HEXAGON

CAEfatigue Software (Cf)

QUICK REFERENCE GUIDE

This document lists and describes the necessary entries (commands) required to run a Cf analysis in the Control File view or Process Flow view. This document also provides direction on how to use the Time Domain Load Scheduler toolset as well as the TIME2PSD toolset.

For theoretical background and practical example, the User should refer to the Cf **User Guide Examples** document.

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Please consult the **Release Notes** file that comes with the installation package for latest software updates.

CAEF:V2023.1.1:Z:Z:Z:DC-QRG-PDF

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1 | REQUIREMENTS

The avoidance of fatigue cracks (fatigue damage) and excessive response due to resonance is a design requirement for nearly all mechanical engineering systems. In fact, for many everyday products like cars, aircraft, trains, etc., fatigue life (or durability) is the limiting design requirement. Testing plays an important role in determining the required level of durability, but analysis is also vital at all stages of product development.

Typical durability analysis processes involve the integration of Finite Element Analysis (FEA) methods to evaluate the structural stress conditions that are caused by real world loading conditions. When the loading source is random in nature, the stress response is then also random in nature and the fatigue damage can be called “vibration fatigue”, “acoustic fatigue”, “sonic fatigue”, “very high cycle fatigue”, etc. In order to evaluate this kind of phenomena analytically, FEA is usually used to calculate the stresses or strains caused by the random loading conditions.

There are several major codes in existence that are used to calculate these random stress or strain conditions. These include, but are not limited to, MSC Nastran (MSC Software), NX Nastran (Siemens), Ansys and LS-Dyna (Ansys Corp), Optistruct (Altair) and Abaqus (Dassault Systems). These codes incorporate analysis procedures to deal with the dynamic response (resonances) in structural systems and they also have vertical applications to perform fatigue life calculations.

These random response and fatigue analysis procedures are generally complete and fully featured when the dynamic behavior is defined in the time domain (using time histories for the loading conditions). However, most dynamic analysts prefer to work in the so-called frequency domain where loads are defined as a function of frequency. CAEfatigue Software (CF) has been created to satisfy the needs of Users where these existing codes are functionally limited. The concept of Cf is to combine stress solver environments with fatigue life calculations where dynamic response is important both in the frequency domain and time domain. The fundamental objective of Cf is that it shall be fast, easy to use and understand, be capable of handling very large models, be able to cater for multiple correlated loads, be able to use mixed random and deterministic loads, have advanced fatigue capabilities (including Strain-Life) and be able to utilize appropriate stress output formats. It is intended to work (as a vertical application) with all major stress solvers and in some cases, it has embedded into the stress solvers.

Getting the Correct Output from the Solver (Nastran, Abaqus, Ansys or LS-Dyna)

MSC Nastran, NX Nastran, NEi Nastran

General Information

- Support is provided for **OP2** files from all Nastran versions and MSC Nastran™ **HDF5** files.
- MSC Nastran™ and NEi Nastran OP2 files must use vIBFAT>Source = Nastran. NX Nastran OP2 files must use vIBFAT>Source = NX. MSC Nastran™ HDF5 files must use vIBFAT>Source = nasth5.
- Currently the MSC Nastran HDF5 format can be used for a single and multi-input PSD analysis (using a Nastran SOL111) or for a linear static analysis (LQSTATIC), linear or nonlinear transient analysis (LTRANS or NLTRANS) or for a non-linear static analysis (NQSTATIC) from a Nastran SOL400 analysis or a SOL111 analysis of composite material in a CAEfatigue RANDOM analysis.
- The OP2 file must be specified using **PARAM,POST,-1** or **PARAM, POST, 1**. For MSC Nastran V2021.2 and later, **PARAM, POST, 1** is recommended/preferred
- Stresses must be written using the default method **(SORT1).**
- Stresses must be requested in the **REAL / IMAGINARY format** i.e., STRESS(SORT1, REAL, PLOT) or **MAG / PHASE format** i.e., STRESS(SORT1, PHASE, PLOT).
- Stresses can be requested using the **CORNER** option (either BILIN, CUBIC or SGAGE) or the **CENTER** option, the following applies:
    - If corner results are selected in Nastran, you will also get center results. Cf will output results for both element center and element nodes (nodes). CORNER option is required for certain functionality such as Seam weld analysis or Virtual Strain gauges

  - If center results are used in Nastran, Cf will output results for the element center ONLY.

- (For frequency domain Random Response) Nastran output must include the **DISP or DISPLACEMENT output** request if displacement, acceleration or velocity response output is required from Cf at the nodes (i.e., D, V or A output for nodes for random response) . Reading the node displacement outputs from the Nastran OP2 file is done within Cf by using the ABSRESP entry in the vFTGDEF entry. NOTE: Cf will calculate displacements, accelerations and/or velocities from the solver nodal displacements.
- (For frequency domain Random Response) If Force (vFTGDEF: ABSRESP: ABSVAR=F) is requested, then **FORCES(SORT1)** for an element set must be specified in the Nastran file.
- (For frequency domain Random Response) If Monitor Point Force (vFTGDEF: ABSRESP: ABSVAR=M) is requested, then **PARAM,POST,1** and **PARAM,POSTEXT,YES** must be specified in the Nastran file.
- (For frequency domain Random Response) If Relative Response (vFTGDEF: RELRESP) is requested, then **PARAM,POSTEXT,YES** must be specified in the Nastran file. (**PARAM,POST, 1** is recommended in case of OP2)
- If Spot Welds (**vFTGDEF: SPOTW**) is requested then **PARAM,POSTEXT,YES** must be specified in the Nastran file.
- If Spot Welds (**vFTGDEF: SPOTW**) is requested then **MPCFORCES(SORT1)=SETID_NODES** must be specified, where SETID_NODES is the set number for the list of grids (nodes) that form the corners of the spot weld CHEXA's. Note: technically, we are getting the forces in the RBE3 elements at the CHEXA node locations.
  - Make sure all grids are in one set, e.g., MPCFORCES (SORT1)=22. NOTE: Nastran will not accept multiple set number i.e., 22, 23, 24.
  - Another element set containing all the CHEXA's will be needed for the Cf analysis. This should be an FSET3 format. This should be an element set, which directly corresponds with the grid set mentioned above.
  - If conventional stress based fatigue calculations and/or random analysis calculations are to be done on other parts of the model, then the appropriate STRESS request and DISP requests must also be made in parallel with the MPCFORCES request.
- (For frequency domain Random Response) If User Welds (**vFTGDEF: USERWHS**) is requested then **FORCE(PLOT)=SETID_ELEMS** must be specified, where SETID_ELEMS is the set number for the list of CBUSH elements that are used to represent the user weld.
- If Seam Welds (**vFTGDEF: SEAMW**) is requested then **STRESS(SORT1, PLOT, CUBIC)=SETID_ELEMS** must be specified, where SETID_ELEMS is the set number for the list of elements running along either side of the seam weld. This set should also be created in FSET3 format for use in CF.
  - If conventional stress based fatigue calculations and/or random analysis calculations are to be done on other parts of the model, then the appropriate STRESS request and DISP requests must also be made.

- It is recommended that only one data block containing stresses using STRESS or ELSTRESS (Physical Output) is requested. This can be achieved by using only one FREQUENCY (Dynamic Solutions Conditions) entry above the 1st subcase or by having the same FREQUENCY ID repeated within all subcases.
- (For frequency domain Random Response) Where a mean stress calculation is specified, the model configuration (elements included in SETS, etc.) must be identical for both the SOL111 (or SOL108) and SOL101 (or SOL106) jobs.
- Subcases in the Nastran file are numbered, and these numbers must be referenced in the mapping entry OP2MAP.

- Cf supports both multiple subcases being used consecutively, and multiple subcases being used simultaneously (with correlation).

Information specific to Time Domain Modal Transient Analysis (LMTRANS)

- CF expects the modal stresses (OP2 or H5) and modal loading (PUNCH or H5) to be calculated and outputted from a single Nastran run. The modal stresses are to be output to the OP2/H5 file in the first subcase that contains the case control entries ANALYSIS = MODES and STRESS (SORT1). The modal participations are to be output using SDISP(PUNCH)=ALL or SDISP=ALL respectively for OP2 or H5 in all succeeding subcases.
- The User can also achieve the same output by running the SOL103 analysis first (creating the modal stress OP2 file), followed by a SOL112 with a restart entry to create the modal loading PUNCH files.
- Conducting a SOL112 analysis without the kind of case control mentioned above but with a STRESS entry, will results in an OP2 files that contains direct stresses (not modal stresses). This analysis can be done with LTRANS: direct time transient as opposed to a modal transient.

OPTISTRUCT

- Optistruct support is provided for OP2 files in the same way as Nastran. See MSC Nastran™ section above. Optistruct OP2 files must use vIBFAT>Source = OS.
- Optistruct behaves in a very similar way to MSC Nastran™ with a couple of small exceptions.
- Firstly, when writing stresses for separate subcases, Optistruct will always write separate data blocks.
- Secondly, when comparing analysis runs with other MSC Nastran codes be careful to check which PARAM instructions are applicable. Not all PARAM codes are used in Optistruct.
- ABSRESP / RELRESP is only supported with the latest 2018 version of Optistruct.
- If center results are used in Optistruct, Cf will output results for the element center ONLY.
- If corner results are used in Optistruct, Cf will add additional results at the centers based on a linear interpolation from the corners results. This is done for purposes like hot spot detection but generally the use of these center results should be avoided (the corner results are more accurate).

LS-DYNA

- Ansys LS-DYNA support is provided for 3dplot files with center stresses for linear transient dynamic analyses only (LTRANS) and must use vIBFAT>Source = lsdyna
- CF does not currently support the addition of static offset
- Ansys LS-DYNA version from April 2020 is tested and supported. Most existing version are also expected to work with CAEfatigue but have not been tested.

ANSYS

- Ansys support is provided for RST files with single or multiple steps (subcases) within each RST and must use vIBFAT>Source = ansys.

- Multiple RST's can be specified in order to apply multiple events (consecutively) but only single random loads are supported for this release (i.e., multiple correlated random inputs are not supported).
- It is assumed that Ansys steps (subcases) are numbered consecutively according to their order in which they are specified. Substeps in the Ansys RST file are not supported.
- Ansys will only output a result at corners (OUTRES,STRS,ALL). Cf will add additional results at the centers based on a linear interpolation from the corners results. This is done for purposes like hot spot detection but generally the use of these center results should be avoided (the corner results are more accurate).
- CF does not currently support the ABSRESP entry (in vFTGDEF) for Ansys so you cannot ask for PSDs of displacement, velocity or acceleration in Cf using the Ansys RST file.
- If a static load is applied this must be provided in a separate RST file. Note: the first subcase in the file will be taken as the Static subcase for the analysis.
- Ansys versions 14.5 and later are supported.

ABAQUS

- Abaqus support is provided for ODB files with single or multiple subcases and must use vIBFAT>Source = abaqus.
- You can use the default Gauss point output results or set the Abaqus results output to either corners or centers (***Element Output, position = NODES or *Element Output, position = CENTROIDAL**) but not to both. Note that in the CSV Control File, the appropriate entry for GIDOUT (Center or Corner) should be specified on the vIBFAT entry.
- If corner results are used in Abaqus, Cf will add additional results at the centers based on a linear interpolation from the corners results. This is done for purposes like hot spot detection but generally the use of these center results should be avoided (the corner results are more accurate).
- Abaqus output must include the *Node Output request for TU displacements if random response output is required at the nodes (i.e., D, V or A) from the Cf run. Reading the node displacement outputs from the Abaqus ODB file is done within Cf by using the ABSRESP entry in the vFTGDEF entry.
- For Spot and Seam Weld analysis, the User must define element sets and the job parameters to be considered for the fatigue analysis and output desired.
- Make sure that the ODB file containing the required harmonic subcases contains only those subcases.
- An ODBMAP entry must be used in Cf to assign number to the STEP names. **This is REQUIRED**.
- Abaqus 6.14, 2016 thru 2022 are supported. Note: Linux Abaqus v2016 is only supported with the FP1825 Fix Pack or newer.

NOTE: If using Abaqus as the solver, you must start your input PSD definitions at f1=0, g1=0 to eliminate the influence of the stress output by Abaqus at 0 Hz. This is a meaningless output that is used in the transfer function and will cause errors in your response results if the input PSD is not set to zero as the initial point. You can also set the second point to amplitude 0 as described in the example.

Example: If your first actual input PSD point is at, say 8 Hz, 15 G^2/Hz, make the first two points f_1=0, g_1=0 and f_2=7.999, g_2=0. Make the third point f_3=8.0, g_3=15.0 and continue with your remaining PSD data points. This will make sure that the 0 Hz stress output point provided by Abaqus (and used in the transfer function) does not influence the response output.

On the following page is a matrix of supported capabilities for each supported solver.

Whichever stress solver is used great care should be taken to ensure there is an adequate distribution of solution frequencies in the transfer function. Solution frequencies need to be adequately spaced to pick up resonances (the FREQ1 and FREQ4 entries in Nastran are a good tool for this) as well as a finely spaced set of solution frequencies in any location where the input load changes.

In all cases, be careful about specifying frequencies at or near zero hertz. Strange results can occur (depending on the unit of load applied) as the frequencies tend to zero. For example, with a multi input full car system it might be appropriate to start the frequencies at 0.5 Hz or 1.0 Hz.

Also, be careful what range of frequencies have been requested for the eigenvalues, especially if frequencies have been requested around the eigen frequencies, because a very large number of modes can occur as the frequency range is increased and the higher modes may have no influence. It is useless to specify solution frequencies in the solver run above the maximum loading frequency in the input PSD(s).

The HOTSPOT flag (in vFTGDEF) can now be used to determine a filtered set of elements, and this could be a logical way to reduce very large models before final processing with the Cf code.

*Force is only supported for Nastran element CBUSH and Abaqus element CONN3D2.

