Field to Report Webinar

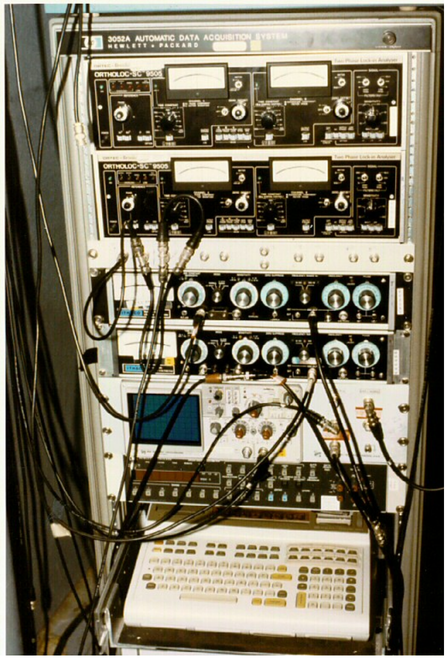
June 2013

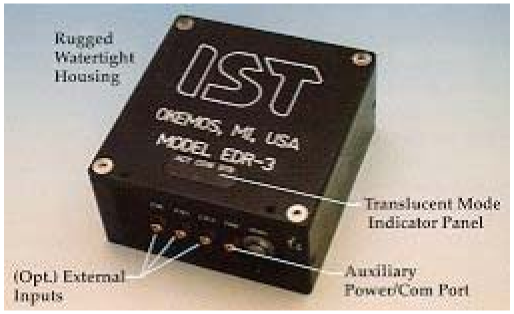
Field Data to Laboratory Testing

1. Collecting Field Data
2. Processing Data
3. Field Data Replication
4. Random Testing and generating a proper PSD
5. Method for Accelerating the PSD

Collecting Field Data

* Courtesy of Wayne Tustin





Data Collection Parameters

- Use an accelerometer that will not saturate
  - 10mV/g often a good choice
- Know the saturation g level of the accelerometer you are using
- Sample at a rate high enough to get all pertinent vibration data
- You can always filter and down-sample later
- You can NOT up-sample later

Accelerometer Error Sources

- Signal conditioning
- Cable disconnects
- Temperature
- Pressure
- Sound
- Force
- Base strain
- Gravity
- Centrifugal force

- Magnetic fields
- Electrostatic fields
- Poor attachment
- Ground loops
- Sensor resonance
- Accelerometer bracket resonance
- Mounting devices natural frequency

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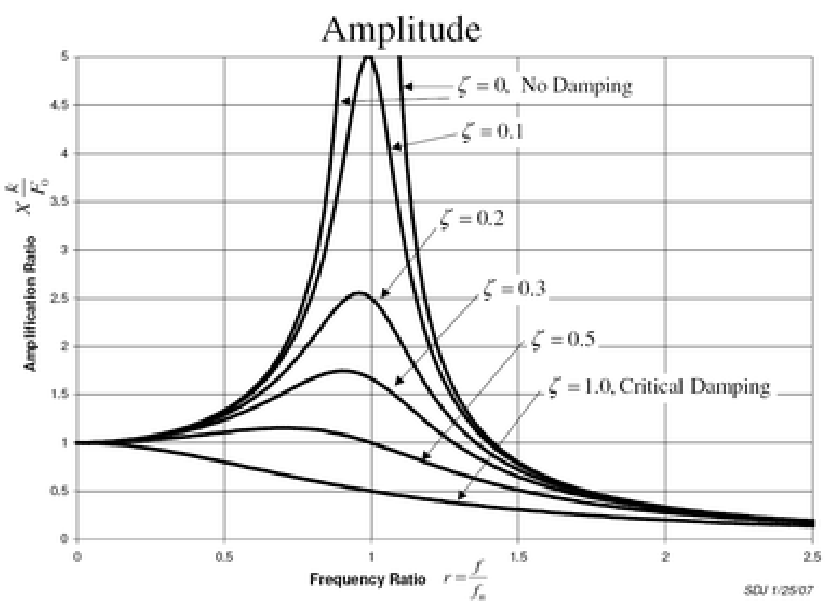
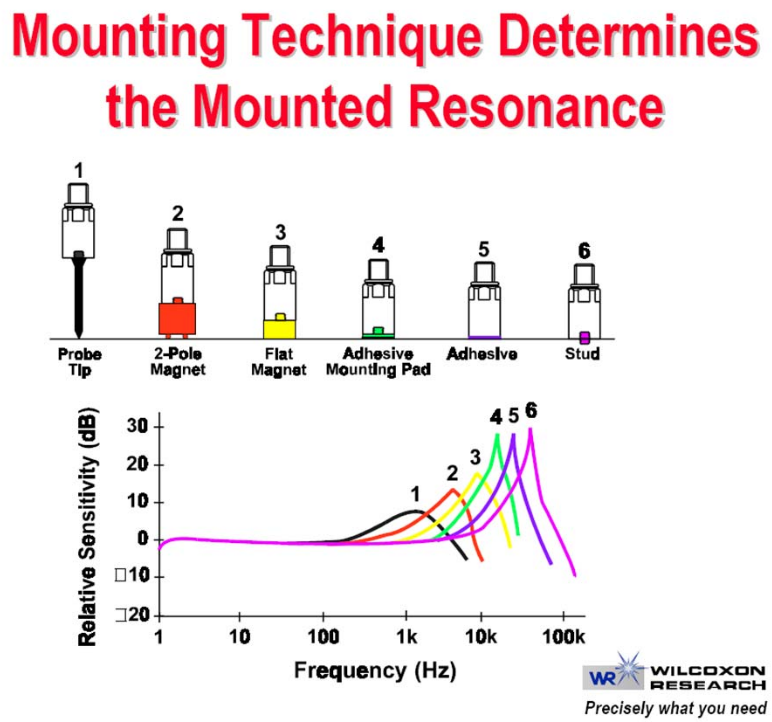
Sensor Resonance

- Accelerometers are a spring-mass system
- All spring-mass systems have a natural resonance
- To make sure your errors are less than 4%, make sure the natural frequency is at least 5x the highest frequency you are measuring
- To make your resonance errors less than 1%, select an accelerometer with a natural frequency 10x the highest measuring frequency



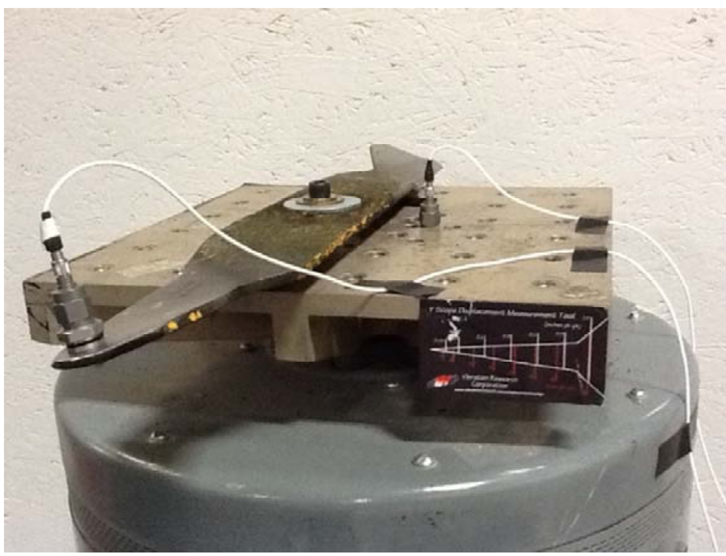
Mounting Devices Natural Frequency

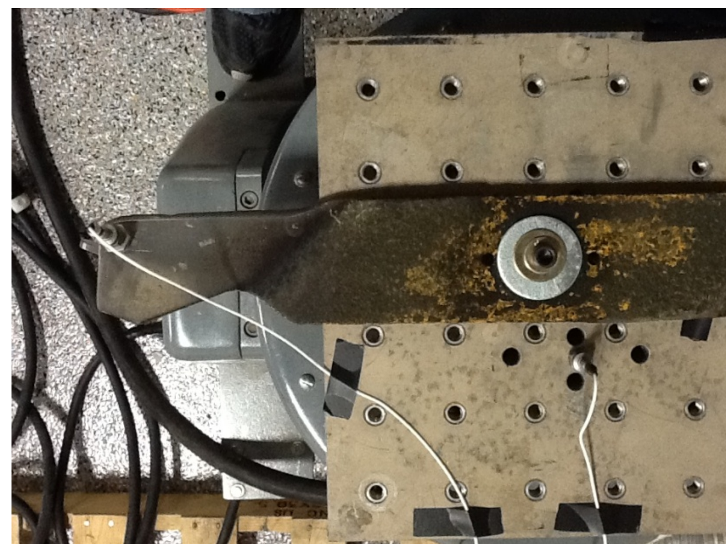
- Probe Tip – 1 KHz
- Magnet Mount – 5 KHz
- Adhesive Pad – 20 KHz
- Super Glue – 50 KHz
- Stud – 80 KHz



