Kurtosis Comparison

The main objective is to produce a relative cumulative metric that does not rely on assumptions or processing limitations of Gaussianity, stationarity, averaging of peaks, being strongly mixed or other shortcomings. First, we need applicability to <u>all</u> shaker and EUE excitations. If, as shown below, different excitations produce identical PSDs and RMS values, and another approach does differentiate, then the DP(f) may not best represent the actual severity.

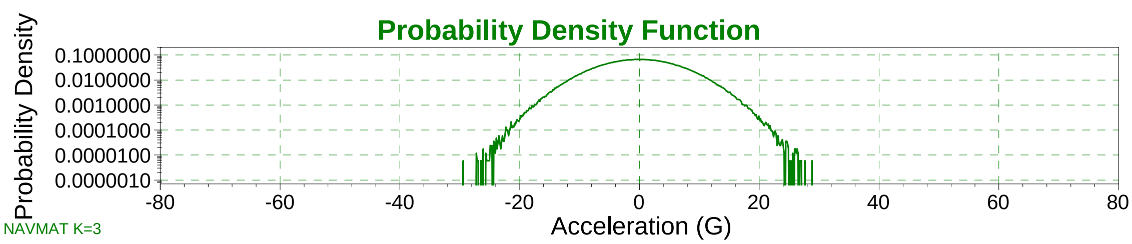
I suggest we address EUEs and shaker excitations including qualification, product and process verification and HALT), and consider the product response as the related, next logical extension.

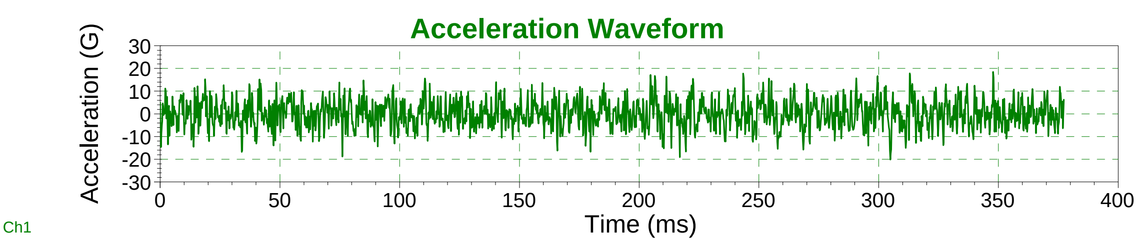
Kurtosis Comparison of NAVMAT Random

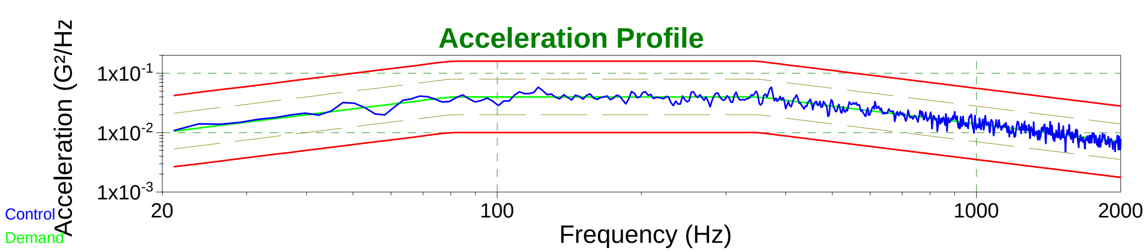
The following four sets of figures present the spectrum, a snapshot of the control time history and the peak probability distribution for a standard NAVMAT P-9492 spectrum run at different kurtosis levels on a Vibration Research 8500 controller (looped on itself). The time histories were recorded for 20 seconds. In addition to the traditional NAVMAT 6 gRMS (0.04 G^2/Hz, Gaussian K=3), the power spectral density was then run with elevated kurtosis levels of K=7, 11 and 17. The patented Vibration Research 8500 Kurtosion™ control was used.

The sets of graphs clearly show **<u>no change</u>** in either the spectral shape, level or the gRMS for the four kurtosis values. Only the acceleration time history generated is changed. This confirms the findings of VR in published works for different excitations and environments. There are indications that higher kurtosis shortens time to failure. It is also important that testing with a Gaussian distribution when the EUE is more severe carries risks of under test for manufacturers and customers.