	Single PSD inputs - stress output	Single PSDs plus static inputs - stress output	Single PSDs plus deterministic inputs - stress output	Single PSDs plus deterministic plus static inputs – stress output	Multiple correlated inputs - stress output	Multiple correlated plus static inputs - stress output	Multiple correlated plus deterministic inputs	Single PSD Inputs - D, V, A or F * output	Single PSD plus static Inputs - D, V, A or F output	Multiple correlated inputs - D, V, A or F * output	Relative random response output (RELRESP)	FLUCT type plus static loadings - stress output
Nastran	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes
Abaqus	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	no
Optistruct	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes
Ansys	yes	yes	yes	yes	no	no	no	no	no	no	no	no

Setting the ABAQUS Library Directory Path

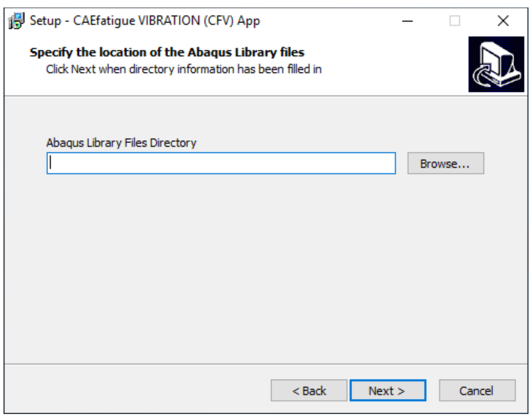
If you choose to use ABAQUS as a Solver, Cf requires access to the Abaqus Library files, which are needed to read in the frequency response function (FRF) ODB file as well as to view the Abaqus model.

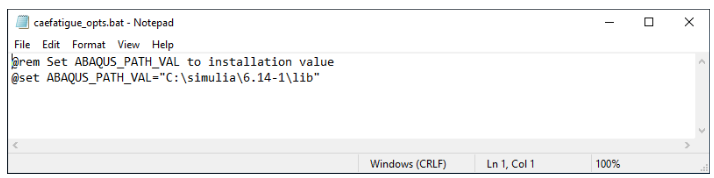
During the installation process, the User can choose to provide the location of the Abaqus Library directory by pointing to the individual directory for a certain version of Abaqus or by pointing to a text file that has multiple Abaqus Library directories already defined.

Below are 3 options to define the Abaqus Library directory location in the order used by CF.

Option 1 – Provide Directory Location during Cf Installation via CAEFATIGUE_OPTS.TXT file

The Abaqus Library Directory is an optional entry available during the Cf installation process. If you select the appropriate check box during the installation, you will be asked to enter the location of the Abaqus Library. This information will be entered into a new file called “***caefatigue_opts.txt***” and placed in the installation directory; by default, C:\Program Files\MSC.Software\CAEfatigue\<ver>\caefatigue_opts.txt.

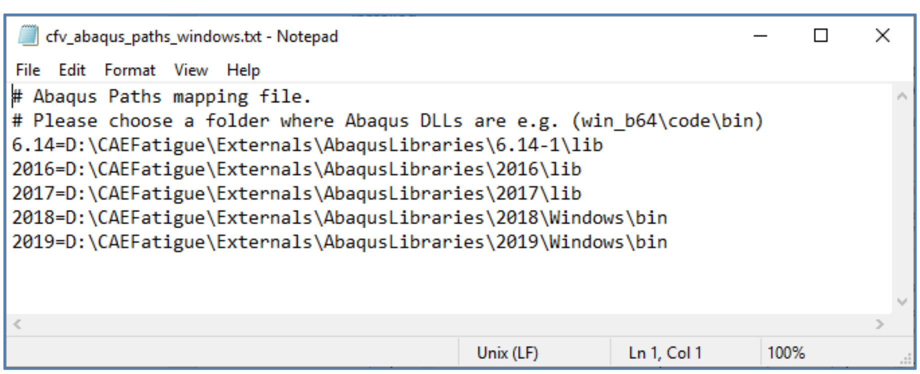




You can also set the path to point to a text file that defines multiple Abaqus Library directory locations for different versions of Abaqus. By doing this, the User can run Cf jobs with different Abaqus models and not worry about the version of those models because the text file will tell Cf where to find the needed libraries.

Below is an example of the text file format. This can be done during the installation (if you have the text file already created) or afterwards by simply editing the OPTS file to replace the contents with the contents of the text file.

Note: please point to the “LIB” directory for Abaqus versions 6.14, 2016 and 2017. Point to the “BIN” directory for Abaqus versions 2018 thru 2021.



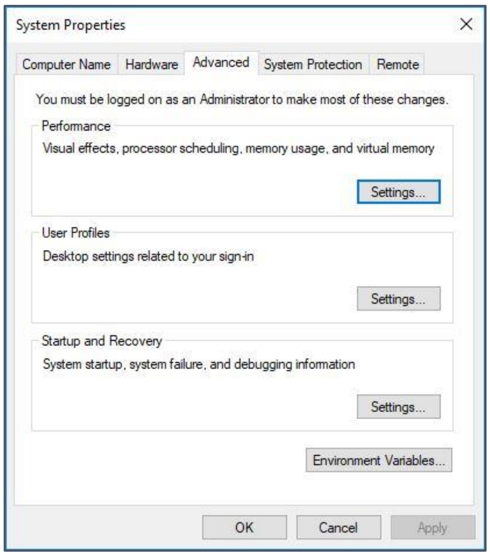
Option 2 – Provide Directory Location via the ABAQUS_PATH Environment Variable

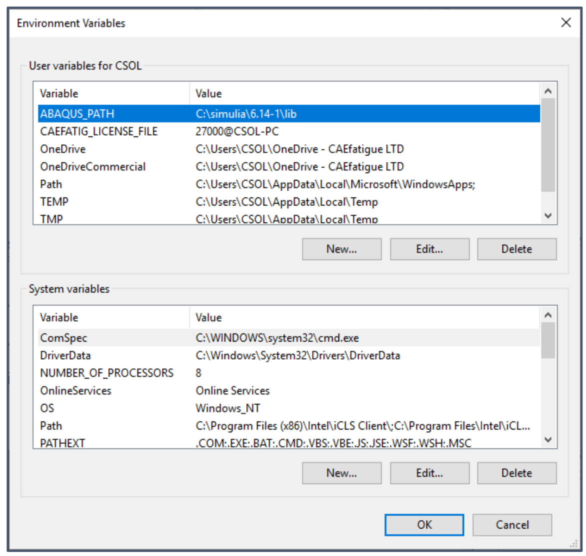
If you choose not to set the directory location via Option 1, the User can choose to create an environment variable called ABAQUS_PATH through the System Properties window. As above, the User can set the variable to point to the location of a Abaqus library directory for a specific version of Abaqus OR the User can point to a text file that contains the Abaqus library directory locations for multiple versions.

Below is an example of the ABAQUS_PATH for a single directory location and an example of the ABAQUS_PATH for a text file that defining the directory paths to multiple Abaqus versions.

ABAQUS_PATH=c:\simulia\6.14-1\lib

ABAQUS_PATH=c:\Abaqus\Abaqus_Directory_Definitions.txt



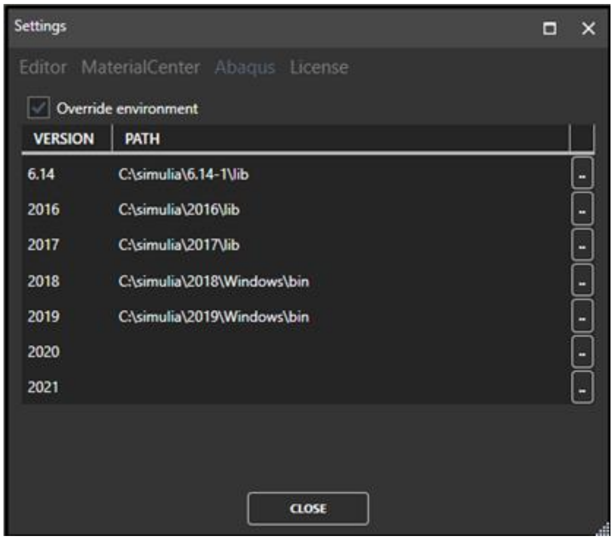


Option 3 - Provide Directory Location via the SETTING menu in CFG

If you do not set the Abaqus Library Files directory via Option 1 or Option 2, you can set the directory paths using the SETTINGS menu in the CAEfatigue GUI (CFG).

To do this, select the SETTING icon when the software is up and running. This will open a SETTINGS menu box where you can set individual paths to individual Abaqus versions. Please ensure the “OVERRIDE ENVIRONMENT” box is CHECKED. This will tell Cf to override both Option 1 and Option 2 (if they are set) and use the locations defined in the Abaqus Setting window. If the User wishes to use Option 1 or Option 2 at a later date, the “OVERRIDE ENVIRONMENT” checkbox must be UNCHECKED.

By default, the directory locations defined in the Abaqus Settings window are stored in a hidden text file called: **…\AppData\Roaming\CAEfatigue\CF_abaqus_paths.txt**. If there is an error with a directory path specified in this window, Cf will report the error in the LOG file and reference this hidden file. If you see this error, the issue is within the Abaqus Setting window



Solver Supported Elements

Nastran

Name	Type	Number of GID's	
CQUAD4/8	Shell	4 corners + center on 2 layers	= 10 GID's
CTRIA6	Shell	3 corners + center on 2 layers	= 8 GID's
CTRIA3	Shell	3 corners + center on 2 layers	= 8 GID's
CTETRA	Solid	4 corners + center	= 5 GID's
CHEXA	Solid	8 corners + center	= 9 GID's
CPENTA	Solid	6 corners + center	= 7 GID's
CBUSH	for forces.		
CPYRAM	Solid (pyramid)	5 corners + 8 midside, if desired	= 5 to 13 GID's

LS-DYNA

The elements supported are NEL8, NEL4, NELT, NEL2 and NEL10.

Ansys

The elements supported are 181, 281 (quads) and 185, 186, 285, 187 (solids)

Abaqus

Triangular Shell (3 main nodes) - CPE3**, CPE6**, CPS3**, CPS6**, CPEG3**, CPEG6**, STRI3**, STRI6**, SC3**, SC6**, CAX3**, CAX6**).

Rectangular Shell (4 main nodes) - CPE4**, CPE8**, CPS4**, CPS8**, CPEG4**, CPEG8**, SC4**, SC8**, S4**, S8**, CAX4**, CAX8**).
Solids (4 main nodes) – C3D4**, C3D10**.
Solids (6 main nodes) – C3D6**, C3D15**.
Solids (8 main nodes) – C3D8**, C3D20**, C3D27**.
Membrane elements M3D3, M3D6 M3D4 M3D8.
CONN3D2 element is supported for force output.

How are Units Handled in CF?

CF assumes the following default units come from the Solver:

Stress => MPa
Force => N
Displacement => mm

If this is not the case, the User must include an **FE_UNITS** entry to define the actual stress units coming from the Solver, i.e., Pa, PSI, KSI, or User Defined units. Cf will write out all results in the FE_UNITS or units provided by the FE model when dealing with displacement, velocity, acceleration or force.

Any material data is also expected to be in the correct units to work with stress in MPa. If they are not, the User must also define the actual material units in the **vMATFTG** entry.

NOTE: Cf expects a consistent system for units and will output results in the following units:

Examples of Consistant Systems of Units for Structural Analysis											
System of Units	***Input***								***Output***		
	Length	**Force**	**Elastic Modulus**	**Mass**	**Mass Density**	**WTMASS Param**	**Acceleration (1 G)**		**Disp**	**Force**	**Stress**
1 Metric meter-kg	m	N	Pa	kg	Kg/m^3	1.0	9.807	m/sec^2	m	N	Pa
2 Metric mm-ton	mm	N	MPa	t or Mg	t/mm^3 or Mg/mm^3	1.0	9807	mm/sec^2	mm	N	MPa
3 English ft-lb	ft	lb_f	psf	slug	$slug/ft^3$	1.0	32.17	ft/sec^2	ft	lb_f	psf
4 English in-lb (mass)	in	lb_f	psi	lb_f - sec^2/in	lb_f - sec^2/in^4	1.0	386.1	in/sec^2	in	lb_f	psi
5 English in-lb (force)	in	lb_f	psi	lb_f	lb_f /in^3	0.00259	386.1	in/sec^2	in	lb_f	psi

Result Quantity	Units
Moment – M0	FE_UNITS or default MPa2
Moment – M1	FE_UNITS or default MPa2 * Hz
Moment – M2	FE_UNITS or default MPa2 * Hz2
Moment – M4	FE_UNITS or default MPa2 * Hz4
E[P]	Hz or (cycles / sec)
E[0]	Hz or (cycles / sec)
Irregularity Factor	No units
Displacement	Units from FE model
Velocity	Units from FE model
Acceleration	Units from FE model
Force	Units from FE model

Result Quantity	Units
RMS stress = √ (M0)	FE_UNITS or default MPa
RMS strain	No units
Mean stress	FE_UNITS or default MPa
Damage	No units
Life	Life per DUR_UNITS
Margin of Safety (MOS)	Percent
Plasticity Index	No units
Freq at Peak Response	Hz
Clearance (collision detection)	Units from FE model
Collision Probability	Percent

System Requirements

The Cf application runs on 64-bit Intel and Intel-compatible processors running a 64-bit version of either Windows or Linux.

- For Windows, Windows 8 or later is supported. The Graphical User Interface support program also requires the Microsoft .NET 4.5 (or later) framework and several Microsoft Visual C++ Runtime Libraries depending on the version of Windows being used. Note that these files will be installed automatically if they are not already installed.

- For Linux, SUSE 12 SP4 or later, RHEL 7.7 or later and compatible systems are supported.

The system should have a minimum of 16 GB RAM. Approximately 4 GB of free disk space is required for the installation and additional disk space will be required to run the Cf application. It is **highly** recommended that additional RAM be available for large models.CF can handle virtually any size results file provided the hardware has sufficient memory to do the solver analysis.

License Requirements and Special Licensing Parameters

Cf requires the installation of MSC Licensing Helium which is available under the MSC Licensing product page within the MSC Software Download Center. Note: if after January 2021, any new installation will require MSC **Licensing Lithium**.

Job Execution / Loss of Connection Timeout Parameter for Command Prompt / Linux Build

If you wish to run consecutive jobs, perhaps in batch mode through your own script, Cf has a special parameter in the script file (caefatigue.bat) that allows Cf to pause execution of the next analysis in the queue while waiting for a license / token to free up.

To invoke the CAEfatigue executable with the TIMEOUT parameter, whether from the Command Prompt or in Linux, use the line below.

CAEFatigue.bat -license-timeout <value> *filename.txt*

Where <value> means

- If -1, the software will wait indefinitely for the next available license / tokens to run the next job in the queue.
- If 0, the software will not wait and will terminate if a license or tokens are not available to output the results of an ongoing analysis or for a new analysis.
- If any other value, the software will wait that value in minutes for an available license / tokens to write out the results of an ongoing analysis or to run the next job in the queue.