Cables and Connections

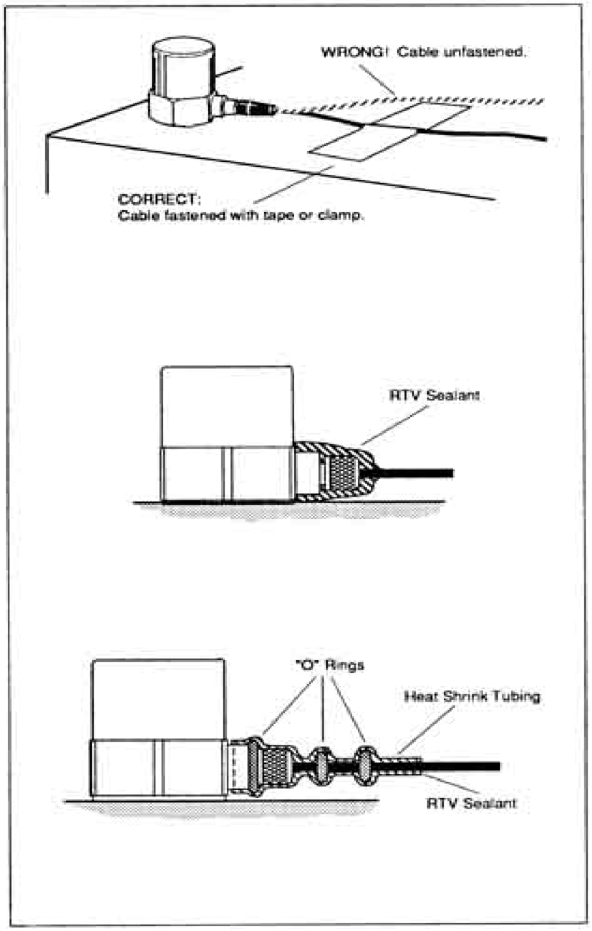
- Cables should be securely fastened to the mounting structure with a clamp, tape, or other adhesive to minimize cable whip and connector strain
- Cable whip can introduce noise, especially in high-impedance signal paths. This phenomenon is known as the **triboelectric effect**
- Cable strain near either electrical connector can lead to intermittent or broken connections and loss of data





Accelerometers

- To protect against potential moisture and dirt contamination, use RTV sealant or heat-shrinkable tubing on cable connections. O-rings with heat shrink tubing have proven to be an effective seal for protecting electrical connections for short-term underwater use
- The use of only RTV sealant is generally only used to protect the electrical connection against chemical splash or mist



Using the Correct Accels

IEPE Accels – Typically good to temps of 225°F

Charge Accels – Typically good to temps of 500°F or more

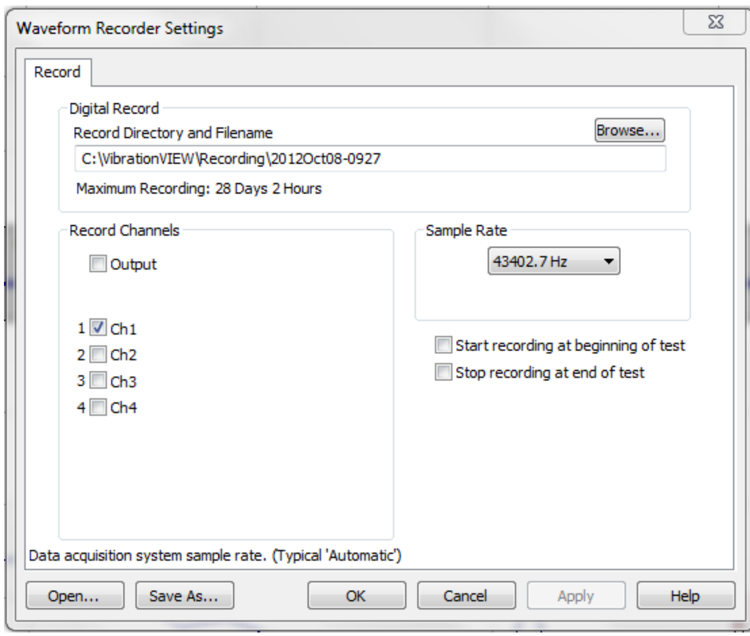
Some charge accels can go as high as 900+°F

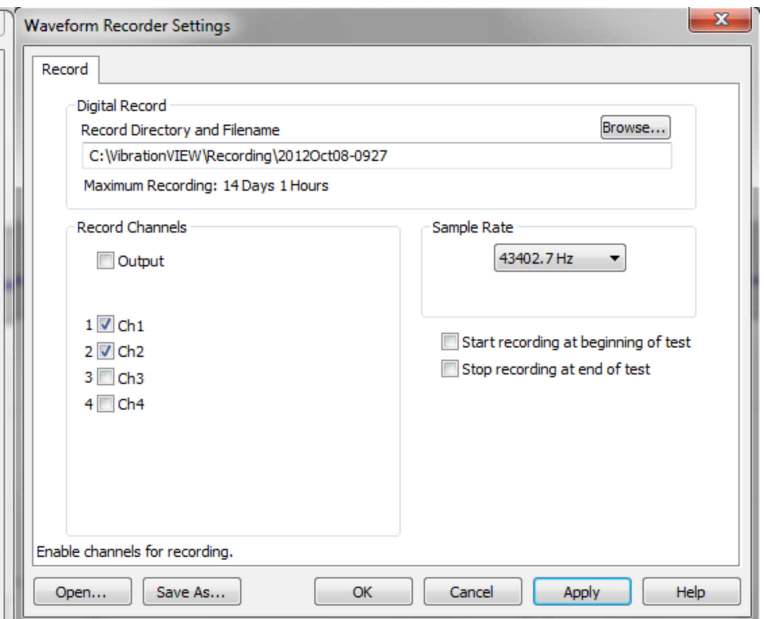
Where to Put the Accelerometer

- Mounting points of the part you want to test
- On the part you want to test
- Position the accelerometer in the axis of predominate vibration
- When controlling in the lab, put the accelerometer in the
  - same location
  - same orientation

Other Considerations

Things affecting Max recording time:
- •Number of channels
- •Sampling rate





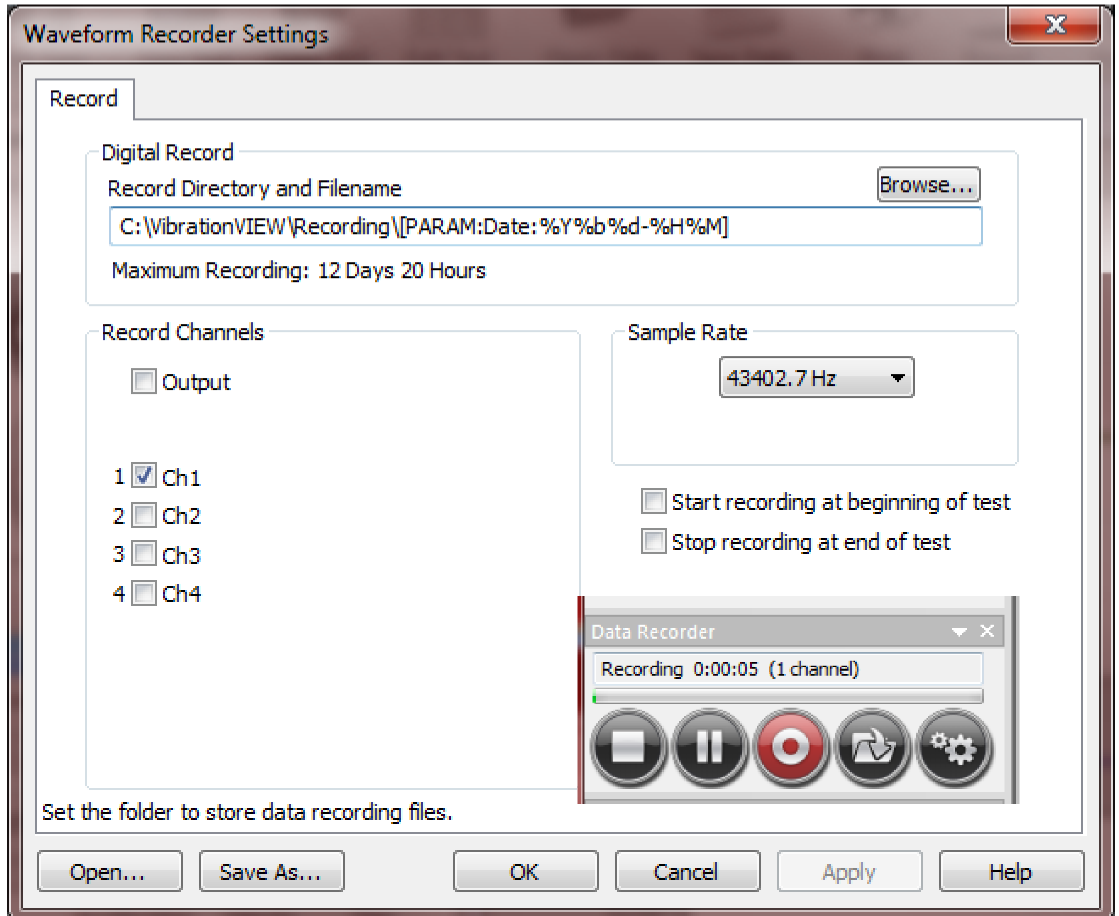
Calculate File Size: (Sample Rate) x (Number of Channels) x Number of Seconds) x (4)