<u>K=3</u>

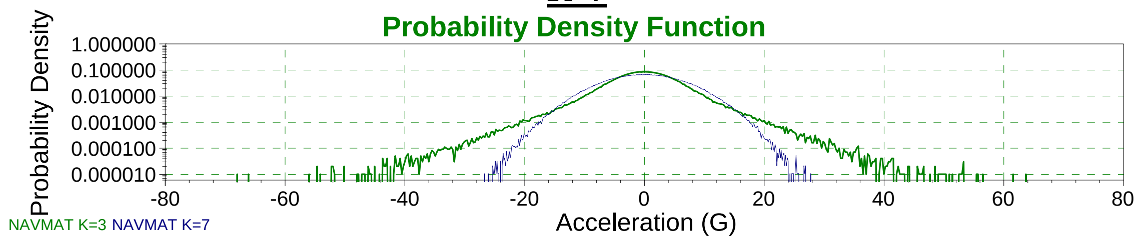


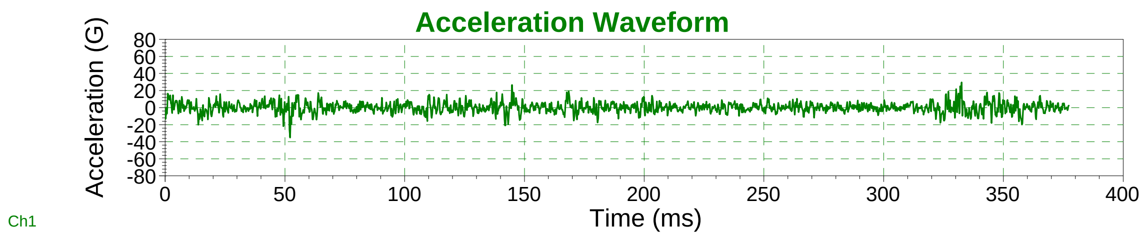


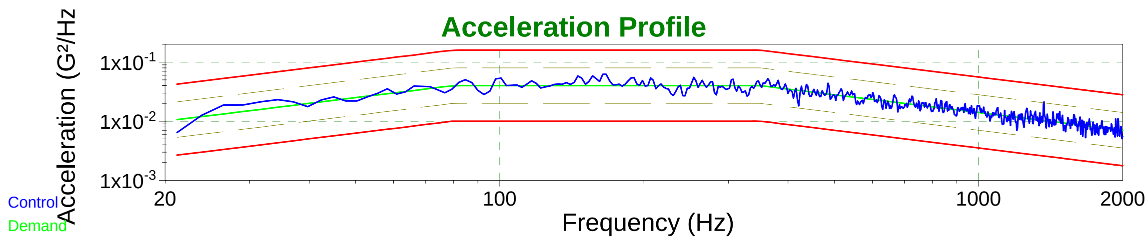


Note that with traditional random control based on a Gaussian distribution of peaks, 4.5 to 5 σ events could be expected. The Vibration Research Kurtosion™ is weighted over the entire bandwidth.