By using the above, the User can add several CAEfatigue.bat entries into a User defined script and if a license is not available, the software will wait for a license to free up instead of terminating Cf because no license was available.

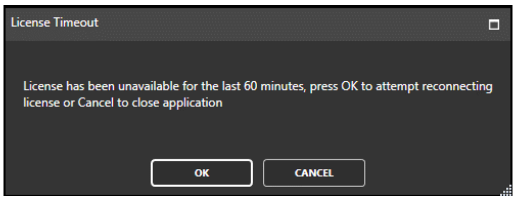
This parameter is also invoked if the connection to the license server is lost. CAEfatigue will check for a license just before writing out results from an ongoing analysis or before starting a new analysis. If a license cannot be found, the job will suspend for the TIMEOUT period and if no license is available during that time, the software will present a warning to Resume or Terminate.

NOTE: this adjustable Timeout parameter is only available for scripting i.e., from the Command Prompt or from Linux.

Loss of Connection Timeout Parameter - Windows

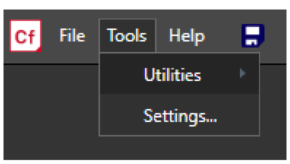
This parameter is invoked if the connection to the license server is lost. If the connection is lost, CAEfatigue will display a warning in the software banner that the license is unavailable, but the software will continue working for 60 additional minutes. The banner warning will stay present for the entire 60 minutes, even if the connection is reestablished.

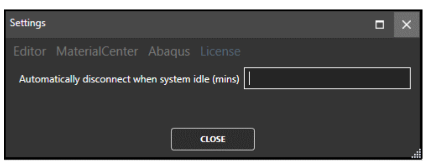
At the end of the 60 minute period, CAEfatigue will provide the User with an option to attempt a reconnection to the license server or to close the software.

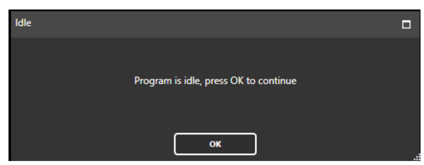


Software Idle Timeout Parameter - Windows

CAEfatigue offers an IDLE timeout parameter that can be set in the TOOLS> Settings box. The IDLE timeout will recognize that you have stepped away from the computer if there is no activity (i.e., keystrokes or mouse clicks) for a period of time and will automatically disconnect you from the license so it can by freed up for others to use. Note: A value of zero (0) or a blank field, means the parameter is disabled.







ADMINISTRATIVE USE: The Idle Timeout can be set by the Administrator as an Environment Variable. Simply create the variable shown below and set the VALUE to the number of minutes desired before idling the software and releasing the license.

CFV_LICENSING_TIMEOUT = <value in minutes>

Noteworthy Limitations of the Software

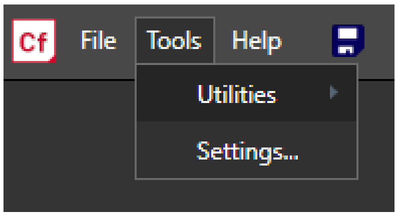
The following limitations exist in this release:

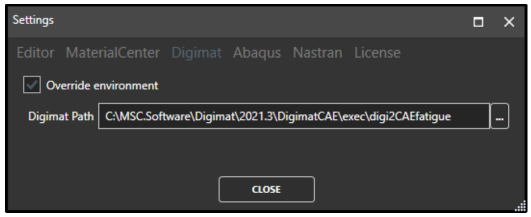
- The Ansys solver is not supported for ABSRESP and RELRESP in the vFTGDEF entry.
- The use of Deterministic loads (DETLOADS, SINGSINE and SINESW) and the use of principal stresses (ABSMAXPR or MAXPREST) are not supported for multi-input PSDs analysis. If principal stress output is requested by mistake, CAEfatigue will change the output to sign von Mises and put a not in the LOG file that this was done.
- The response time history created by vFTGDEF> TIMEOUT is in Stress range in case of SN material and Strain amplitude in case of EN material

Connecting to Digimat

CAEfatigue offers the ability to obtain SN curves for Short Fiber Reinforced Plastics (SFRPs) from Digimat when doing certain Time Domain or Frequency Domain analysis. To do this, Cf must know where the **digi2caefatigue** interface file is located and the User must have a Digimat license. The path to the Digimat interface file is set in the CAEfatigue **Tools>Settings** window as discussed earlier. Typically, this path is similar to:

```
C:\MSC.Software\Digimat\2021.<ver>\DigimatCAE\exec\digi2CAEfatigue
```

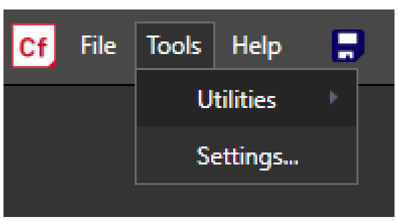


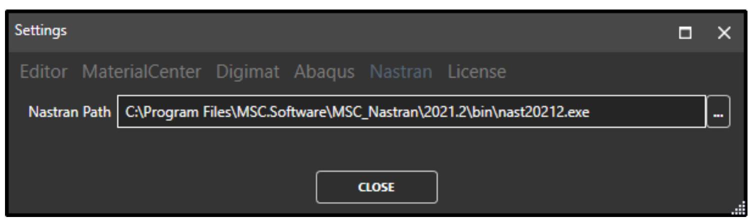


Connecting to MSC Nastran™

CAEfatigue offers the ability to run a NEF job from within the Cf GUI. To do this, Cf must know the executable file for MSC Nastran™ and the User must have a MSC Nastran™ license. The path to the MSC Nastran™ executable is set in the **Tools>Settings** window as discussed earlier. Typically, this path is similar to the example shown below for Nastran v2021.2.

```
C:\Program Files\MSC.Software\MSC_Nastran\2021.2\bin\nast20212.exe
```





Using 3rd Party Software

This software makes use of various 3rd party libraries as referenced in the Appendix section.

About This Document

This document forms part of the documentation for the Cf software product. The reader is also referred to the Cf ***User Guide*** and the ***User Guide Examples*** document. This Quick Reference Guide is intended to be used by engineers or designers with a basic knowledge of fatigue, FEA and Dynamics.

The Cf software program also includes a Windows™ graphical User interface for visualizing output results. The User can also use other GUI's programs such as Patran, or HyperView to see output results or the results can be visualized using standard tools like EXCEL™ with our CSV output option.

Contacts

Please submit customer support requests through the email ***caefatigue.support@mscsoftware.com***.

2 | INTRODUCTION TO THE CAEFATIGUE SOFTWARE (CF) COMMAND ENTRIES AND FIELDS

CF operates like Nastran, meaning, the operation of the software is based on the instructions found in a Control File.

This Control File is created directly by defining ENTRIES (rows) and FIELDS (cells) in a text file that provides the software with all the parameters needed to execute a random response or fatigue calculation. The Control File can also be created indirectly by using the Process Flow interface to define an analysis through a graphical layout. From that layout, Cf will create the appropriate Control File.

This section will introduce the large array of instructional entries and fields that are available for both the fatigue analysis (in the frequency domain and time domain) and the time history to PSD conversion tool - TIME2PSD – that is also included in the Cf software.

An introduction to the Control File User Interface and Process Flow User Interface can be found in the CAEfatigue User Guide.

Entries (Commands) and Fields used in Frequency Domain Analysis

Below is the complete set of available entries that can be used to do a Cf frequency domain analysis (either in the Control File view or Process Flow view). In a typical analysis, only small selection of these items are used. Please note: Entries in *GREY* are not currently supported.

DATA COLUMN 1	DATA COLUMN 2	DATA COLUMN 3	DATA COLUMN 4	DATA COLUMN 5	DATA COLUMN 6	DATA COLUMN 7	DATA COLUMN 8	DATA COLUMN 9
vIBFAT	JOBID	OFILTYPE (*CSV*)	SOURCE (*NASTRAN*)	GIDOUT (*CENTER*)	LOGLVL (*0*)	JOB_NAME (*control file name*)		
	"OPTIONS"		STRLIM (*0*)			OUTDIR		
PARALLEL	TH_CAP							
OP2MAP(S)	FILE_NAME (for dynamic and static (S) stresses from NASTRAN)							
	$CFLCID_i$	$OP2LCID_i$						
ODBMAP(S)	FILE_NAME (for dynamic and static (S) stresses from ABAQUS)							
	$CFLCID_i$	$ODBLCID_i$						
vFTGDEF	JOBID	ATYPE (*DIRLIK*)	TOPRMS (*100*)	MID	CLIPLEV (*same as MAXSTR*)	MAXFREQ (*99.9*)	MAXSTR (*3 for SINES 10 Otherwise*)	STRBINS (*1280 for Sines 32 Otherwise*)
	"ELSET"	$ELSID_1$	MID_1	$ELSID_2$	MID_2	CONTINUE		
	"HOTSPOT"	NHS (*1*)	HSGATE (*1*)	HSFLAG	STOP (*NO*)			
	"FILTER"	TOPRMS	TOPRMSD	TOPRMSV	TOPRMSA			
	"DIAGNOS"	*NHSD*	HSSET	*CHSET*	*VAR* (*STRESS*)			
	"PSDOUT"	$PSDVAR_1$	$PSDID_1$	CONTINUE				
	"CRITOUT"	CRITVAR1	CRITID1	CONTINUE				
	"PSDMOUT"	OUTVAR	G_1	DOF_1	CONTINUE			
	"SGATE"	METHOD (*4*)	*EVOPT*	*MODE*	*TYPE*	*T_ACC*	*PL_LIM*	
	TARGET_FILE (results that SGATE will try to achieve)							
	"USERWHS"	$HLSID_1$	MID_1	$TENSID_1$	$HLSID_2$	MID_2	$TENSID_2$	
		$HLSID_3$	MID_3	$TENSID_3$	CONTINUE			
	"SPOTW"	SPSID1	MID1	DIAM	T1	T2		
		SPSID2	MID2	DIAM	T1	T2	CONTINUE	
	"SEAMW"	SWSIDi	MID1	NDSID1	*BTHRESH (0.5)*	*RTHICK (1.0)*	nTHICK (*0.16667*)	WTYPE (Toe)

	“ABSRESP”	ABSVAR$_1$ (*DVAF*)	SETID$_1$	ABSVAR$_2$ (*DVAF*)	SETID2	CONTINUE		
	“RELRESP”	RELVAR	SETID	PARAM1 (*same as MAXPEAK*)	PARAM2			
	“RELRESP2”	RELVAR	NODEID$_1$	NODEID$_2$				
	“SNXML / ENXML”	SETNAME	SETID1	SETID2	SETID3			
FE_UNIT	JOBID	CNVRTS (*MPa*)	FE_L_MAG (*1.0*)	CONJCON (*B*)	CNVRTF (*N*)	CNVRTL (mm)		
vMATFTG	MID	CNVRTM (*MPa*)	AMP_RNG (*RANGE*)	SN_TYPE				
	“STATIC”		UTS	E	Code		SE	
	“CYCLIC”	K’	n’					
	“SN”	SRI1	b1	Nc1	b2 (*0.0*)	Nfc (*1.0E30*)	SE	
	“KADJ”	KU	KT	KRNUM	KRDESC			
	“SN0” “SN1” “SN2”	SRI1	b1	Nc1	b2	Nfc	MSS	SE
		SF-FXY	DE-FXY	TE-FXY	SF-MXY	DE-MXY	TE-MXY	
		SF-FZ	DE-FZ	TE-FZ	SF-MZ	DE-MZ	TE-MZ	
	“SNx_FKM”	M1	M2	M3	M4			
	“SNBR1” “SNBR0”	SRI1	b1	Nc1	b2	Nfc	SE	
	“SEAM_FKM”	M1	M2	M3	M4	MSS		
	“EN”	σ'_ϕ	B	ε'_ϕ	c	K’	n’	Y (*0.5*)
		SEe	Sep	Sec				
	“AUTOSN” or “AUTOEN”	Can be used instead of SN or EN						
	“MMPDS”	A1	A2	A3	A4			
	“TABLE”	TID$_1$	T$_1$	SE	CONTINUE			
	“FILE”	UDID	Type	XML_File_Reference				
	“DIGIMAT”	TYPE	File_Location					
vMATSTAT	MID	CNVRTM (*Mpa*)						
	“STATIC”		UTS	E				
	“CYCLIC”	K’	n’					
vMATXML	MID							
	XML filename							
	Crossover filename							
vFTGPARM	JOBID							

	"STRESS"	COMB *(SGVON)*	CORR *(NONE)*	NCALC *(NAVER)*	DEBUG *(NONE)*	TOLER *(1.0E-5)*	MAXPEAK *(CLIPLEV / 2)*	RCCT *(60.0)*
	"CYCPROC"	TRSTIN *(NO)*	*EVALL* *(NO)*	HYST *(CORR)*	TRSTOUT *(NO)*			
	"SPOTW"	COMB *(CRITICAL PLANE)*	CORR *(None)*	NANGLE *(18)*	SWLOC *(0)*	ZCOMP *(1)*	MIDDLE *(0)*	
	"SEAMW"	COMB *(ABS MAXPR)*	CORR *(None)*	THICK *(0)*	WELDTOP *(Upper)*			
	"CERTNTY"	CERTSV *(50.0)*						
	"USERWHS"	COMB *(SGVON)*	CORR *(NONE)*	NANGLE *(18)*	SWLOC *(0)*			
	"FOS"	LIFE	BACKACC *(5.0)*	MAXFAC *(5.0)*	MINFAC *(0.2)*			
vFTGSEQ	JOBID	EVNTOUT *(0)*	DUR_UNITS *(SECONDS)*	MOS_DUR *(SUM of EVENTS)*	TSCALE *(1.0)*	NREP *(YES)*		
	$EVID_1$	EVT_1 *(1.0)*	$EVID_2$	EVT_2 *(1.0)*	CONTINUE			
	"UNITS"	EQUIV	EQNAME					
vFTGEVNT	EVID	$FLOAD_1$	$FLOAD_2$	CONTINUE				
	"NAME"	EVENT_NAME						
vFTGLOAD	FLOAD	TYPE *(PSD)*	SID	SCALE *(1.0)*	OFFSET			
LCID	FILE_NAME							
vRANDPS	SID	J	K	X *(1.0)*	Y *(0.0)*	TID		
vTABRND	TID	XAXIS *(LINEAR)*	YAXIS *(LINEAR)*	UDID				
	f_1	g_1	f_2	g_2	endt			
vUDNAME	UDID							
	FILE_NAME							
vRANDT	SID	T	Units *(SECONDS)*					
NBLOAD	SID	LCID	f_1	b_1	h_1	CONTINUE		
DETLOAD	SID	LCID	f_1	g_1	CONTINUE			
SINGSINE	SID	LCID	f_1	g_1				
SINESW	SID	LCID	f_1	g_2	f_n	g_n	SWTYPE *(LINEAR)*	SWNUM *(50)*
	"PARAMS"	SWRATE	N_SWEEPS	FRF_UNIT	LD_UNIT			
KTDATA	JOBID	ELSETi	SCALEi	OFFSETi				

FSET3	ELSID	DES	ID_1	ID_2	ID_3	ID_4	ID_5	CONTINUE
INCLDIR	JOBID	DIR_NAME *(LOCAL DIRECTORY)*						
INCLUDE	FILE_NAME							
RESTART	FILE_NAME							
VECTOR	JOBID	VXCOMP	VYCOMP	VXCOMP	VINCR			
PERTURB	PTYPE	VALUE						
FNOTCH	FNID							
	$LCID_i$	f_{ia}	f_{ib}	$SCALE_i$ *(0.0)*				

A brief description of each entry is given in the table below. For a full explanation of the individual entries please refer to the relevant sections in this document.