Power Invertors: Alternator noise

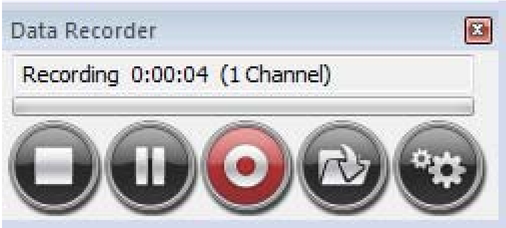
Battery life:
- Hand held recorder
- Laptop

Recording Your Field Data

- Directory and Filename
  - Browse for Recording folder
- Record Channels
  - Choose which channels to record
  - Record Output Drive signal
- Sample Rate
  - Choose the appropriate sample rate
  - The sample rate is tied to the open/running profile
  - In System Check, 10kHz is the minimum sample rate available



Make sure to hit “Start Record”



Seems like a no-brainer but it can happen ☺

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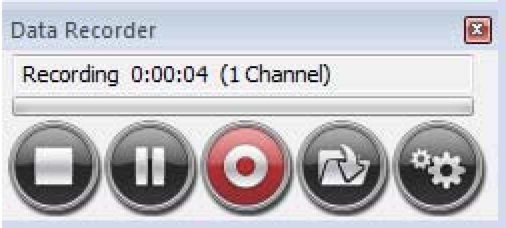
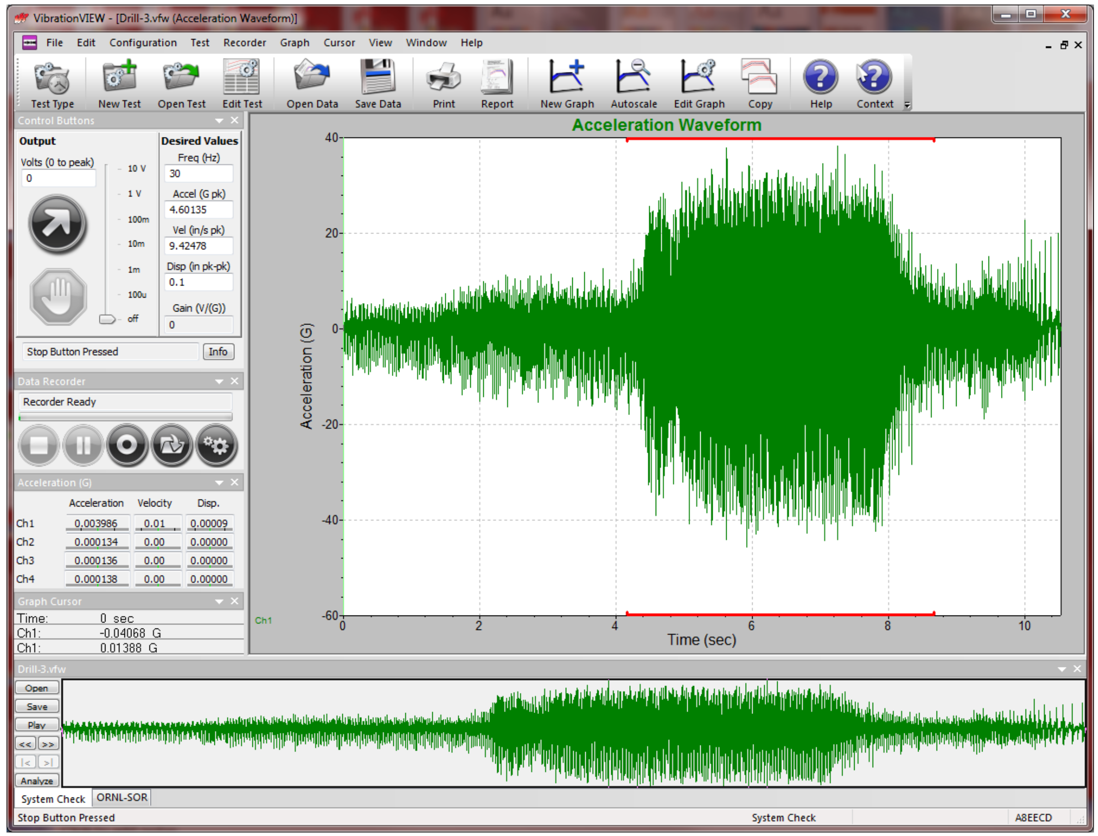
Record the Data

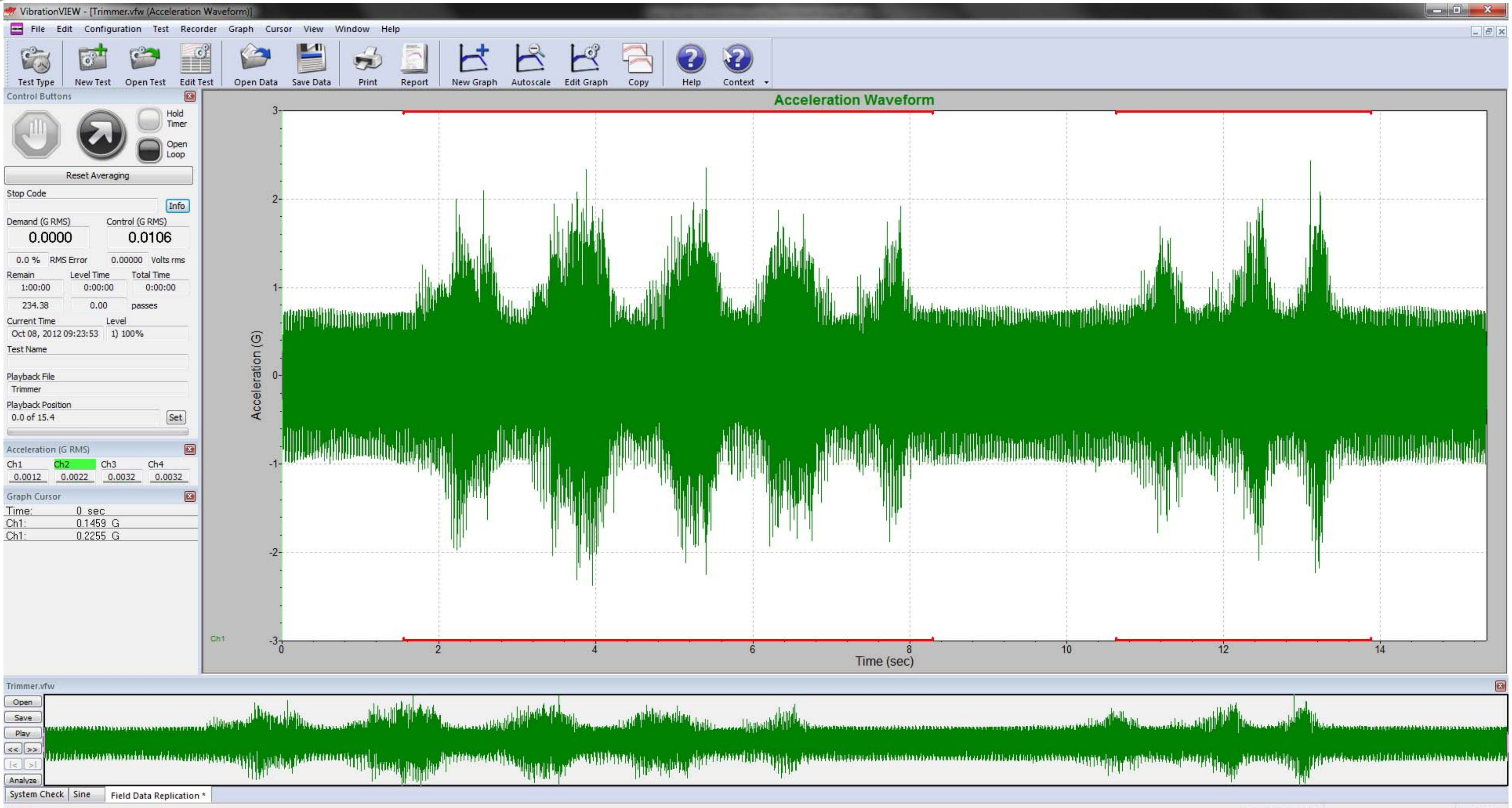


Frequency Range and Filtering

- You must determine what frequency to include in the test
- This will affect the level of the test
- High Frequency will increase peaks and RMS
- One has to determine if those levels are critical to the product in the real world
- Often, High Frequency does not affect the product and can be filtered out



