Fatigue Damage Import

How to use the fatigue damage spectrum for accelerated tests

David VandeBunte

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Abstract

Test engineers often ask how to create a random profile from recorded data. Even after coming up with a profile, it may not be clear how long to run it or how to speed up time to failure. This tech note addresses how to answer these questions using the concept of material fatigue and VibrationVIEW.

Question

I have 10 min. of road data and would like to make a random test that re-creates the same spectrum from the field in my lab. How can I run an equivalent of 600 min. of road data in 150 min. on my shaker?

Answer

Begin by finding the random import tab and choosing the fatigue damage technique. To do this, create a new "Random" test, click "Advanced" at the bottom of the dialog, and navigate to the "Import" tab. In the section "Import Method" on the dialog, choose "Fatigue Damage" to indicate you would like to (1) see a fatigue damage spectrum and (2) automatically adjust the time your test runs after the file is scanned (Figure 1).

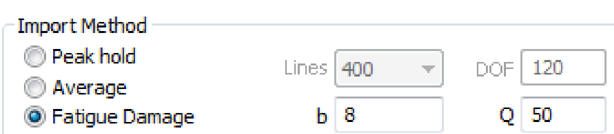

Figure 1: Select fatigue damage radio button

There are two parameters associated with a fatigue damage spectrum. The first is a material parameter 'b' (beta) used in an idealized S-N curve. Estimate this value based on the materials present in the test item, or use the suggested value of 8. In general, the more accurate your value of beta the better your results will be (the validity of the outputs depends on the inputs).

The second parameter is the quality factor 'Q' of the narrowband filters that separate the bins of the spectrum. You can control how sharp or shallow the transitions in the fatigue damage spectrum are by adjusting the value of 'Q'. Figure 2 shows how choosing 'Q' affects the results in practice.

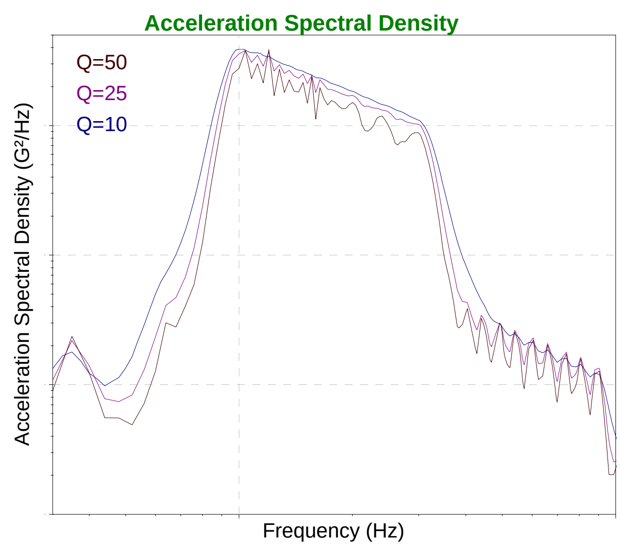

Figure 2: Quality factor 'Q' and output

Beyond these two process parameters, the frequencies that the fatigue damage spectrum is calculated on can be customized along the bottom of the tab (Figure 3). It will save calculation time if you reduce these frequencies to only the bins you are interested in or increase the octave spacing.

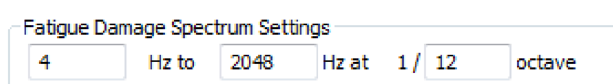

Figure 3: Customize frequency axis

At this point, you are ready to scan the file. Click on the "Browse" button along the top of the tab and navigate to the file that has 10 min. of recorded field data. After you select the file in the file browser it will automatically be scanned.

After you've scanned the file you can look at the fatigue damage spectrum using a dropdown at the top of the edit test dialog (Figure 4). This is an intermediate result on the way to the acceleration spectral density we're interested in.

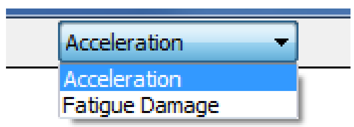

Figure 4: Choose which graph is displayed

Finally, the three timing fields are enabled the same time the fatigue damage spectrum becomes available. The "Target Life" box should be set to how long you would like the test item to survive in the field – for example, we would like our item to survive for 10 hours (600 min.) before breaking (Figure 5). The "Test Duration" field is for how much time is allotted for the test on a shaker. The lower you make this time, the more you are "accelerating" your test and perhaps introducing inaccuracy. In this example, the ratio between the target life and the test duration is 4, which may or may not be reasonable depending on the test item.

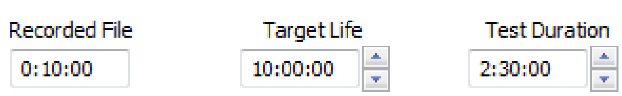

Figure 5: Reduce test time

The general principle to keep in mind here is that we are applying the same amount of fatigue damage in a shorter amount of time.

Frequently Asked Questions

Will the Fatigue Damage Spectrum reflect any test item resonances?

If the field recording was taken on the test item while it was in the field, then the acceleration waveform includes information about the item resonances and these will also show up in the fatigue damage spectrum. Otherwise the acceleration waveform doesn't include the required information about the item's resonances.

Does the Fatigue Damage Spectrum take Kurtosis into account?

Yes, the kurtosis in the field is measured in the acceleration waveform. However, the fatigue damage import method assumes a Gaussian ASD (with kurtosis = 3) as output. This means that kurtosis causes damage that increases the magnitude of the fatigue damage spectrum, but that damage is converted back into a Gaussian ASD. The damage due to kurtosis will actually end up increasing the Gaussian ASD's magnitude.

Although the damage is not lost, it comes back in a different form. Alternative methods that import a test with equivalent kurtosis and a reduced acceleration spectral density are also being looked into.

What is a reasonable factor to use when accelerating the test?

There is a different answer to this question for every test item. Factors that will limit how far you can accelerate the test include:

1) Multiple resonances in the test item. Some theoretical conversions assume one dominant resonance.
2) Composite materials where it is difficult to estimate beta.
3) Exceeding instantaneous stress limits such as yield stress or ultimate stress (this method assumes the test item fails due to fatigue damage).

In general, you are going to be more accurate the less you scale down your test.