Brief Description of Entries and Fields used in Frequency Domain Analysis

ENTRY NAME	DESCRIPTION
vIBFAT	**Vibration Fatigue Output Request**
JOBID	CF job ID.
OFILTYPE	Choice of CSV, FEF, CSVFEF, H3D, FEFH3D, CSVH3D, H3Dxx, CSVH3Dxx, FEFH3Dxx (where xx = nb/nt/nw), FEFyy, CSVFEFyy (where yy =eb/et/ew/nb/nt/nw). FEF is a flat ASCI Patran Neutral file. H3D is an Altair binary format file.
SOURCE	Must be Nastran, Ansys, Abaqus, LSDyna or Optistruct.
GIDOUT	CORNER, NODAV, CENTER, CENTUPP or CENTLOW.
LOGLVL	Level of messaging; 0 = standard, 1 = +PSD, 2 = +Fatigue.
JOB_NAME	Used to tag all output files. No character limit for entry.
“OPTIONS”	FLAG. Indicates various options are to follow.
STRLIM	Set to “1” to only use elements from ELSETS. Set to “0” to use all elements in Solver file.
OUTDIR	Directory location where all output files should be written. No character limit on entry.
OP2MAP(S)	**Nastran Subcase Mapping Entries**
FILE_NAME	File name of Nastran OP2 file.
$CFLCID_i$	CF Load case ID number. Must start at 1.
$OP2LCID_i$	Subcase ID in OP2 file.
ODBMAP(S)	**Abaqus STEP Mapping Entries**
FILE_NAME	File name of Abaqus ODB file.
$CFLCID_i$	CF load case ID number. Must start at 1.
$ODBLCID_i$	Name of relevant STEP in Abaqus ODB file.
vFTGDEF	**Fatigue Element Definitions**
JOBID	CF job ID.
ATYPE	Dirlik, NB (narrow band), Stein (Steinberg), Sines (sines only), or Simsine.
TOPRMS	Top RMS stress percentage used to filter analysis set.
MID	ID of a vMATFTG entry (leave blank for **Random Only Response**).
CLIPLEV	Value of stress clipping as a function of RMS.
MAXFREQ	Frequency value for moment integration.
MAXSTR	MAX stress as function of RMS, to be used in RCC.
STRBINS	Number of bins to use in RCC histogram.
“ELSET”	FLAG. Element set ($ELSID_i$) and property (MID_i) pairs to follow.
$ELSID_i$	Unique FSET3 ID.
MID_i	Unique vMATFTG ID (leave blank for **Random Only Response**).
“HOTSPOT”	FLAG. Conduct Hot Spot detection with following parameters.

NHS	Number of hot spots to be detected.
HSGATE	Number of elements to show around hot spot.
HSFLAG	Set Name.
STOP	Terminate job after hot spot 1st pass.
“FILTER”	FLAG. Filter element / grids based on RMS.
TOPRMS	Pass through element based on RMS stress. Alternate location to input TOPRMS.
TOPRMSD	Pass through grids based on % RMS displacement.
TOPRMSV	Pass through grids based on % RMS velocity.
TOPRMSA	Pass through grids based on % RMS acceleration.
“DIAGNOS”	FLAG. Write output diagnostics results to diagnose.csv file.
NHSD	*Number of monitoring location (hotspots) to use.*
HSSET	FSET3 ID that list elements to be used.
CHSET	*FSET3 ID that list channels to be used*
VAR	*Output options including Stress, Stain, Damage.*
“RCCOUT”	FLAG. Indicates RCC and damage response output.
RCCVAR$_i$	Option is BOTH (RCC and Damage).
RCCID$_i$	FSET3 set of nodes or elements to be used in RCC and damage output.
“PSDOUT”	FLAG. Indicates PSD response output.
PSDVAR$_i$	Choice of S, D, V, A, F and/or M output requested in this order.
PSDID$_i$	FSET3 set of nodes or elements to be used in PSD response assessment. MONPNT3 Set Name for OUTVAR = “M”.
“CRITOUT”	FLAG. Indicates 2D/3D critical plane output parameters to follow.
CRITVAR$_i$	Choice of DS (damage and RMS stress). Only RMS in Frequency Domain.
CRITID$_i$	Set of Element ID for output
“PSDMOUT”	FLAG. Indicates PSD matrix response output.
OUTVAR$_i$	Choice of D, V, A or M.
G$_i$	Grid IDs for output matrix or MONPNT3 Set Name for OUTVAR = “M”.
DOF$_i$	Degrees of Freedom for output.
“SGATE”	FLAG. Conduct Surrogate Load analysis with the following parameters.

METHOD	Method used for the optimization.
EVOPT	*Choice of optimization type; Stress, Damage or EV_NUM*
MODE	*Choice of optimization type; Stress, Damage or EV_NUM*
TYPE	*Type of Surrogate Load to be created.*
T_ACC	*Test acceleration percentage.*
PL_LIM	*Limit of test acceleration.*
TARGET_FILE	Name of target results file that feature will try to achieve with Surrogate Load.
“USERWHS”	FLAG. Element set (HSSID$_i$), property (MID$_i$) and Tensor data (TENSIDi) to follow.
HSSID$_i$	FSET3 ID of the CBUSH or CONN3D2 entries to be used in the fatigue analysis.
MID$_i$	Unique vMATFTG ID for Heat Stakes.
TENSID$_i$	ID of vUDNAME filename entry specifying tensor data.
“SPOTW”	FLAG. Conduct Spot Weld analysis with the following parameters.
SPSIDi	ID of an FSET3 entry listing the elements that represent spot welds.
MIDi	ID of vMATFTG definition for spot weld elements.
DIAM, T1, T2	User specified values for nugget diameter, top shell thickness and bottom shell thickness.
“SEAMW”	FLAG. Conduct Seam Weld analysis with the following parameters.
SWSIDi	ID of an FSET3 entry listing the elements that represent seam welds.
MIDi	ID of vMATFTG definition for seam weld elements.
NDSIDi	ID of an FSET3 entry listing grids of the elements to be retrained for the analysis.
BTHRESH	*Threshold value of the bending ratio used in interpolation between stiff and flexible SN curves.*
RTHICK	*Reference thickness / threshold for sheet thickness correction used for seam welds.*
nTHICK	Sheet thickness correction exponent used seam welds.
WTYPE	Location on weld for results output.
“ABSRESP”	FLAG. Calculate absolute random response.
ABSVAR$_i$	Character combination of D, V, A or M.
SETID$_i$	ID of a FSET3 entry with list of grid IDs for DVA data output or MONPNT3 Set Name for “M”.

“RELRESP”	FLAG. Calculate relative random response.
RELVAR	Choice of D only.
SETID	ID of FSET3 entry with list of grid IDs to be used in relative response assessment.
PARAM1	Parameter for 3rd stage filtering to create pairs of nodes for relative displacement assessment.
PARAM2	Parameter for 2nd stage filtering to create pairs of nodes for relative displacement assessment.
“RELRESP2”	FLAG. Calculate distance only.
RELVAR	Choice of D only.
$NODEID_1$	ID of first node
$NODEID_2$	ID of second node
“SNXML / ENXML”	FLAG. Used with vFTGXML
SETNAME	Nastran set or FSET3 set
SETIDi	ID of set
FE_UNIT	**FE Stress Units**
JOBID	CF job ID.
CNVRTS	FE stress unit conversion.
FE_L_MAG	Global scale factor applied to equivalent stresses calculated within CAEfatigue.
CONJCON	Choice for how multi-input PSD’s are calculated.
CNVRTF	FE force unit conversion.
CNVRTL	FE length unit conversion.
vMATFTG	**Fatigue Materials Properties**
MID	Material ID.
CNVRTM	S-N units’ conversion.
AMP_RNG	S-N data format in AMP or RANGE.
SN_TYPE	Curve type for Multi-SN definition.
“STATIC”	FLAG. Static material properties UTS, E Code and SE to follow.
“CYCLIC”	FLAG. Cyclic stress-strain properties K’ and n’ to follow.
“KADJ”	FLAG. Surface finish / treatment corrections to follow.
“SN”	FLAG. S-N curve parameters SRI1, b1, Nc1, b2, Nfc, SE.
“SN0”, “SN1”, “SN2”	FLAG. S-N spot weld curve parameters SRI1, b1, Nc1, b2 Nfc, MSS, SE, SF, DE, TC.
“SNx_FKM”	FLAG. Mean stress slope parameters M1 through M4 representing sensitivity to mean stress.

“SNBR1”, “SNBR0”	FLAG. S-N seam weld curve parameters SRI1, b1, Nc1, b2, Nfc and SE.
“SEAM_FKM”	FLAG. Mean stress slope parameters M1 through M4 representing sensitivity to mean stress along with MSS.
“EN”	FLAG. E-N curve parameters σ'_f, b, c, ε'_f, K’, n’, Y to follow.
AUTOSN or AUTOEN	FLAG. Allow for automatically generated SN or EN curves to be used instead of defined SN or EN curves.
“MMPDS”	FLAG. MMPDS data coefficients to follow.
“TABLE”	FLAG. Tabular S-N data provided in TID_i table and SE to follow.
“FILE”	FLAG. Material data will be referenced in external file.
UDID	ID of vUDNAME that references XML file
Type	Type of data
XML_File Reference	Reference to unique material entry in XML file.
“DIGIMAT”	FLAG. Material data to come from DIGIMAT
Type	Type of Digimat file imported
File_Location	Path to Digimat file
vMATSTAT	**Random Response Materials Properties**
MID	ID.
CNVRTM	S-N units’ conversion.
‘STATIC”	FLAG. Static material properties UTS and E to follow.
“CYCLIC”	FLAG. Cyclic stress-strain properties K’ and n’ to follow.
vMATXML	**Material Mapping – Nastran to XML**
MID	ID.
XML File	XML filename
Crossover File	Crossover filename
vFTGPARM	**Fatigue Parameters**
JOBID	CF Job ID.
“STRESS”	FLAG. Indicates stress is used in the fatigue calculation.
COMB	Stress combination MAXPREST, ABSMAXPR, SGVON, COMPX, COMPY, COMPZ, COMPXY, COMPXZ, COMPYZ, CRIT30, CRIT90, CRIT180, CRIT360.
CORR	Mean stress correction method for SN or EN. Can be None, Goodman, Modgood, Gerber, Gdmant, Grbert, MMPDS, Interp-, Interp, SOD, SWTIT, SWTITC, Walker, Morrow.

NCALC	Average (NAVER), Middle (NMID) or Upper (NUPPER).
DEBUG	FRF set to 1.0 (UNITTF) or detailed S-N output (MATOUT).
TOLER	Tolerance used when performing Neuber Rule correction.
MAXPEAK	Calculates MAX stress/strain or MIN stress/strain for output to CSV file.
RCCT	Duration for Time History with vFTGDEF ATYPE = SIMSINE.
“CYCPROC”	FLAG. Indicates rainflow cycle counting parameters are to follow.
TRSTIN	Indicates nonlinear or elastic-plastic stress is coming from Solver. Also called Neuber Stress.
EVALL	Options for calculating Mean Stress and largest rainflow cycle.
HYST	Options for dealing with hysteresis loops.
TRSTOUT	Indicates nonlinear or elastic-plastic stress is written to the output files. Also called Neuber Stress.
“SPOTW”	FLAG. Indicates spot weld analysis parameters are to follow.
COMB	Equivalent stress to use in the spot weld fatigue calculation.
CORR	Mean stress correction. Can be None, Simple, FKM (TD only).
NANGLE	The number of calculation angles in 360 degrees around the spot weld.
SWLOC	Location to report fatigue life.
ZCOMP	Whether to include the compressive part of the axial force steady state response.
MIDDLE	Whether to include the results of the middle sheet in the spot weld.
“SEAMW”	FLAG. Indicates seam weld analysis parameters to follow.
COMB	Stress / strain combination to use in the seam weld fatigue calculation.
CORR	Mean stress correction. Can be None, Simple, FKM (TD only).
THICK	Thickness correction to be applied.
WELDTOP	Indicates which side of weld is top.
“CERTNTY”	FLAG. Indicates that a confidence level parameter will follow.
CERTSV	Confidence Level
“USERWHS”	FLAG. Indicates parameters for User Welds to follow.
COMB	Equivalent stress

CORR	Mean stress correction
NANGLE	The number of calculation angles in 360 degrees around the User weld.
SWLOC	Location to report fatigue life.
“FOS”	FLAG. Indicates parameters for factor of safety calculation.
LIFE	Target life to set for analysis
BACKACC	Back calculation accuracy for iterations
MAXFAC	Max factor of safety to calculate
MINFAC	Min factor of safety to calculate
vFTGSEQ	**Fatigue Load Sequence**
JOBID	CF job ID.
EVNTOUT	Output for each individual event. 0 = none or 1 = yes.
DUR_UNITS	Duration units in seconds, minutes, hours or days.
MOS_DUR	Required duration for complete duty cycle of testing.
TSCALE	Global scale factor applied to equivalent stresses calculated within CAEfatigue
NREP	If YES, values in EVT are Event Duration in REPEATS.
$EVID_i$	ID of a FTGEVNT.
EVT_i	Event duration.
“UNITS”	FLAG. Indicating a fatigue equivalent unit is to be used.
EQUIV	Number of equivalent units.
EQNAME	Equivalent Name.
vFTGEVNT	**Fatigue Load Events**
EVID	Event ID.
$FLOAD_i$	ID of an FTGLOAD entry or SID of a DETLOAD or NBLOAD entry.
“NAME”	FLAG. Indicating an event name is to be used.
EVENT_NAME	Event name.
vFTGLOAD	**Fatigue Load Variation**
FLOAD	ID.
TYPE	PSD, STATIC, ZEROPSD, FLUCT, MEANLDS, TIME112, TIME103, TIME101
SID	CF set ID of a VRANDPS or NBLOAD.
SCALE	Scale factor applied to loading.
OFFSET	Offset to apply to static stress; read from static stress OP2 file.
LCID	CF load case ID mapped to solver subcase ID. Use MULTI for multiple inputs.