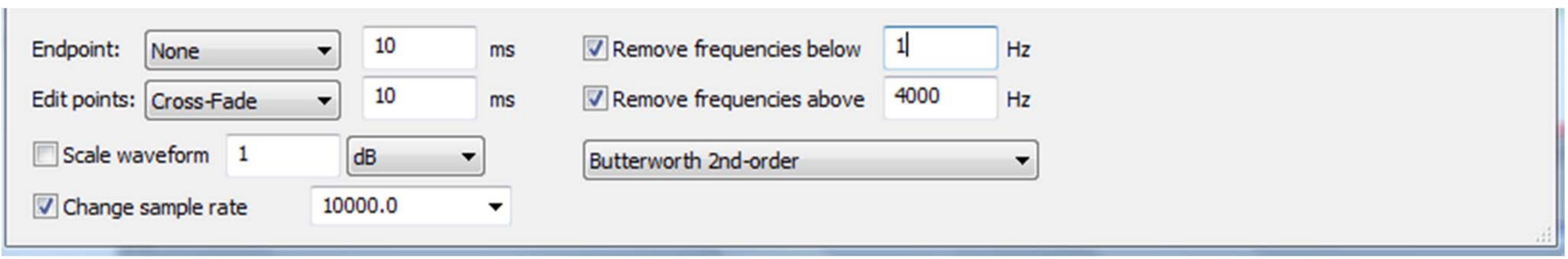
Editing Data



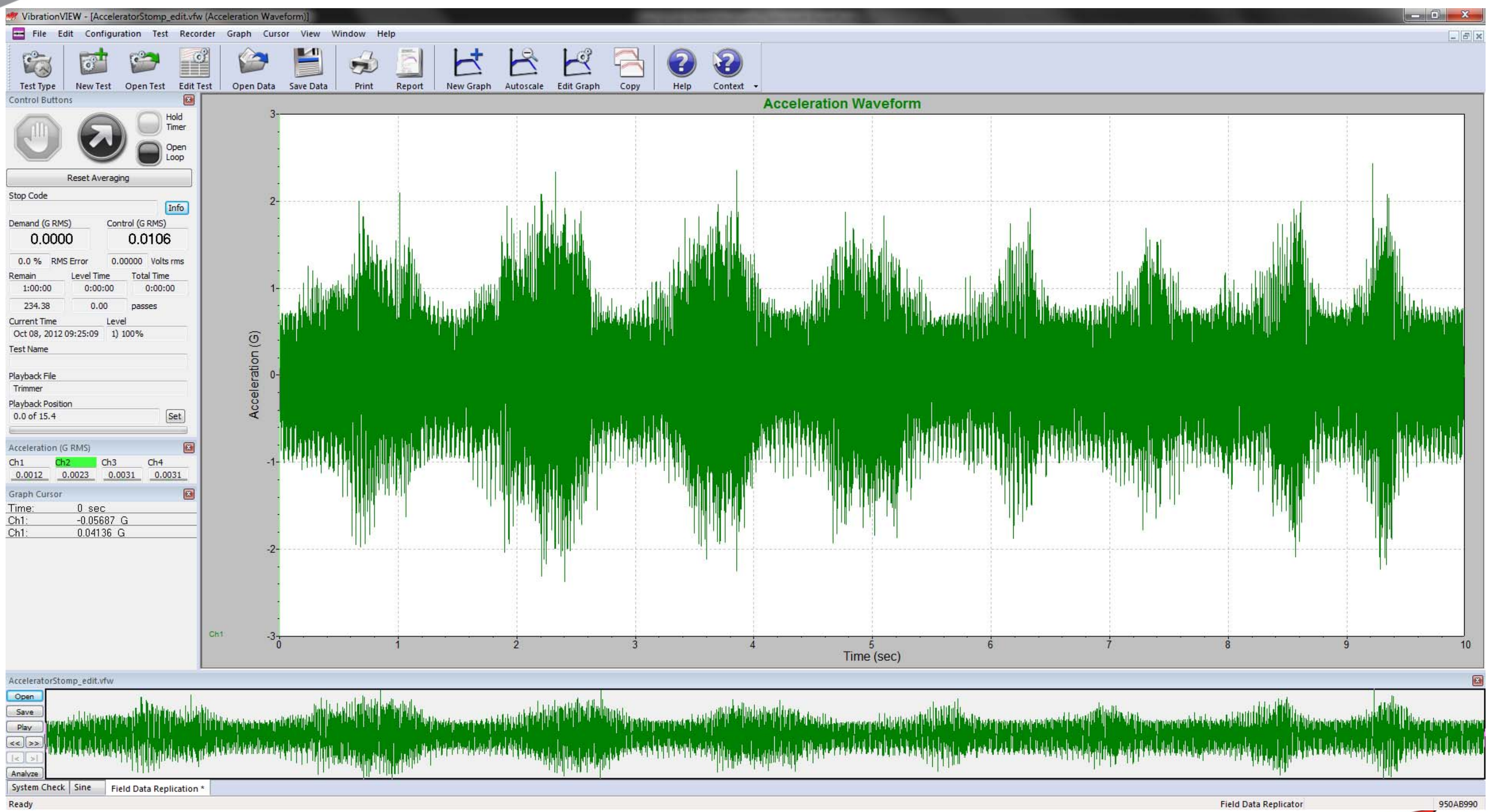
Removing the data from the beginning and ending areas can reduce the "dead-space" from the recorded file that might not be necessary.

Save New Waveform File

- Save Waveform
  - Edit End points and Scale Waveform
  - Down Sample file
  - Remove High and Low frequencies
  - Assign filter type



Final Processed Data



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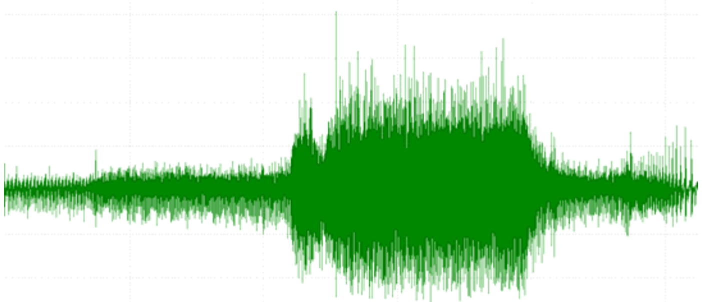
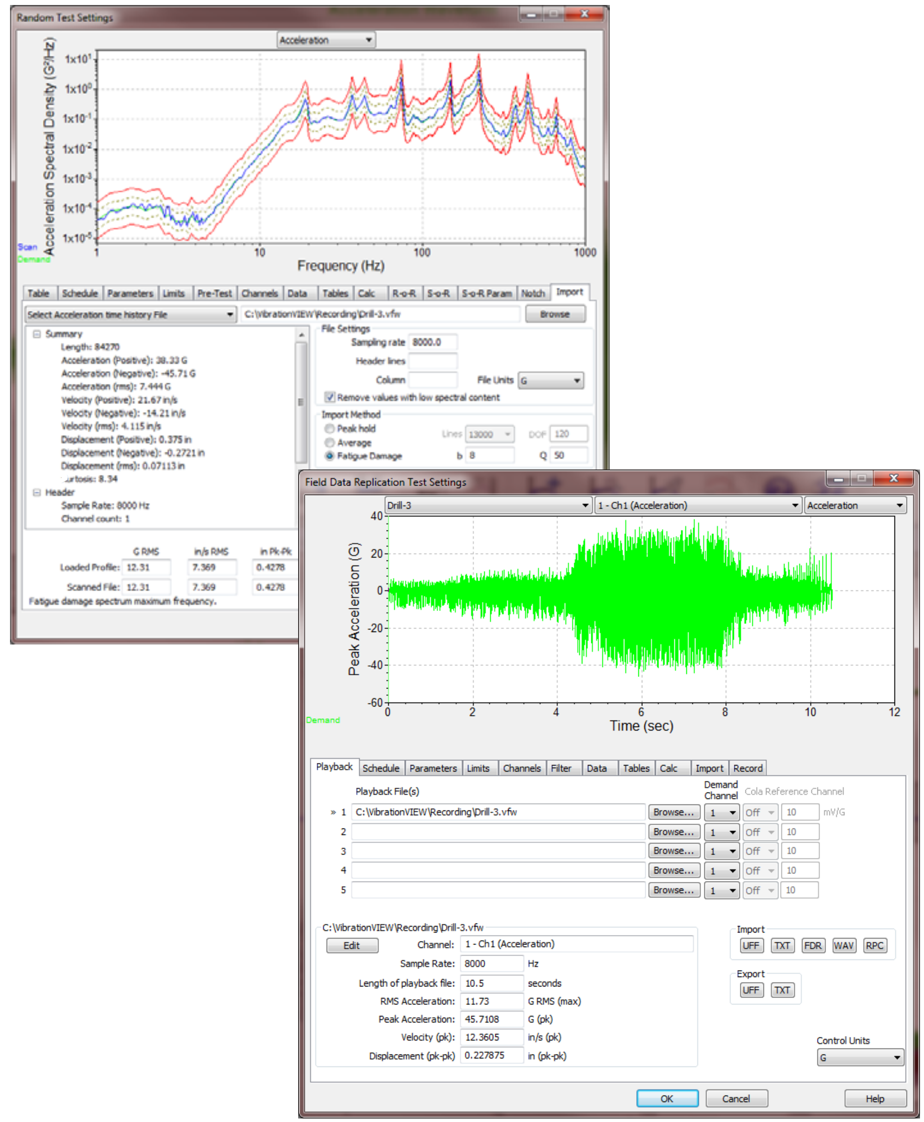
Designing a Test





