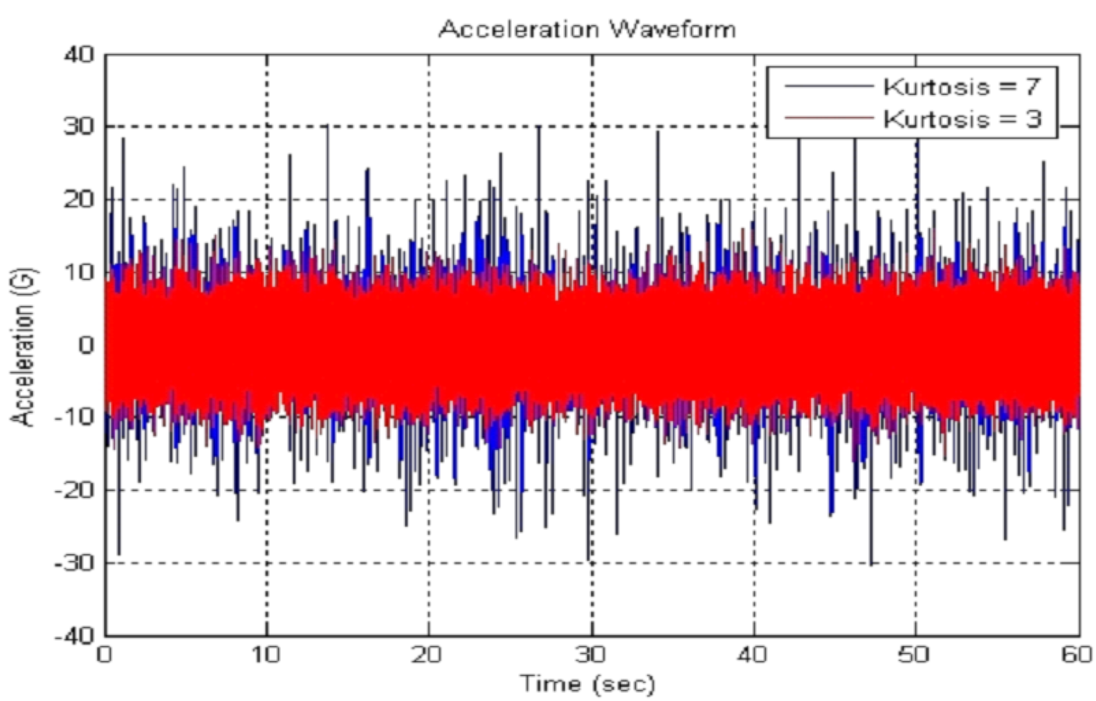
length: 52.8 hours
RMS: 0.077G_{RMS}
kurtosis: 8.3

The cumulative file shows:

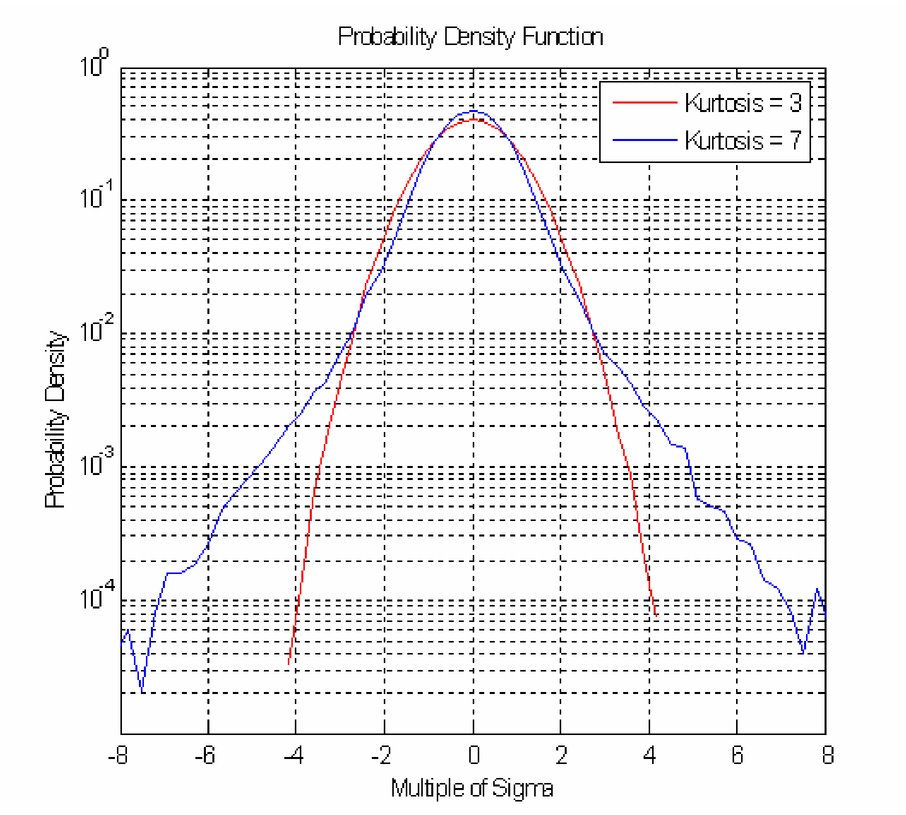
length: 54.3 hours
RMS: 0.082 $_{GRMS}$
Kurtosis: 13.2

The higher kurtosis of the cumulative data is a direct reflection of the 1 hour of 0.23 GRMS data followed by 53 hours of 0.077 G_{RMS} rail data. As suggested above, one can conclude that the initial truck transport is more severe than the rail (plus truck) portion of the trip. Handling during early or late segments could also produce some of the 2-3 g transient events observed.

The figure below is an example of peak acceleration events (blue) in actual road time histories. They are much higher than those (red) generated to meet the test specs. Note K values. There are fewer events around the zero mean of Gaussian random excitation



The ISTA/ASTM random vibration test spectra are all based on 3 sigma-limited Gaussian distribution (red curve) for which coincidentally, is Kurtosis=3. The PSD, however, and the root of its area, G_{RMS}, do not indicate in any way, the severity of peak accelerations that differ from the standard Gaussian normal distribution used for test specifications. The Gaussian PPDF (peak probability distribution function) is shown in RED in the following figure.



Using traditional (ISTA/ ASTM) random vibration to include these peaks, one would have to increase the power of the test, G_{RMS}, across the entire frequency spectrum. This clearly constitutes an over-test condition. The need for the higher velocities that are needed to test to higher Kurtosis adds design implications and higher cost to vibration test system

The original DynaMax PSDs showed significantly higher average over a couple of import bandwidths in the truck fundamental range. High Kurtosis, broader and thicker tails in this figure prove that the load spends more time under higher peak accelerations than traditional random testing generates.

The VR reprint from TEST-Engineering & Management, October/November 2005.