File_Name	Location and name of the stress file.
vRANDPS	**Power Spectral Density Specification**
SID	ID.
J	CF load case ID that will be applied to the transfer function.
K	CF load case ID that will be applied to the transfer function. For single input PSD, J equals K.
X, Y	Real and imaginary components of the complex number. For single input PSD, X=1.0, Y=0.0. Note: X cannot equal Y.
TID	Unique ID for associated vTABRND
vTABRND	**PSD and Material Definition Table**
TID	ID.
XAXIS	"LINEAR" or "LOG" X axis.
YAXIS	"LINEAE" or "LOG" Y axis.
UDID	ID of a vUDNAME entry.
f_i	Frequency value in cycles per unit time.
g_i	Y value of table entry.
endt	Signifies end of input for vTABRND.
vUDNAME	**User Defined File Name**
UDID	Unique ID (Integer>0)
File_Name	Location and name of user defined file.
vRANDT	**PSD Time Specification**
SID	Random analysis set ID
T	Time of event
Units	Units of T
NBLOAD	**Narrow Band PSD Load Specification**
SID	CF set ID referenced in vFTGEVNT.
LCID	Load Case ID mapped to solver subcase ID
f_i	Frequency value in cycles per unit time.
b_i	Width of narrow band frequency block.
h_i	Y value of table entry (PSD units).
DETLOAD	**Deterministic Load Specification**
SID	CF set ID referenced in vFTGEVNT.
LCID	Load Case ID mapped to solver subcase ID
f_i	Frequency value in cycles per unit time.
g_i	Y value of table entry (sine amp units).
SINGSINE	**Single Sine Wave Deterministic Load Specification**
SID	CF set ID referenced in vFTGEVNT.

LCID	Load Case ID mapped to solver subcase ID
f1	Frequency value in cycles per unit time.
g1	Y value of table entry (sine amp units).
SINESW	**Swept Sine Wave Deterministic Load Specification**
SID	CF set ID referenced in vFTGEVNT.
LCID	Load Case ID mapped to solver subcase ID
f_1	Frequency value in cycles of first sine wave.
g_1	Peak value (amplitude) of first sine wave.
f_n	Frequency value in cycles of last sine wave.
g_n	Peak value (amplitude) of last sine wave.
SWTYPE	The sweep type in Decibel (LOG/DB), Octave (OCT) or Linear (HZ).
SWNUM	Number of sine bands to use.
"PARAMS"	FLAG. Indicating additional sweep parameters to follow.
SWRATE	Sweep rate per second in Hz, DB, or OCT.
N_SWEEPS	Number of times the sine is swept through the frequency range.
FRF_UNIT	Units of loading used to create FRF.
LD_UNIT	Units of loading used to define sweep.
FSET3	**KT Material Parameters**
JOBID	CF Job ID.
ELSIDi	ID of FSET3 file containing elements
SCALEi	Scale factor to apply to elements.
OFFSETi	Offset factor to apply to elements.
FSET3	**Element or Grid Set Definition**
ELSID	ID.
DES	Must be "ELEM" or "NODE".
Id_i	Element or Node numbers.
INCLDIR	**Directory Location for "INCLUDE" files**
JOBID	CF Job ID.
DIR_NAME	Directory location for the INCLUDE files. No character limit for entry.
INCLUDE	**External Text File to be Used for "includes"**
FILE_NAME	Name of include file.
RESTART	**Option to request restart from intermediate data file.**
FILE_NAME	Name of restart file.

VECTOR	**Vector Application of Solver Results**
JOBID	CF Job ID.
VXCOMP, VYCOMP, VZCOMP	X, Y and Z components of a vector that will be created from the X, Y and Z Solver FRF values. Values for components must add up to 1.0.
VINCR	Number of angle increments. Check multiple vectors through an increment of angles.
FNOTCH	**Method to apply filters (notches) to transfer function inputs.**
FNID	ID number for FNOTCH
$LCID_i$	Solver subcase ID number for Transfer Function
f_{ia}	Start frequency for notch.
f_{ib}	End frequency for notch.
$SCALE_i$	Scale factor to apply to notch. Default is none.
PERTURB	Option to create damage increments for incoming load changes.
PTYPE	Relative or absolute.
VALUE	Value of perturbation.

Entries (Commands) and Fields used in Time Domain Analysis

Below is the complete set of available entries that can be used to do a Cf time domain analysis (either in the Control File view or Process Flow view). In a typical analysis, only small selection of these items are used. Please note: Entries in *GREY* are not currently supported. See descriptions in previous section for more information or refer to the relevant sections in this document.

DATA COLUMN 1	DATA COLUMN 2	DATA COLUMN 3	DATA COLUMN 4	DATA COLUMN 5	DATA COLUMN 6	DATA COLUMN 7	DATA COLUMN 8	DATA COLUMN 9
vIBFAT	JOBID	OFILTYPE (*CSV*)	SOURCE (*NASTRAN*)	GIDOUT (*CENTER*)		JOB_NAME (*control file name*)		
	"OPTIONS"		STRLIM (*0*)			OUTDIR		
MEMORY	MEM_CAP							
PARALLEL	TH_CAP							
CUDA	STATUS							
PARAM	NAME	SETTING						
OP2MAP(S)	FILE_NAME (for dynamic and static (S) stresses from NASTRAN)							
	$CFLCID_i$	$OP2LCID_i$						
ODBMAP(S)	FILE_NAME (for dynamic and static (S) stresses from ABAQUS)							
	$CFLCID_i$	$ODBLCID_i$						
vFTGDEF	JOBID		TOPSTR (*100*)	MID				STRBINS (*32*)
	"ELSET"	$ELSID_1$	MID_1	$ELSID_2$	MID_2	CONTINUE		
	"TIMEOUT"	TIMEVAR1	TIMEID1 or RUNTIME					
	"CRITOUT"	CRITVAR1	CRITID1					
	"HOTSPOT"	NHS (*1*)	HSGATE (*1*)	HSFLAG	STOP (*NO*)			
	"FILTER"					TOPDMG		
	"RCCOUT"	*$RCCVAR_1$*	*$RCCID_1$*	*CONTINUE*				
	"USERWHS"	*$HLSID_1$*	*MID_1*	*$TENSID_1$*	*$HLSID_2$*	*MID_2*	*$TENSID_2$*	
		$HLSID_3$	*MID_3*	*$TENSID_3$*	*CONTINUE*			
	"SPOTW"	SPSID1	MID1	DIAM	T1	T2		
		SPSID2	MID2	DIAM	T1	T2	CONTINUE	
	"SEAMW"	SWSIDi	MID1	NDSID1	BTHRESH (0.5)	RTHICK (1.0)	nTHICK (*0.16667*)	WTYPE (Toe)
	"SEAMW3DH"	SWSIDi	MID1	*MaxDepth*	Num_Layers (1)	BTHRESH (0.5)		

	"SEAM7608"	SPSID1	WeldClass	SCF *(1.0)*	Distance	Tref	k	
	"HISTRCC"	ELSET/TIMEOUT/PSEUDO	ELSID					
FE_UNIT	JOBID	CNVRTS *(MPa)*	FE_L_MAG *(1.0)*		CNVRTF *(N)*	CNVRTL *(mm)*		
vMATFTG	MID	CNVRTM *(MPa)*	AMP_RNG *(RANGE)*	SN_TYPE				
	"STATIC"		UTS	E	Code		SE	
	"CYCLIC"	K'	n'					
	"SN"	SRI1	b1	Nc1	b2 *(0.0)*	Nfc *(1.0E30)*	SE	
	"KADJ"	KU	KT	KRNUM	KRDESC			
	"SN0" "SN1" "SN2"	SRI1	b1	Nc1	b2	Nfc	MSS	SE
		SF-FXY	DE-FXY	TE-FXY	SF-MXY	DE-MXY	TE-MXY	
		SF-FZ	DE-FZ	TE-FZ	SF-MZ	DE-MZ	TE-MZ	
	"SNx_FKM"	M1	M2	M3	M4			
	"SNBR1" "SNBR0"	SRI1	b1	Nc1	b2	Nfc	SE	
	"SEAM_FKM"	M1	M2	M3	M4	MSS		
	"EN"	σ'_ϕ	b	ε'_ϕ	c	K'	n'	Y *(0.5)*
		SEe	SEp	SEc				
	"AUTOSN" or "AUTOEN"	Can be used instead of SN or EN						
	"MMPDS"	A1	A2	A3	A4			
	"TABLE"	TID_1	*T_1*	CONTINUE				
	"FILE"	UDID	Type	XML_File_Reference				
vFTGPARM	JOBID							
	"STRESS"	COMB *(SGVON)*	CORR *(NONE)*		DEBUG *(NONE)*	TOLER *(1.0E-5)*		
	"SPOTW"	COMB *(CRITICAL PLANE)*	CORR *(None)*	NANGLE *(18)*	SWLOC (0)	ZCOMP (1)	MIDDLE (0)	
	"SEAMW"	COMB *(ABS MAXPR)*	CORR *(None)*	THICK *(0)*	WELDTOP *(Upper)*			
	"SEAM7608"	COMB *(ABS MAXPR)*	CORR *(None)*					
	"FOS"	LIFE	BACKACC *(5.0)*	MAXFAC *(5.0)*	MINFAC *(0.2)*			

	"MULTIAX"	METHOD (*None*)						
DSP	TYPE	NAME						
vFTGSEQ	JOBID	EVNTOUT (*0*)	DUR_UNITS (*SECONDS*)	MOS_DUR (*SUM of EVENTS*)	TSCALE (*1.0*)	NREP (*YES*)		
	EVID$_1$	EVT$_1$ (*1.0*)	EVID$_2$	EVT$_2$ (*1.0*)	CONTINUE			
	"UNITS"	EQUIV	EQNAME					
vFTGEVNT	EVID	FLOAD$_1$	FLOAD$_2$	CONTINUE				
	"NAME"	EVENT_NAME						
vFTGLOAD	FLOAD	TYPE		SCALE (*1.0*)	OFFSET			
LCID	FILE_NAME							
vUDNAME	UDID							
	FILE_NAME							
KTDATA	JOBID	ELSETi	SCALEi	OFFSETi				
FSET3	ELSID	DES	ID$_1$	ID$_2$	ID$_3$	ID$_4$	ID$_5$	CONTINUE
SGAUGE	ID	TYPE						
	"NODE"	NODEID						
	"GLOBDIR"	COORDX	COORDY	COORDZ				
	"NORMAL"	COORDX	COORDY	COORDZ				
OUTPUT	"RESULT"	FORMAT						
INCLDIR	JOBID	DIR_NAME (*LOCAL DIRECTORY*)						
INCLUDE	FILE_NAME							

A brief description of additional entries and fields available for a time domain analysis is given in the table below. For a full explanation of all entries please refer to the appropriate sections in this document.

Brief Description of Additional Entries and Fields used ONLY for Time Domain Analysis

ENTRY NAME	DESCRIPTION
MEMORY	**MAX Memory for Time Domain Analysis**
MEM_CAP	Maximum memory that can be used in Gb
CUDA	**GPU Memory for Time Domain Analysis**

STATUS	Use available GPU memory
PARAM	**Setting Parameters**
NAME	Name of Parameter
SETTING	New value for Parameter
DSP	**Peak Valley Extraction**
TYPE	Analysis type is “filter”
NAME	Analysis is “peakvaly”
PARALLEL	**Parallel Processing for Time Domain Analysis**
TH_CAP	Maximum threads that can be used.
vFTGDEF	**Fatigue Element Definitions**
TOPSTR	Show top % of model based on largest stress range. Options available.
“TIMEOUT”	FLAG. Indicates time history output parameters to follow.
$TIMEVAR_i$	Choice of S (stress)
$TIMEID_i$ OR RUNTIME	Set of Element ID for output OR various options to automatically output stress time histories at different elements.
“FILTER”	FLAG. Indicates ability to filter damage results.
TOPDMG	Show top % of model based on damage.
“RCCOUT”	*FLAG. Indicates RCC and damage response output.*
$RCCVAR_i$	*Option is BOTH (RCC and Damage).*
$RCCID_i$	*FSET3 set of nodes or elements to be used in RCC and damage output.*
“SEAMW3DH”	FLAG. Indicates parameters from 3D seam weld analysis will follow.
SEAMID	ID of the FSET3 containing elements and nodes
MID	ID of seam weld material
Max_Depth	*Distance from the surface downwards.*
NUM_LAYERS	The number of element layers from the surface downwards.
BTHRESH	Threshold value of the bending ratio used in interpolation.
“SEAM7608”	FLAG. Indicates parameters from BS7608 weld analysis will follow.
SEAMID	ID of the FSET3 containing elements and nodes.
WeldClass	ID of weld class to use in analysis.
SCF	Local stress concentration factor.