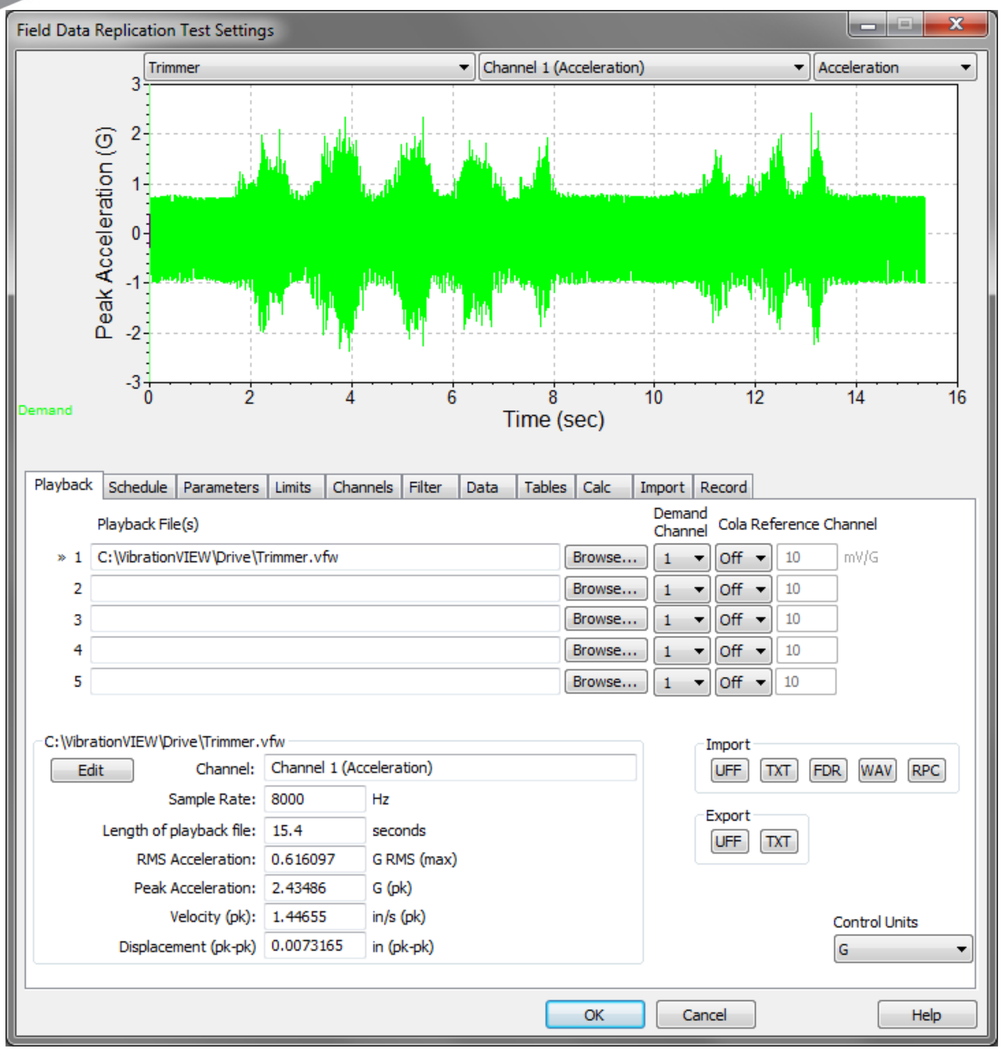
Vibration Testing and the Real World

- 1) Field Data Replication
  - Run your data 1:1 as it happened in the real world
  - Can be time consuming
- 2) Random Import
  - Run your recorded data
  - Run Random peaks as average, peak hold or somewhere in the middle
  - How long?
- 3) Fatigue Damage Spectrum
  - Incorporates Henderson-Piersol method into random testing
  - Gets real world data on the shaker in an accelerated way

1-Field Data Replication

- Take a recorded data file and play it 1:1 on a shaker system
- This method replicates exactly as seen in the field
- Is the most “real world” test you can have

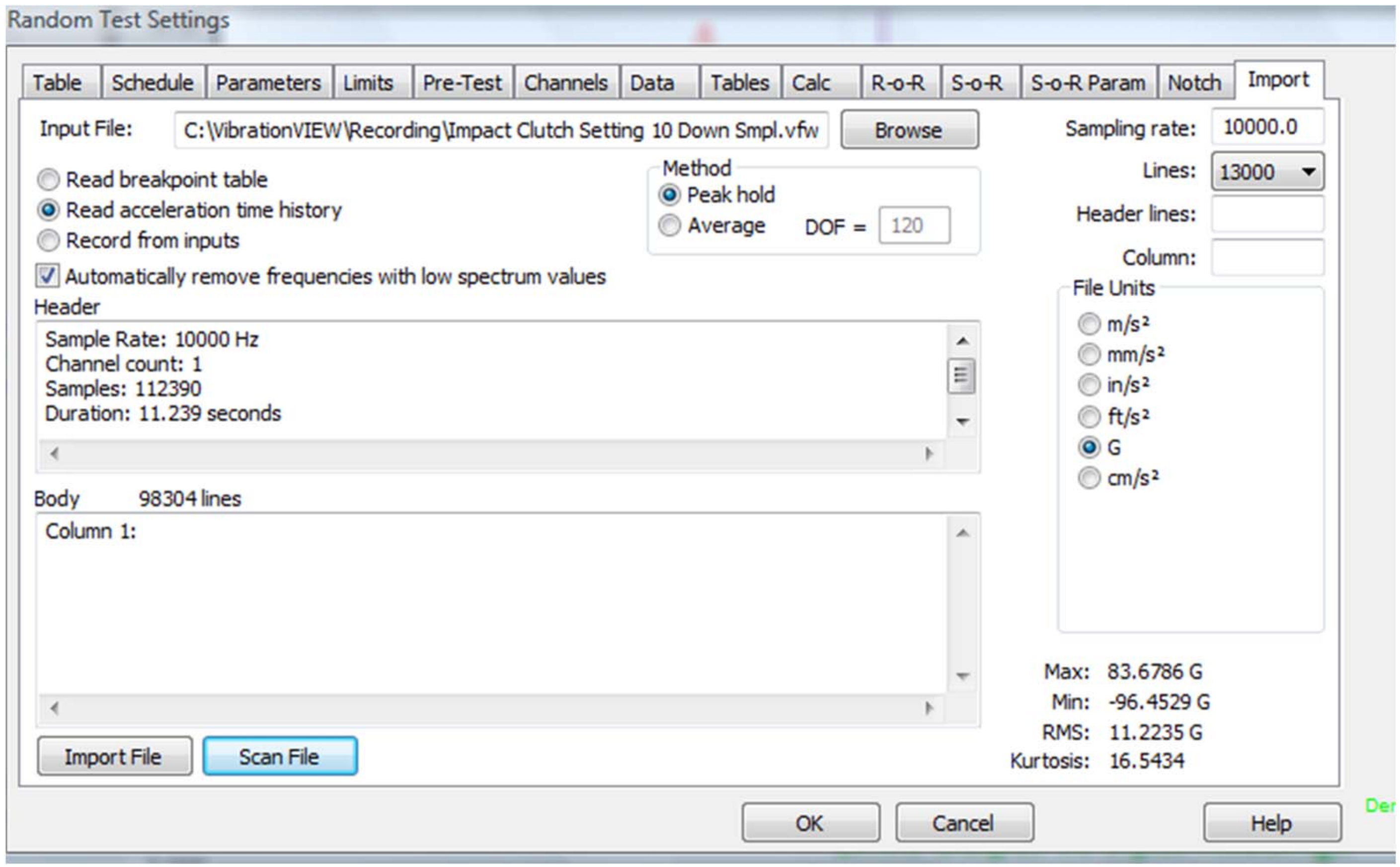
1-Field Data Replication



- Takes a long time to replicate all the recorded data to match the life of the product at 1:1 - not accelerated levels
- Can increase the level to accelerate the test
- How much is up to the user
- Not a Randomized test of what ***might*** happen

