Jade Vande Kamp

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Abstract

Answers to commonly asked questions about Fatigue Damage Spectrum (FDS)

What is the purpose of FDS?

The Fatigue Damage Spectrum (FDS) software is a tool designed to give engineers the ability to create a random test profile that is the damage equivalent to weighted time history files that portray the end use environment of a product. In addition to this real-world relationship, the FDS can be used to compare multiple failure runs of a product, compare specifications to real world data, and determine if current testing is valid or if a product is being under/over tested.

Is it possible to combine multiple end use environments to create a single PSD?

The FDS software can be used to create a single PSD profile that includes multiple input time history files. These time history files can be weighted individually by time or cycles to create a total Target Life for the product. When combining data, the same *m*, Q, and frequency range are used to create an equal relationship between each imported file. The output PSD will be the damage equivalent of all imported files, based on the target life for each waveform, and the FDS settings.

To what degree can a test be accelerated? Is there a recommended ratio?

An accelerated test is not the same as running for the full amount of time! In general, the less the test is accelerated, the more accurate a reflection of the real world data it will be. At a minimum, the instantaneous stress limit of the product cannot be exceeded. This limit varies depending on the

construction of the product. Also, FDS uses the stress-strain curve to determine the amount of acceleration, so the test acceleration is only as accurate as the chosen value for 'm'. The more acceleration applied, the more important the accuracy of 'm' becomes.

According to MIL-STD-810G, test engineers should not accelerate tests by applying excessive amplitudes "simply to achieve short test durations. Such excessive amplitudes may lead to wholly unrepresentative failures and cause suppliers to design material to withstand arbitrary tests rather than the in-service conditions" (p. 237)

This standard (MIL-STD-810G) also defines an "exaggeration factor" and says that "It is recommended that the exaggeration factor be kept to a minimum value consistent with the constraints of in-service time and desired time, and should generally not exceed values of $1.414^{\wedge}(S1/S2)$ or $2^{\wedge}(W(f)1/W(f)2)$." According to this statement, for a material with m=7.5, the maximum ratio between the in-service time and the test time can be $1.414^{\wedge}(7.5) \approx 13.4$.

How can I create a time history file from my existing PSD's?

The simplest method to get a time history file from a PSD is to import the PSD using the random import tab, run the test, and record the 'CH1' time waveform (use demonstration mode, or loop the drive to 'CH1 with a short BNC Cable). No connection to an actual shaker is necessary because a PSD is not uniquely associated with the time waveform. FDS is a time-based algorithm, meaning that if run the same PSD repeatedly you WILL NOT get the exact same FDS, but you will get a good approximation. It is also possible to assume random phases to go from

a PSD to a time waveform using a tool like MATLAB, but the results would not be significantly different.

Is it possible to determine how much damage is caused by an individual PSD?

No by itself. A PSD is only associated with an acceleration waveform, but the FDS requires both m and an acceleration waveform. If the m and Q values of a product are known, and the time history data is imported, an FDS can be generated.

Can FDS be used to determine which PSD causes more damage?

To do a comparison between two PSD's, using FDS, the m and Q value must be the same. From this perspective, the FDS is an identical transformation applied to both PSD's, there is no new information being added through the FDS generation process. The comparison would provide identical information to a direct comparison of the PSD's in the frequency domain.

An example of an FDS comparison is using field time history data and a PSD based on a specification. These two FDS's should line up quite closely IF the combination of end use environments is accurately reflected in the standard PSD. This comparison can be used to validate a PSD, and assure engineers that a product is not being over or under tested.

What 'm' and Q value should be used? Is it possible to determine the 'm' and Q of a product?

See V-Note# 0017 for general values of m and Q

See V-Note #0018 for instructions on determining m and Q

How does kurtosis factor into how the PSD is imported?

Measuring the acceleration waveform in the field will naturally measure the kurtosis. When we calculate the FDS, increased kurtosis will result in more damage experienced at generally all frequencies (if done correctly). However, converting the FDS back into Acceleration Spectral Density (ASD) will result in an ASD that is Gaussian (k=3). The damage due to kurtosis from the time history file is calculated into the FDS, and spread under the ASD with this import method.

The Kurtosion® package can be used to create a higher kurtosis output FDS. There are a few reasons why this might be useful:

1. Lower the G_{RMS} requirement of the test. (NOTE: the G_{RMS} is decreased, but the peak requirement is increased. This is useful when a system cannot handle the sustained load of the test, but is capable of reaching the higher peaks)
2. Create peaks that are equal to the input waveform.

The output PSD, based on the FDS, with or without added kurtosis, will be the damage equivalent to the combined input time history files.

For instructions to create an FDS Test see V-Note 0019