Distance	Distance along element normal to move the stress calculation.
Tref	Reference thickness required for Thickness Correction.
k	Power exponent required for Thickness Correction.
"HISTRCC"	Flag to indicate computation of Rainflow cycles and histogram
ELSET/TIMEOUT	Either via an ELSET flag followed by an FSET3 ID or TIMEOUT flag to indicate to use entities chosen in TIMEOUT
ELSID	FSET3 ID in case of ELSET flag above
vFTGPARM	**Fatigue Parameters**
"MULTIAX"	FLAG: Indicated that a Multiaxial assessment is required.
METHOD	The type of assessment.
"SEAM7608"	FLAG: Indicated that parameters for a BS7608 weld analysis is to follow.
COMB	Stress / strain combination to use in the seam weld fatigue calculation.
CORR	Mean stress correction.
SGAUGE	**Software Strain Gauge**
ID	ID of the strain gauge.
TYPE	Type of the strain gauge, Single, Tee, Rect, or Delta.
"NODE"	FLAG: Indicated that the strain gauge is at a node.
NODEID	ID of the node where the strain gauge is located.
"GLOBDIR"	FLAG: Indicated the definition of the strain gauge direction in global coordinate system.
COORDX	X coordinate of the direction vector.
COORDY	Y coordinate of the direction vector.
COORDZ	Z coordinate of the direction vector.
"NORMAL"	FLAG: Indicated the definition of the strain gauge normal vector.
COORDX	X coordinate of the normal vector.
COORDY	Y coordinate of the normal vector.
COORDZ	Z coordinate of the normal vector.
OUTPUT	**Output Control**
"RESULT"	FLAG: Indicated the control of csv results output.
Format	Format is "Compact".

Entries (Commands) and Fields used in a TIME2PSD Analysis with Descriptions

Below is the complete set of available entries that can be used to do a Cf TIME2PSD analysis. Please note: Entries in *GREY* are not currently supported. See descriptions information that follows or refer to the relevant sections in this document.

DATA COLUMN 1	DATA COLUMN 2	DATA COLUMN 3	DATA COLUMN 4	DATA COLUMN 5	DATA COLUMN 6	DATA COLUMN 7	DATA COLUMN 8	DATA COLUMN 9
vIBFAT	JOBID				LOGLVL (0)	JOBNAME		
TIME2PSD	SRATE (*1*)	EVIDST	TABIDST	EVENT_N (*1*)	WINDOW (*Hanning*)	FORMAT (*CSV*)	MINF	MAX (*the Nyquist Frequency*)
	"FILEDIR"	TS_file_directory						
	"dcyfile"	*DCY_filename*						
	"MAPPING"	skip	CHAN_N	*T_UNITS (seconds)*	chan1	chan2	chan3	chan4
	chan5	chan6	chan7	chan8	chan9	chan10	chan11	cont
	"autoT"	T_Init (*0.5*)	K_PTS (*100*)	K_PCENT (*2*)	Level (*50*)	Method (*5*)		
	"autoD"	T_DEL (*0.5*)	RMS_FL (*50.0*)	HPFILT (1.0)				
	"Post"	Operation (Diagonal)	Type (if Scale)	Event	Channel			Scale (1.0)
	"Post"	Operation (Diagonal)	Type (if Envelope or Average)	Action (Scale)	Envelope Channel	*StartF*	*EndF*	Scale (1.0)
	"Post"	Operation (Target)	Type (if stress)	Event	Channel	Element	Node	Layer
	"Post"	Operation (Target)	Type (if acce)	Event	Channel	Direction		
	"EV_OPTS"	EV_NUM	*NSI (1)*	*RMSI (1)*	*TSMOOT (1)*	SF (*1.0*)	T	δ (*0.0*)
	Load_name							
	"SUBEV"	S1	S2	S3	S4	S5	S6	
	T1	T2	T3	T4	T5	T6	T7	T8

GREEN = Control Entry or Flag **BLACK = Enter User Data** **GREY = Not Currently Supported** **RED = Special User data fields can be any number of characters** **ORANGE – Default entries**

NOTE:

See vIBFAT entry for details regarding the first row. Note the following difference:

a. LOGLVL=0: Produces PSDM files with the following format "***load_name" _ "event number" _PSDM.txt***.

b. LOGLVL=1 or 2: Produces PSDM files mentioned above PLUS the files below. These files are needed if you wish to use the FFT PLOTTER to view results.

   i. ***_autoPSD_debug.txt*** files that provide XY data to plot Channel PSD data versus Frequency.

   ii. ***_time_data.txt*** files that provide XY data to plot Channel Time History data versus Time (for the original time histories).

   iii. ***_time_data_del.txt*** files that provide XY data to plot Channel Time History data versus Time (after DELETES has modified time histories).

   iv. ***_subev_time_data.txt*** files that provide XY data to plot Channel Time History data verse Time (after SUBEV has modified the time histories).

- "auto" is a legacy entry that will only be supported for a short time. "auto", "autoT" and "autoD" applies only to events where the values for buffer window length, overlap and T are not specified. If these values are specified, TIME2PSD will do calculations based on these inputs.
- TIME2PSD can only be used as a pre-processing step. It must be run before the main fatigue (CF) job is executed.

ENTRY NAME	DESCRIPTION
SRATE	If using an RPC (RSP) file, SRATE will automatically be obtained from the file and this entry will be ignored. If using an CSV file, the User must input the sampling rate (SRATE) of the time history. -- Required, Real>0, Default=1.
EVIDST	Start (vRANDPS) ID for events. -- Required, Integer>0, no default.
TABIDST	Start ID for vTABRND tables. -- Required, Integer>0, no default.
EVENT_N	Number of time history event files. -- Required, Integer>0, Default=1.
WINDOW	Window function to use. Options are Hanning Window or no window. This is applied to the "block" of data extracted from the total time signal. -- Optional, Character, Default=Hanning.
FORMAT	Format of time signal files. Options are RPC or RSP for binary format road load data. CSV for text format. **NOTE: the CSV file must only contain columns of Y data, i.e. no X value starting column.** Header rows of text are allowed. -- Required, Character, Default=CSV.
MINF	Frequency below which the PSD data will be set to zero. Must be less than MAXF. – Optional, Real≥0.0, Default=0.0.
MAXF	Max frequency in output (used to override the Nyquist frequency when outputting PSD data). This is useful when PSDM files are much larger than necessary due to frequency content in the time history that is well above the last FRF frequency of interest. This entry has the effect of suppressing the writing of all PSD and cross PSD frequencies above MAXF. Must be greater than MINF. – Optional, Real>0.0, Default = the Nyquist Frequency.

"FILEDIR"	FLAG. Used to specify the directory where all input time history files are located and where output data files will be written when vIBFAT > LOGLVL=1.
TS_filedirectory	This should correspond to the name of the directory. – Required, Character, no default.
"dcyfile"	*FLAG. Name of the DCY file used to specify repeats of each event, the event names and order of events.*
DCY_filename	*This should correspond to the DCY filename. If no file exists, then the vFTGSEQ entry in the Cf analysis must be used to specify the time durations. – Optional, Character, no default.*
"**MAPPING**"	FLAG. Used to specify the order of channel data. Required when not all channels are used from the RPC/RSP/CSV file. Otherwise, this entry it optional – Optional, Integer>0, no default.
skip	Number of header lines to skip in an asci file. – Optional, Integer>0, no default.
CHAN_N	Number of channels in event file to use. Required if not all channels from RPC/RSP/CSV file are used in conversion. Otherwise, format is -- Optional, Integer>0, no default.
T_UNITS	*Time units. Options are seconds and hours. – Optional, Character, Default=seconds.*
$chan_i$	Location in asci input file for channel "i" of data. – Optional, Integer>0, no default.
"EV_OPTS"	FLAG. Optional Event parameters are to follow (one set for each Event).
EV_NUM	Number of Event. First EV_NUM must equal EVIDST number and each consecutive EV_NUM must increase by 1. Example: EVIDST=55 so therefore, EV_NUM_1=55, EV_NUM_2=56, EV_NUM_3=57, etc. The number of EV_OPTS entries must match the number specified in EVENT_N. – Required, Integer>0, no default.
NSI	*Number of non-stationary intervals for this Event. – Optional, Integer>0, Default=1.*
RMSI	*Number of rms scaling intervals for this Event. – Optional, Integer>0, Default=1.*
TSMOOTH	*Number of adjacent time points to be used for temporal smoothing of response PSD for this Event. – Optional, Integer>0, Default=1.*
SF	Scale factor to apply to time signals in this Event before FFT. – Optional, Real>0.0, Default=1.0.
T	Length of FFT buffer window function in time for this Event. NOTE: if using AutoT, this entry must be left blank otherwise this entry will override AutoT. - Required, Real>0.0, no default.
δ	Overlap or gap in time between windows for this Event. Positive value mean overlap. Negative value means gap. Value must be less than T. NOTE: if using AutoT, this entry must be left blank otherwise this entry will override AutoT. – Required, Real≥0.0, Default=0.0.

Load_name	Name of the input time history loading file used for this event (e.g. “load.rsp”). – Required, Character, no default.
“SUBEV”	FLAG indicating that a subevent will be created using the specified times S_1, S_2, etc. This entry must be placed below the Load_Name entry of the Event of interest along with the T values (if used).
S_i, S_{i+1}	Used to separate time segments within an Event (defined by pairs of time values S_1-S_2, S_3-S_4, S_5-S_6, etc.) that become additional events in the analysis. – Required, Real>0.0, no defaults.
MANUAL DELETES	
T_i, T_{i+1}	These entries are used to manually delete sections in an Event (or subevent) and are defined by pairs of time values t_1-t_2, t_3-t_4, t_5-t_6, t_7-t_8, etc. These portions of the Event are removed before the FFT process is applied. The T1 value can be set to START if the User wishes to use the first point in the Event. The last value can be set to END if the User wishes the deleted section to span to the end of the Event. These T values must be listed directly below the Load_Name to which it applies. IF SUBEV is being used, then SUBEV would be below the Load_Name entry **first**, followed by the Delete T values. NOTE: if using AutoD, this field must be left blank otherwise this field will override AutoD. – Optional, Real>0.0 and Character=Start or END, no default.

Additional Automatic Functions - AutoT, AutoD.

“autoT”	FLAG indicating that an automatic FFT buffer window length “T” will be calculated.
T_Init	Initial value of the FFT window length in seconds. – Required, Real>0.0, Default=0.5.
K_PTS	Target value / range to use for calculation of K_PTS based on Methods 1 to 6 described below. If a single value is specified, then the range to be used is determined using K_PCENT above and below the single value. Example: 3,4 for range input or 3 for target value (best values to use for Method 1 through 4). – Required, Integer>0, Default=100 (for Method 5).
K_PCENT	Percentage used to define a range of K_PTS when only a single value is specified for K_PTS. – Required, Real>0.0, Default=2 (2%).
Level	Percentage of maximum used as the reference line when evaluating K_PTS above and below the reference line. – Required, Integer>0, Default=50 (50%).
Method	The method to use when evaluating K_PTS. – Required, Integer=1 to 6, Default=5. 1 – Number of K_PTS above a line defined as a percentage (level) of the maximum. 2 – As Method 1 but normalized by total number of points in PSD plot. 3 – As Method 1 but where the Level used is the PSD average defined as the sum of the PSD values divided by the total number of points in the PSD plot.

	4 – As Method 3 but where the result calculated for K_PTS is normalized by the total number of points in the PSD plot. 5 – K_PTS is calculated as the number of peaks or valleys in the PSD plot. 6 – As Method 5 but where the result calculated for K_PTS is normalized by the total number of points in the PSD plot.
“autoD”	FLAG indicating that automatic deletes based on signal intensity will be calculated. Note: TIME2PSD will look for Ti values FIRST to use for the manual deletion of time history segments from within an event. If Ti values are not present, the software will use AutoD to make automatic deletes within each event using the parameters defined for AutoD.
T_DEL	Value of window length in seconds used for deletes assessment. – Required, Real>0.0, Default=0.5.
RMS_FL	RMS level of window (of length T_DEL) as a percentage of PSD file average below which deletes will apply. – Required, Real>1.0, Default=50.0 (50%).
HPFILT	High pass filter value used to pre-filter the time data before deletes are assessed. Any data removed by the filter is restored before the FFT processing. – Required, Real>0.0, Default=1.0.

Entries required for Bounding Diagonals

“**Post**”	Optional FLAG indicating that a Bounding Diagonals request has been made.
Operation	Type of operation to be carried out. Current options are Diagonal and Target. – Required, Character, no default.
Type	The type of action to be carried out. Options are Scale and Envelope for Operation=Diagonal and Stress and Acce for Operation=Target. – Required, Character, no default.
Event	Event ID. – Required, Integer, no default.
Action	Action to be carried out. Only option is SCALE when using Operation=Diagonal and Type=Envelope or Average. – Required, Character, no default.
Channel or Envelope Channel	Channel or Envelope Channel ID. – Required, Integer, no default.
Element	Element ID. – Required, Integer, no default.
Node	Node ID. – Required, Integer, no default.
Layer	Layer ID. Options are None, Lower and Upper. Used only for Target>Stress selection – Required, Character, no default.
Direction	Acceleration direction required when Operation=Target and Type=acce. Options are X, Y, Z, Mx, My and Mz. – Required, Character, no default.

Scale	Scale factor to apply. Used only for Operation=Diagonal – Required, Real>0.0, Default=1.0.

Rules for Entries and Fields in a Fatigue Control File or TIME2PSD

If the User is going to use the Control File view to run a fatigue analysis or TIME2PSD analysis, with few exceptions, the Control File is 10 columns wide with 8 characters per column (called a field). An exception is made for identifying the filenames or locations where you are allowed more than 8 characters. The case of a field does not matter: DIRLIK is the same as dirlik.

The 10th field is left blank even in the case of continuations. Continuations are detected automatically because more information is expected by the program.

Comment lines are to begin with $, % or #. In-line comments (comments on the same line as an entry line) also supported. Tab characters are not supported so in the case of blank entries, the User must use blank spaces to create the blank field (not tabs).

Special Rules for the INCLUDE Entry in a Fatigue Control File

INCLUDE entries permit the addition of a text string (saved as a text file) into the fatigue control file. No nesting of includes is allowed and the "Include" must be a whole line containing only the include instruction,

e.g., ***INCLUDE LOADFILE_A*** or ***INCLUDE MAT_A***. Any included filename name must not have spaces.

If needed, an optional **INCLDIR** entry can be used to define the directory location of the “Include” file as follows:

INCLDIR JOBID "address of directory for include files"

Note: ALL Include entries that follow will use this directory location. This may be changed before further includes are specified by adding another INCLDIR entry. In case of errors during input or during the solution phase, the log file (extension .log) is to be consulted for the cause of the error and to see where the included files were being pulled from.