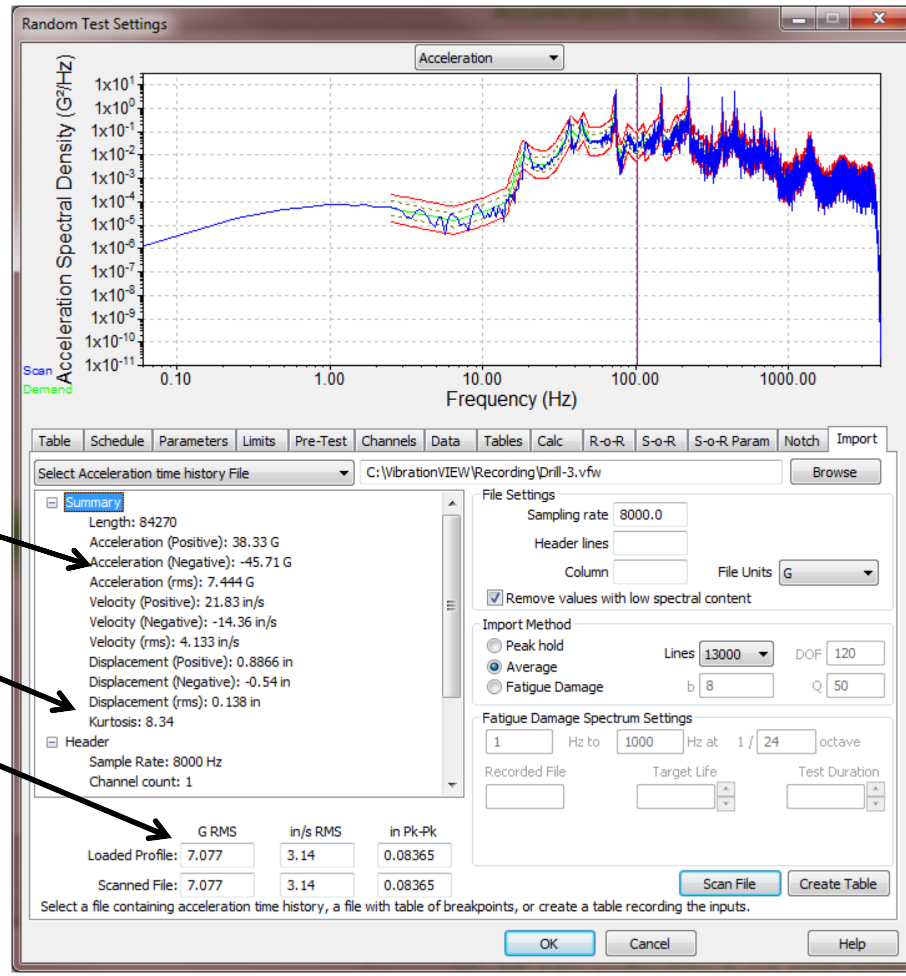
2-Create a Random PSD

- Browse for File
  - Lines of Resolution
  - Set Method to Peak Hold
  - Scan File if you make changes
- Import File
  - Imports file to Table tab
  - Remove unwanted breakpoints
  - Calculate GRMS, Peak G's, Crest Factor



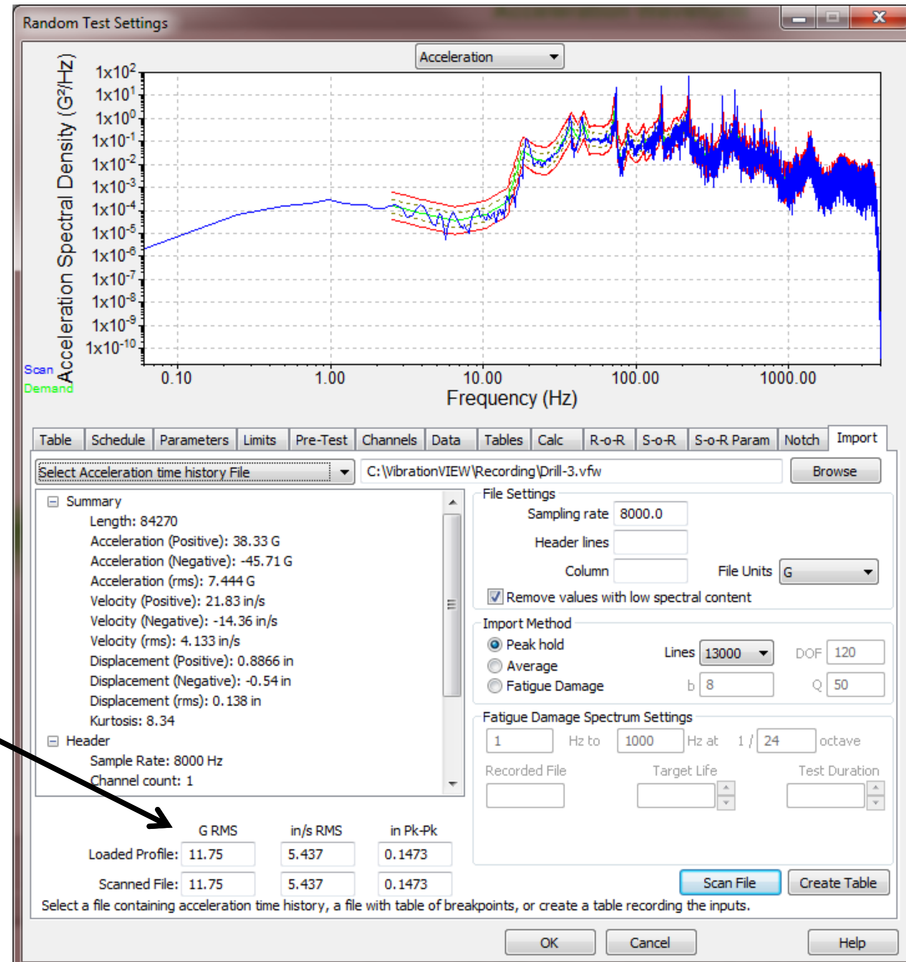
2-Random Import – Average Method

- Summary of Random import – average method
  - Peak G: -45 G's
  - Kurtosis of recorded data is 8.34
  - 7.07 Grms



2-Random Import – Peak Hold Method

- Summary of Random import – Peak hold method
  - Kurtosis of recorded data is 8.34
  - Peak G: -45 G's
  - 11.75 Grms



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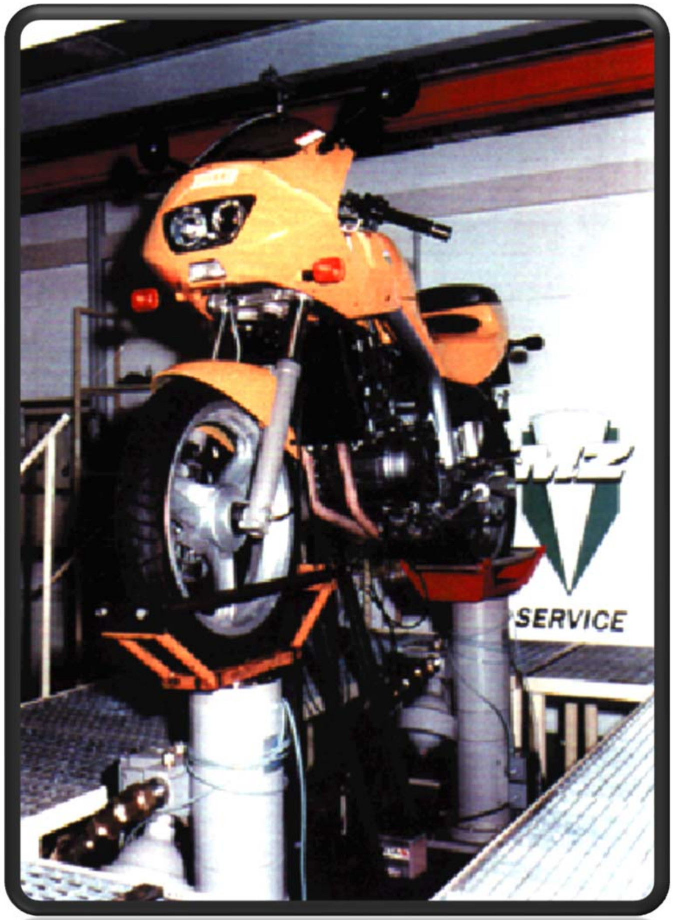
Random Import Results