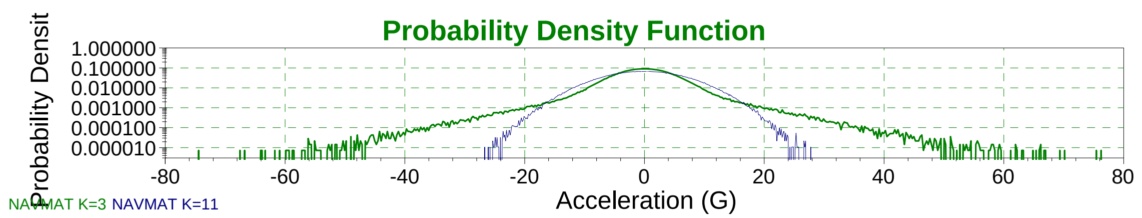
K=7

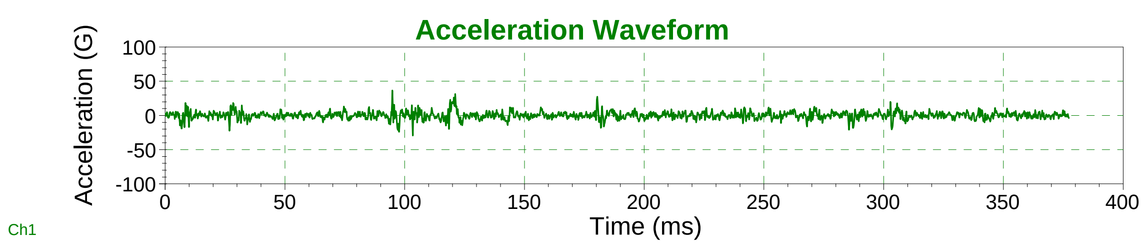


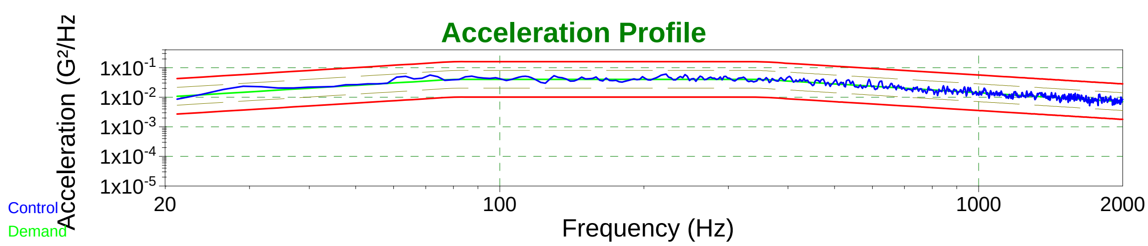




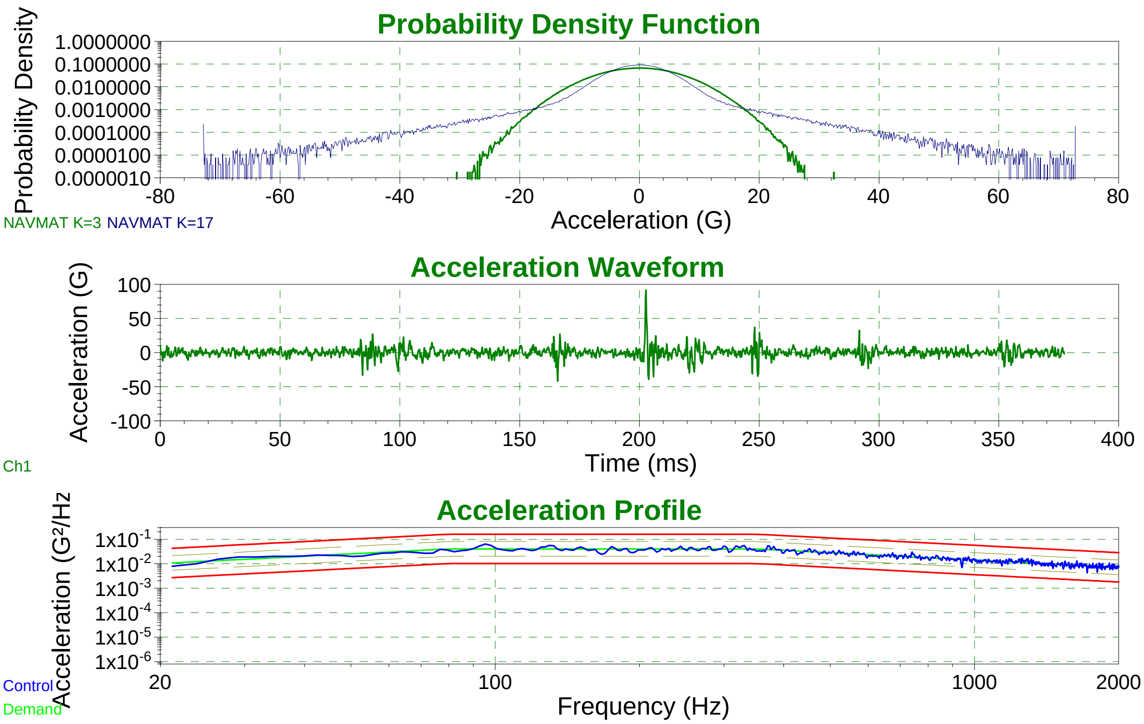
K=11







K=17



The data for K=17 clips @ approximately 74 g because we did not use the VR option that accommodates the spectrum greater than 4 kHz, but still shows that high kurtosis is not all at high frequency. K=17 has been observed on pneumatic HALT (repetitive shock) machines. The Step Stress process could be conducted by increasing kurtosis above the measured EUE as define by the replication of the field environment, or by the qual test or other prescribed specification requirements. The power of the test remains unchanged.

Viewing this data presentation from the "analysis" rather than the "control" perspective, I suggest that if the Henderson-Piersol velocity PSD-based DP(f) fatigue metric shows no differences for different peak probability distributions of differing kurtosis, then it fails to accommodate the effects of acceleration peaks generated by RS machines and many EUEs. John and Phillip Van Barens' paper, "Kurtosion™—Getting the Kurtosis into the Resonances", was presented at SAVIAC 2007. The conclusions suggested that the effects of Popoulis Rule and the central limit theorem are not absolute in describing that high kurtosis peaks do not reach product resonances and thus have no effect.

Acknowledging the differences in bandwidth over which ED and RS shakers have higher intensity, the 3 or 6 DoF versus SDoF of ED shakers, and the importance of each product's response function, I still think we need another look. These considerations define the need for an improved cumulative metric is more about EUEs, shakers and differentiating severity of broad applications that include the sub-applications of HALT and HASS excitations and relating them.