3 | CONTROL OF OUTPUT RESULTS AND LOADS SCALING

Output Control Options – OFILTYPE & LOGLVL (in vIBFAT), ELSET (in vFTGDEF) and EVNTOUT (in vFTGSEQ)

Great care should be taken with the control of outputs because using various settings can mean that important output is not obtained, or enormous, unnecessary volumes of output can be written to the hard drive.

There are 4 variables that control output.

1. The OFILTYPE (vIBFAT entry) controls whether a CSV file, FEF file (Patran Neutral), H3D file (HyperView) or combinations of these files are written. The CSV file is the most complete version of results. When written to FEF and H3D files the results are split into subcategories for nodes and elements, and then into top, bottom and worst. It is also possible to limit which of these FEF files are written, for example element top only. In the current release, HyperView (H3D) files can only be written for element results. The latest CFG interface also includes a CSV to H3D translator that converts the results into a single H3D file for reading into HyperView. This is a much more elegant option than specifying H3D as part of OFILTYPE. The H3D translator is accessed from the “utilities” icon in the top right menu bar.
2. The LOGLVL (vIBFAT entry) controls whether additional data is written to the output file (0=Basic Output, 1=Basic plus PSD Output and 2=Basic plus PSD and Damage Output). Care should be taken when specifying LOGLVL=1 or 2 to restrict the element locations where results are requested (via ELSET) otherwise there will be a large amount of output created for every element / node in the model. Even for LOGLVL=0, PSD response and transfer function output is still written for the element with the highest RMS stress in the model. It is this element that is plotted by default in the included CFG GUI. Please note, however, that if the highest stress element is not included in the Users ELSET sets then the PSD.csv file may be blank.
3. ELSET (vFTGDEF entry) combined with FSET3, can be used to limit results output to the element groups listed on an FSET3 entry. It is **highly recommended** that an ELSET / FSET3 combination be used if LOGLVL is set to 1 or 2. Otherwise, Cf will write out PSD and RCC data for **ALL** elements in the model file. This can significantly delay the Cf analysis while the software writes out this data.
4. EVNTOUT (vFTGSEQ entry) controls whether individual event results are written (1) or just results for the sum of events (0). Requested summed results (EVNTOUT=0), will reduce the output data written to the main results CSV file. NOTE: If FEF/H3D files are requested for EVNTOUT=0, there will be 6 FEF/H3D files written - top (T), bottom (B) and worst (W) for both nodes and element centers. If FEF/H3D files are requested for EVNTOUT=1, there will be 6 files for each event and the sum of the events, which will be a significant increase in output. **A better option for writing H3D files can be found in the UTILITIES menu of the GUI**.

Standard Cf output goes to the CSV / FEF / H3D files, as requested, and will include the items listed in the table below for each Element ID, Grid ID, Layer ID and Event. All results are written to one CSV file. Separate FEF/H3D files are written for each event and the sum of events. Results are also written separately for top layer, bottom layer or worst. Where solids elements are included in the model, these results are written to all 3 (top, bottom and worst). Results are also written separately for element center results and element nodal results. For example, with a QUAD 4-noded shell element there will be a center result written to both top and bottom layer FEF/H3D files. There will also be 4 nodal results written to both the top and bottom FEF/H3D files. The following options are possible.

Note that *** can be FEF or H3D.

Table 3-1 Options for OFILTYPE (note that the CSV file can be translated into an H3D file in the Utilities section of the GUI).

	*.log	*.csv	PSD.csv (Frequency Domain Only)	RCC.csv (Frequency Domain Only)	Element FEF/H3D results			Nodal FEF/H3D results		
OFILTYPE					**Top**	**Bottom**	**Worst**	**Top**	**Bottom**	**Worst**
CSV	✓	✓	✓	If LOGLVL=1 or 2						
FEF or H3D	✓		✓	If LOGLVL=1 or 2	✓	✓	✓	✓	✓	✓
CSV***	✓	✓	✓	If LOGLVL=1 or 2	✓	✓	✓	✓	✓	✓
CSV***ET	✓	✓	✓	If LOGLVL=1 or 2	✓					
CSV***EB	✓	✓	✓	If LOGLVL=1 or 2		✓				
CSV***EW	✓	✓	✓	If LOGLVL=1 or 2			✓			
CSV***NT	✓	✓	✓	If LOGLVL=1 or 2				✓		
CSV***NB	✓	✓	✓	If LOGLVL=1 or 2					✓	
CSV***NW	✓	✓	✓	If LOGLVL=1 or 2						✓
***$$	✓		✓	If LOGLVL=1 or 2	same options as CSV***$$ where $$ can be ET, EB, EW, NT, NB, NW					

If vIBFAT: GIDOUT=NODAV output is requested, it is assumed the FE model results file contains element corner results. In this case each set of results at a node (keeping layers separate) will be combined separately at each frequency. For a shell, this will result in one single corner result for top layer and another for the bottom layer (at each frequency). For a CQUAD4 mesh there will generally be 4 or more results for each node (at both top and bottom). The example below shows the results obtained with GIDOUT=CORNER and GIDOUT=NODAV for example TPL1.txt (output files will start with the text Result1). Depending on LOGLVL, additional CSV files are created and contain the following for each frequency, element, Grid ID, and layer.

LOGLVL = 0: writes the following files:

- **Results1.log** – log file containing job execution runtime information and details on the top 10 damaging elements
- **Results1.csv** – CSV file containing the information listed below for all elements and grids (nodes) in the model.
- **Results1PSD.csv** – CSV file containing input (load) PSD, equivalent stress (transfer function), response PSD and moment information for the element with highest RMS stress output **ONLY**.
- **Results1.CFdata** & **Results1.CFdata2** – these are binary files required by the program do display GUI information. This is also the files that are read for the RESTART entry.

LOGLVL = 1: writes the same output as LOGLVL=0 with the following changes/additions:

- **Results1PSD.csv** – CSV file now contains the PSD and moment information for all elements in the model.
- **Results1RCC.csv** – new CSV file that contains a Palmgren-Miner cumulative damage sum (Damage) at each element / grid (node) location.

LOGLVL = 2: writes the same output as LOGLVL=1 with the following changes:

- **Results1RCC.csv** – CSV file now contains (1) Rainflow Cycle Count (actual number of cycles to failure “n”) for each specified grid ID (node) as a function of stress (BIN). (2) The stress value (S) at the center of each BIN. (3) Allowable number of cycles to failure “N” for each specified GID as a function of stress (BIN). (4) Palmgren-Miner cumulative damage sum for each stress (BIN).

Table 3-2 Control of output information using vIBFAT entry LOGLVL.

	Log file	Main CSV file	CSV(PSD) file LOGLVL=0	CSV(PSD) file LOGLVL=1	CSV(RCC) file LOGLVL=1	CSV(RCC) file LOGLVL=2
Run time information	✓					
All 4 spectral moments		✓				
Cumulative moments for specified GID's			✓	✓		
Input PSD, Transfer Function, Response PSD for worst element node			✓	✓		
Input PSD for specified GID's (as function of frequency)				✓		
Transfer function for specified GID's (as function of frequency)				✓		
Response PSD for specified GID's (as function of frequency)				✓		
RMS stress		✓				
RMS strain		✓				
E[0]		✓				
E[P]		✓				
Irregularity factor		✓				
Mean Stress		✓				
Mean + X Sigma stress		✓				
Mean – X Sigma stress		✓				
Mean + X Sigma strain		✓				
Mean – X Sigma strain		✓				
Damage/event		✓				
Damage/duty cycle		✓				
Log Damage/event		✓				
Log Damage/duty cycle		✓				
Life (User units)/event		✓				
Life (User units)/duty cycle		✓				
Life (cycles)/event		✓				
Life (cycles)/duty cycle		✓				
MOS/event		✓				
MOS/duty cycle		✓				
Plasticity Index		✓				
Frequency at Max Response		✓				
Actual "n" - Rainflow cycle count for specified GID's (as function of stress BIN)						✓
Allowable "N" for specified GID's (as function of stress BIN)						✓
Palmgren Miner damage sum for specified GID's (as function of stress BIN)					✓	✓

CSV Output File Formats – Main, PSD, DVA, D_REL, Spot, Seam, Force, etc.

The Cf program will write out **many** types of output files depending on the output requests specified in the control deck. The most common (and by default) is the MAIN CSV file, which is detailed below. See **Appendix Section** for details on all the type of output files including (but not limited to):

- filename**.csv** – contain default output data including spectral moment, basis random response, stress, strain, damage, life, etc.
- filename**psd.csv** – contains Input PSD, Transfer Function and Response PSD output data generated for the PSD Plotter.
- filename**_dva.csv** – contains displacement, velocity and/or acceleration output data generated when request is for advanced random response output (vFTGDEF: ABSRESP)
- filename**_d_rel.csv** – contains the output data generated when request is for collision detection (vFTGDEF: RELRESP).
- filename**_spot.csv** – contains the output data generated when request is for spot weld (vFTGDEF: SPOTW).
- filename**_seam.csv** – contains the output data generated when request is for seam weld (vFTGDEF: SEAMW).
- filename**_force.csv** – contains the output data generated when requesting force data (vFTGDEF: ABSRELP: ABSVAR=F and vFTGDEF:USERWHS).
- Filename**_CRITOUT.csv** – contains the output data generated when requesting 3D critical plane data (CRITOUT) for a time domain analysis.
- **TIMEOUT**_Filename**.h5** – contains the output data in an HDF5 format that is generated when requesting stress response time history data (TIMEOUT) for a time domain analysis.

Main CSV File Format

The results within the **filename.csv** output file are listed in the following order:

A	B	C	D	E	F	G	H	I	J
Element	Grid	Layer	Elset ID	MID	Event	M0	M1	M2	M4
K	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**
rms	rms_strain	E[0]	E[p]	Irr_ Factor	Mean Stress	Mean + MAXPEAK * rms	Mean - MAXPEAK * rms	Mean + MAXPEAK * rms strain	Mean – MAXPEAK * rms strain
U	**V**	**W**	**X**	**Y**	**Z**	**AA**	**AB**		
Damage (for Duty Cycle)	Log Damage (for Duty Cycle)	Life (in Duration Unit)	Log of Life (in Duration Unit)	MOS / FOS *	Plasticity Index	Frequency at Max Response	Critical Plane Angle	**	

* Margin of Safety (MOS) is replaced by Factor of Safety (FOS) when FOS is requested.

** EXTRA COLUMNS of data will be in the CSV file if vFTGPARM>MULTIAX is set to any value other than NONE. See User Guide “Introduction to Multiaxial Assessment” for further information on the additional columns added to the CSV file depending on the multiaxial assessment method chosen.

Some comments:

- The order and listing of output will change with various selected parameters (i.e. selection of SIMSINE, inclusion of Event name, etc.). However, the above listing is typical for stress output.
- **RMS Strain** (column L) is the elastic plastic strain calculated using the elastic FEA stress results and the Neuber Rule for conversion. This column will only be populated if the cyclic strength coefficient (K') and strain hardening exponent (n') are provided in the vMATFTG or VFTGSTAT entries.
- For a **Time Domain** analysis, columns Q, R, S, T are replaced by MAX Stress, MIN Stress, MAX Strain and MIN Strain.
- The **Margin of Safety - MOS** (column Y) is a percentage value that can be positive or negative. If positive, the User can increase the loading until the positive percentage becomes zero. At this point, the model will fail within the required duration specified by the User (vFTGSEQ: MOS_DUR). If the percentage is negative, the model will fail sooner than the required duration.
- The **Plasticity Index** (column Z) is defined as the real (elastic plastic) max strain (***Mean + MAXPEAK*rms_strain***) divided by the FEA (elastic) strain (***Mean + MAXPEAK * rms_stress*** / ***E***). There is no Plasticity Index for a Time Domain analysis.
- The **Critical Plane Angle** (column AB) is populated if vFTGPARM>COMB = critical plane angle when doing a Time Domain analysis. Also, the MEAN + / - columns are replaced with MAX / MIN data when doing a Time Domain analysis.
- **Damage** values are presented as Damage for a Duty Cycle, i.e. damage / sec * event duration (converted to seconds from duration units), whereas **Life** is presented as life in duration units. LIFE is the number of duration units required for fatigue FAILURE due to the input loading applied in the Cf file.
- A summary of the fatigue damage results (for top 10 elements) is presented in the LOG file.

Example Output:

Table 3-3 Frequency Domain analysis output results for elements 13897 and 5971 from TPL2 in User Guide.