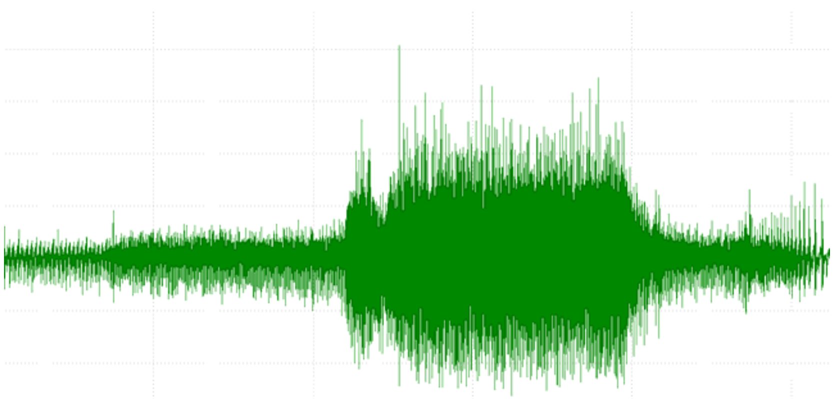
This is all very good but questions still remain....

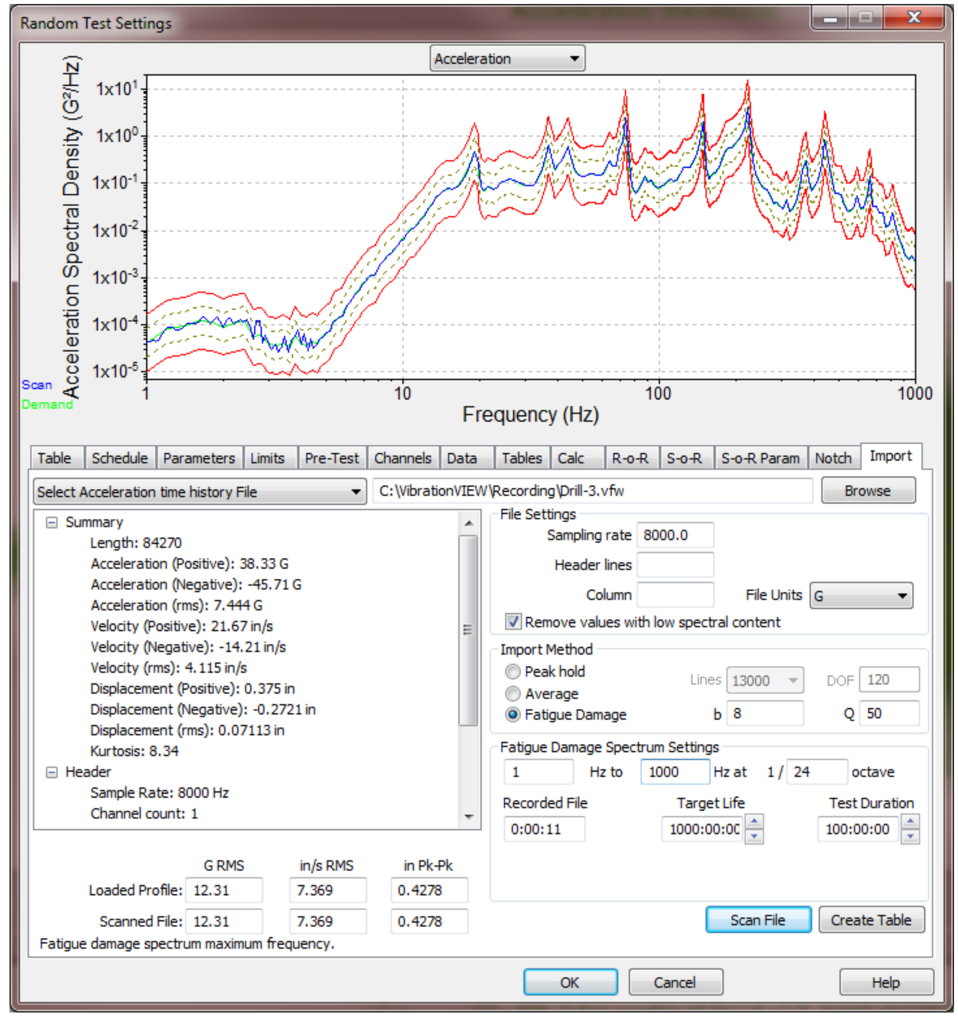
1) How long do I run this test?

2) Can I accelerate the test (shorten time)?

3-Fatigue Damage Spectrum

A Tool for Accelerated Testing

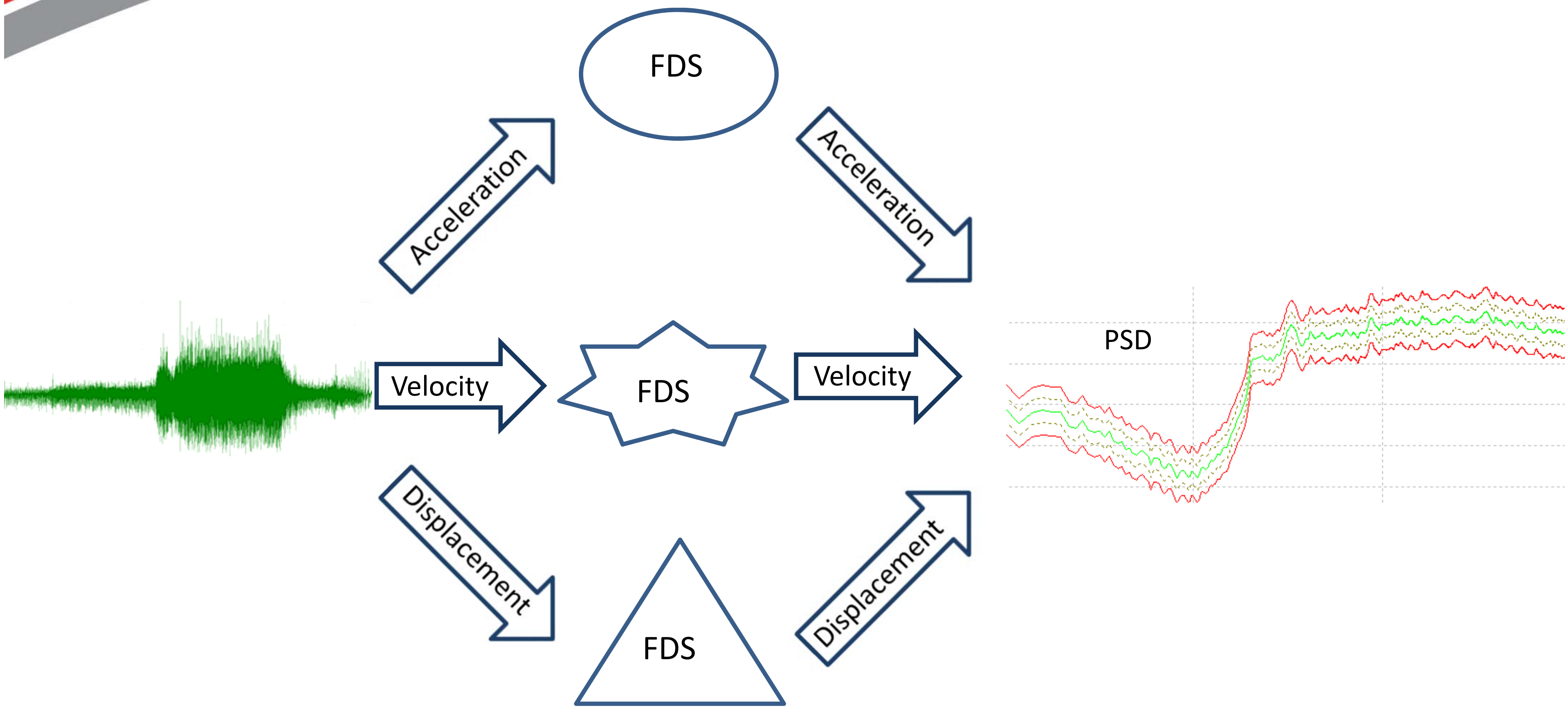




3-Fatigue Damage Spectrum

- Test engineers often ask how to create a random profile from recorded data
- FDS is an effective tool that can show the damage a product will experience at a particular frequency and helps determine how long to test in a lab and correlate that to the life of the product.
- FDS answers the questions:
  - What profile?
  - How long to run?

Methods for FDS Generation



εa = test or environment strain amplitude
σ'f = fatigue strength coefficient (material property)
E = modulus of elasticity (material property)
Nf = number of cycles to failure
b = fatigue strength exponent (material property)
ε'f = fatigue ductility coefficient (material property)
c = fatigue ductility exponent (material property)

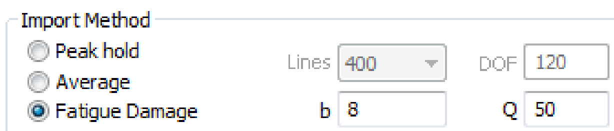
$$\varepsilon_a = \frac{\sigma'_f}{E}\left(2N_f\right)^b + \varepsilon'_f\left(2N_f\right)^c$$

3-Fatigue Damage Spectrum Example

I have 10 mins. of road data and would like to make a random test that recreates the same spectrum. Want to run an equivalent of 3600 hrs. of road data in 36 hrs.

1) Import data into the “Random Import” tab and click “scan file”

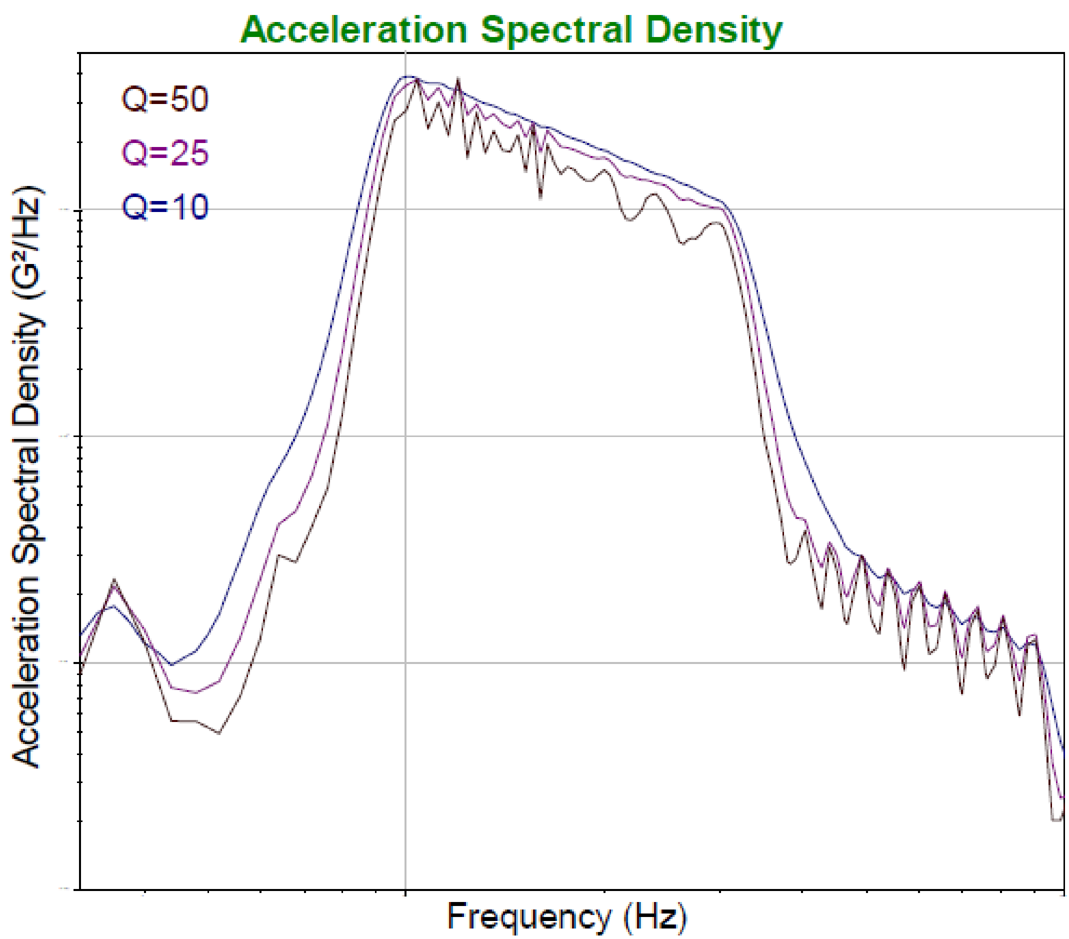
2) on the import method choose “fatigue damage”



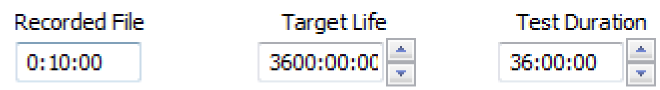
3) Select a ‘b’ and ‘Q’ value for your data and product

- “b” is calculated with: $N = c * S-b$
- “Q” or quality factor is used in narrow band pass filter calculations, and will affect the smoothness of the Fatigue damage (see next slide)
- If not sure then Mil-Std 810 suggests b=8 and Q=50 (see pg. 288 of MIL-STD 810G)

Different Q Value results in…



3-Fatigue Damage Spectrum Example

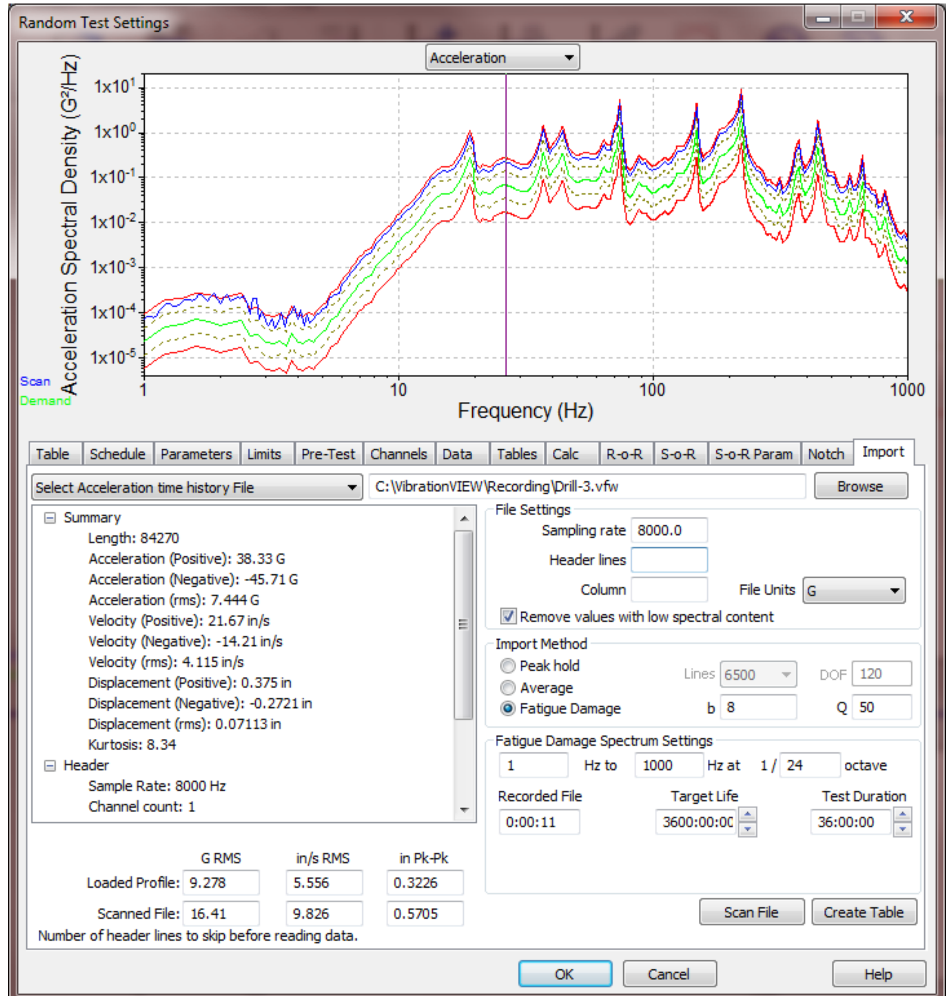


- 4) Enter the values into "Target Life" and "Test Duration" boxes.
  - Target life - should be set to how long you would like the test item to survive in the field – for example, we would like our item to survive for 3600 hours before breaking
  - Test Duration - field is for how much time is allotted for the test on a shaker. The lower you make this time, the more you are "accelerating" your test and perhaps introducing inaccuracy.
  - The ratio between the target life and the test duration is 100, which may or may not be reasonable depending on the test item.
- 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.

Fatigue Damage Spectrum in Practice

- Summary of Random import – Fatigue Damage
  - 9.28 Grms → 16.4 Grms
  - Kurtosis of recorded data is 8.34
  - Peak G: -45 G's3

- FDS answers the questions:
  - 1) How long do I run this test? – 36 hrs
  - 2) Can I accelerate it? Yes, 100 times



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