Element	Grid	Layer	Elset Id	Material ID	Event	m0	m1	m2	m4	rms	rms_strain	E[0]	E[p]	Irr_Factor	Mean Stress	Mean+ 3*rms	Mean- 3*rms	Mean+ 3*rms_strain	Mean- 3*rms_strain	Damage (Duty Cycle)	Log Damage (Duty Cycle)	Life (seconds)	Log of Life (seconds)	MOS	Plasticity Index	Freq at peak
5971	0	none	600	60	100	4.40E+02	4.08E+03	8.01E+04	6.74E+07	2.10E+01	0.00E+00	1.35E+01	2.90E+01	4.65E-01	0.00E+00	6.29E+01	-6.29E+01	0.00E+00	0.00E+00	1.40E-11	-1.09E+01	7.12E+10	1.09E+01	7.67E+01	0.00E+00	4.88E-01
5971	2658	none	600	60	100	8.06E+02	7.23E+03	1.37E+05	1.14E+08	2.84E+01	0.00E+00	1.30E+01	2.89E+01	4.51E-01	0.00E+00	8.52E+01	-8.52E+01	0.00E+00	0.00E+00	1.61E-09	-8.79E+00	6.19E+08	8.79E+00	7.28E+01	0.00E+00	8.85E+00
5971	2622	none	600	60	100	3.75E+02	4.12E+03	8.60E+04	7.65E+07	1.94E+01	0.00E+00	1.51E+01	2.98E+01	5.08E-01	0.00E+00	5.81E+01	-5.81E+01	0.00E+00	0.00E+00	4.65E-12	-1.13E+01	2.15E+11	1.13E+01	7.66E+01	0.00E+00	8.85E+00
5971	2671	none	600	60	100	3.63E+02	3.24E+03	6.06E+04	4.87E+07	1.91E+01	0.00E+00	1.29E+01	2.84E+01	4.55E-01	0.00E+00	5.72E+01	-5.72E+01	0.00E+00	0.00E+00	2.94E-12	-1.15E+01	3.40E+11	1.15E+01	7.67E+01	0.00E+00	8.85E+00
5971	2616	none	600	60	100	6.27E+03	5.57E+04	1.03E+06	8.15E+08	7.92E+01	0.00E+00	1.28E+01	2.81E+01	4.56E-01	0.00E+00	2.37E+02	-2.37E+02	0.00E+00	0.00E+00	8.40E-03	-2.08E+00	1.19E+02	2.08E+00	2.65E+01	0.00E+00	8.85E+00
13897	0	lower	600	60	100	1.57E+03	1.36E+04	2.55E+05	2.30E+08	3.97E+01	0.00E+00	1.27E+01	3.00E+01	4.24E-01	0.00E+00	1.19E+02	-1.19E+02	0.00E+00	0.00E+00	2.88E-07	-6.54E+00	3.47E+06	6.54E+00	6.20E+01	0.00E+00	8.85E+00
13897	0	upper	600	60	100	1.57E+03	1.36E+04	2.55E+05	2.30E+08	3.97E+01	0.00E+00	1.27E+01	3.00E+01	4.24E-01	0.00E+00	1.19E+02	-1.19E+02	0.00E+00	0.00E+00	2.88E-07	-6.54E+00	3.47E+06	6.54E+00	6.20E+01	0.00E+00	8.85E+00
13897	2858	lower	600	60	100	1.72E+03	1.48E+04	2.73E+05	2.43E+08	4.15E+01	0.00E+00	1.26E+01	2.98E+01	4.22E-01	0.00E+00	1.24E+02	-1.24E+02	0.00E+00	0.00E+00	5.76E-07	-6.24E+00	1.74E+06	6.24E+00	6.03E+01	0.00E+00	8.85E+00
13897	2858	upper	600	60	100	1.72E+03	1.48E+04	2.73E+05	2.43E+08	4.15E+01	0.00E+00	1.26E+01	2.98E+01	4.22E-01	0.00E+00	1.24E+02	-1.24E+02	0.00E+00	0.00E+00	5.76E-07	-6.24E+00	1.74E+06	6.24E+00	6.03E+01	0.00E+00	8.85E+00
13897	2859	lower	600	60	100	2.29E+02	1.87E+03	3.15E+04	2.62E+07	1.51E+01	0.00E+00	1.17E+01	2.88E+01	4.07E-01	0.00E+00	4.54E+01	-4.54E+01	0.00E+00	0.00E+00	4.38E-14	-1.34E+01	2.28E+13	1.34E+01	7.67E+01	0.00E+00	8.85E+00
13897	2859	upper	600	60	100	2.29E+02	1.87E+03	3.15E+04	2.62E+07	1.51E+01	0.00E+00	1.17E+01	2.88E+01	4.07E-01	0.00E+00	4.54E+01	-4.54E+01	0.00E+00	0.00E+00	4.38E-14	-1.34E+01	2.28E+13	1.34E+01	7.67E+01	0.00E+00	8.85E+00
13897	2756	lower	600	60	100	4.09E+03	3.59E+04	6.91E+05	6.36E+08	6.39E+01	0.00E+00	1.30E+01	3.03E+01	4.29E-01	0.00E+00	1.92E+02	-1.92E+02	0.00E+00	0.00E+00	4.59E-04	-3.34E+00	2.18E+03	3.34E+00	3.90E+01	0.00E+00	8.85E+00
13897	2756	upper	600	60	100	4.09E+03	3.59E+04	6.91E+05	6.36E+08	6.39E+01	0.00E+00	1.30E+01	3.03E+01	4.29E-01	0.00E+00	1.92E+02	-1.92E+02	0.00E+00	0.00E+00	4.59E-04	-3.34E+00	2.18E+03	3.34E+00	3.90E+01	0.00E+00	8.85E+00

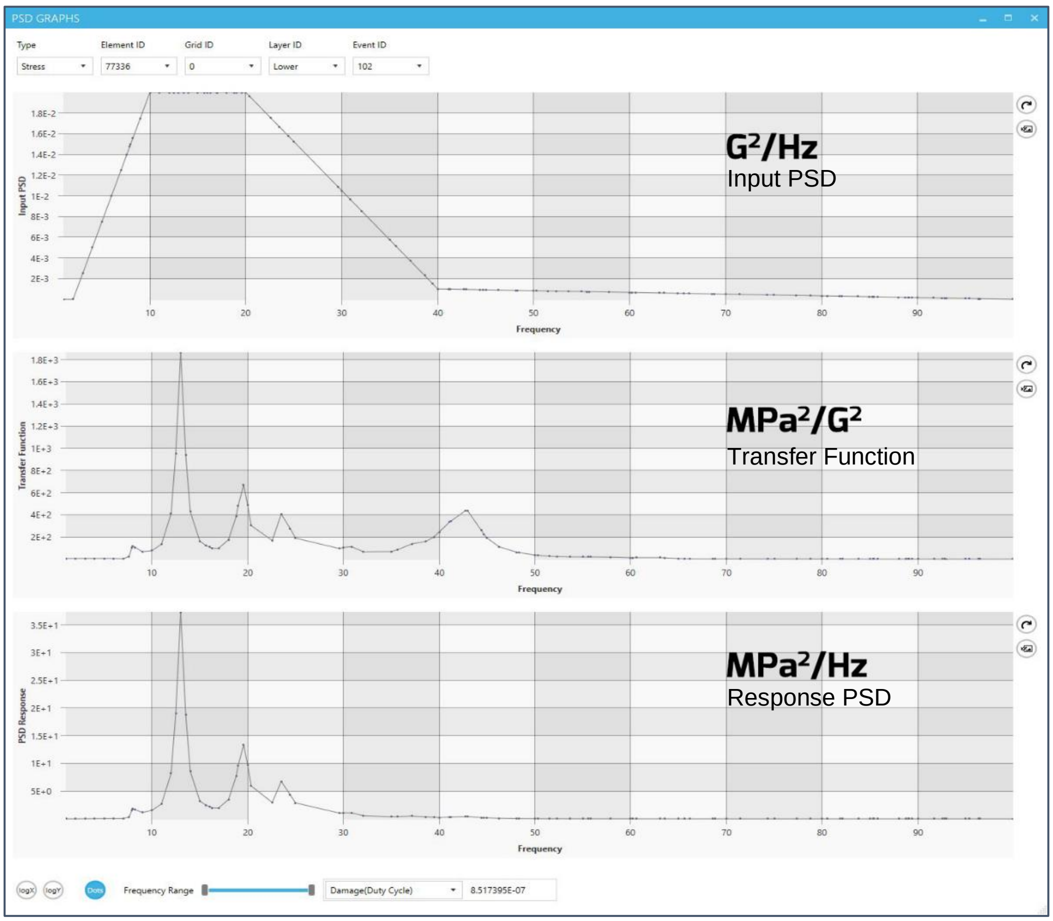
Global Scaling Options - FE_L_MAG (in FE_UNITS), TSCALE (in vFTGSEQ) and SCALE (in vFTGLOAD)

It is often necessary to scale the output provided by the solver or scale the input defined by the User in CF. Below are examples of where and how to scale these loads in the Frequency Domain based on the assumptions below.

First, the scaling will be done on acceleration input and stress output are:

- A one-unit gravity load (**G**) generates an FRF stress output (**MPa**) within the OP2, HDF5, ODB or RST file.
- A **G²/Hz** input PSD (defined within CF) MULTIPLIED by a **MPa²/G²** transfer function (generated by Cf from solver MPa output) EQUALS a **MPa²/Hz** response PSD generated by CF. See following image for graphical representation.

Figure 3-1 Example of Input PSD, Transfer Function, Response PSD and the units for each.



SCALING OPTION 1: FE_L_MAG entry in the FE_UNITS Entry:

a. FE_L_MAG is a scale factor applied to the equivalent stress calculated within CAEfatigue from the complex stress tensor coming from the Solver. It is used to adjust the stress if they were created using the wrong magnitude or unit within the solver and therefore, do not match the units in CAEfatigue. After this scale factor is applied, the equivalent stress is squared to create the transfer functions.

Wrong Magnitude Example: If something other than unity (1) was used to calculate the stress output in the solver for the FRF and time domain analyses, we can use FE_L_MAG to adjust the equivalent stresses to accommodate for this.

FE_L_MAG=0.5 tell Cf that 0.5 G load was used and the original output stresses (MPa) from the solver need to be doubled to represent the stress that would have resulted if 1.0 G had been used instead of 0.5 G. This can be shown by the following

$$\frac{New\ Stress}{Original\ Stress} = \frac{Unit\ Load}{Original\ Load}$$

$$New\ Stress = Original\ \ Stress * \frac{Unit\ Load}{Original\ Load}$$

$$New\ Stress = Original\ Stress * \frac{1\ G}{0.5\ G}$$

Where **FE_L_MAG** equals the Original Load used of 0.5 G. In other words, the equivalent stress output (MPa) will be DIVIDED by the value entered for FE_L_MAG to calculate the new equivalent stress that would be generated from a Unit Load (G).

Wrong Unit Example : If the unit loading used in the solver was in different units than what is being used in CAEfatigue then we can use FE_L_MAG to adjust the equivalent stresses to accommodate for this.

Let's assume that 1 in/s^2 was used as the unit load in the solver, but the PSD has units of G in in/s^2. That means that 1G (or 386.1 in/s^2) should have been used in the solver instead of 1 in/s^2. We could rerun the solver, but it is easier to set **FE_L_MAG= (1/386.1) or 0.00259** to tell CAEfatigue that the stresses coming over from the Solver were actually made using 1 in/s^2 and not 1G. Knowing this, CAEfatigue will divide the stresses by this FE_L_MAG value to get stresses that are much larger; as if they had been generated by 1G loading instead of 1 in/s^2 loading This action will adjust the stress to match the G unit of the PSD.

b. CF then takes this new equivalent stress values and generates Transfer Function points by squaring the stresses (MPa^2) and dividing by G^2 as shows in the Transfer Function image.

c. FE_L_MAG is a global scale factor for all equivalent stress points (MPa) from the solver and is applied BEFORE the transfer function is generated within CF.

Format in Control File:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FE_UNIT	JOBID	CNVRTS	**FE_L_MAG**	CONJCON				

Format in Process Flow:

(Found in **Frequency Analysis** box in PSD analysis or **Time Analysis** box in LQSTATIC and LMTRANS analysis)

<u>SCALING OPTION 2: TSCALE entry in the vFTGSEQ entry:</u>

a. TSCALE also tells Cf that you want to scale the Cf equivalent stress values. For example, **TSCALE=2** will multiply the stress output by 2 prior to the calculation of the Transfer Function; the exact opposite of FE_L_MAG. This can be shown by

$$\frac{New\ Stress}{Original\ Stress} = \frac{Unit\ Load}{Original\ Load}$$

$$New\ Stress = Original\ \ Stress * \frac{Unit\ Load}{Original\ Load}$$

$$New\ Stress = Original\ Stress * \left(\frac{1\ G}{0.5\ G}\right) \quad or \quad Original\ Stress * 2$$

Where **TSCALE** equals the Unit Load / Original Load, which equals 2. In other words, the original equivalent stress output (MPa) will be <u>MULTIPLIED</u> by the value entered for TSCALE to calculate the new equivalent stress that would be generated from a unit G load. TSCALE is the reciprocal of FE_L_MAG.

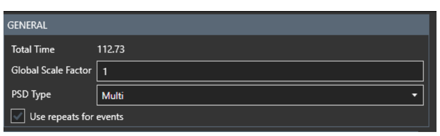
b. CF then takes this new scaled equivalent stress value and converts it to a point on the transfer function by squaring it (MPa^2) and dividing by G^2.

c. TSCALE is a <u>global</u> scale factor for all original equivalent stress output points (MPa) and is applied <u>BEFORE</u> the transfer function is generated within CF.

Format:

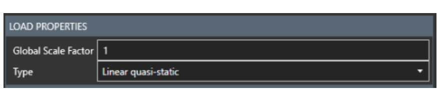
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGSEQ	JOBID	EVNTOUT	DURATION UNIT	MOS_DUR	**TSCALE**			
	EVID1	EVT1	EVID2	EVT2	EVID3	EVT3	…	…
	“UNITS”	EQUIV	EQNAME					

Format in Process Flow (Frequency Domain):

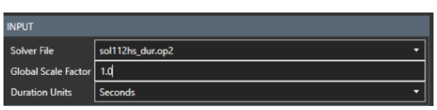


(Frequency Load Scheduler in PSD analysis)

Format in Process Flow (Time Domain): If the User wishes to scale the equivalent stress for any reason, they can also us this entry.



(Time Load Scheduler box in LQSTATIC analysis)



(Modal Transient Loads box in LMTRANS analysis)

Revisit previous example of unit load used but in the wrong units.

In some cases, the FRF calculation is done within the solver using a 1 **m/s²** unit load, however, the input PSD being specified is in units of **G** (gravity). As stated in the previous example, the units between INPUT PSD and TRANSFER FUNCTION **must match up** in order to get the correct units for RESPONSE PSD. To correct this mismatch of units, we can use TSCALE to scale the equivalent stress to get results that would have been calculated if we had used a 1 G unit load in the original FRF calculation.

Since 9.81 m/s^2 is equivalent to 1 G, we set **TSCALE = 9.81**. This tells Cf that the original unit load equivalent stress values need to be multiplied by 9.81 in order to get the equivalent stresses to be equal to those what would have been generated using a 1 G unit load instead of a 1 m/s^2 unit load.

$$New\ Stress = Original\ Stress * \left(\frac{1\ G}{0.102\ G}\right) \quad or \quad Original\ Stress * 9.81$$

NOTE: For **Time Domain** analysis, TSCALE is applied to ALL vFTGLOAD entries because transfer functions are not used in a Time Domain analysis. – Optional, Real>0.0, Default=1.0.

SCALING OPTION 3: SCALE entry in the vFTGLOAD entry:

a. Be careful as this is very different from FE_L_MAG and TSCALE.

b. This is a scale factor applied to the input PSD (G^2/Hz), not to the original FRF stresses as in the case for FE_L_MAG and TSCALE. For example, applying **SCALE=2** will multiply each point on the input PSD by 2 but will not change the original stress output from the solver (MPa) that was read from the OP2, ODB or RST file.

c. Multiplying the input PSD by 2 is actually multiplying each G^2/Hz point in the PSD by 2, which will create a different damage outcome than multiplying the original stress output (MPa) by 2, followed by squaring the MPa value to make the transfer function.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	FLOAD	TYPE	SID	**SCALE**	OFFSET			
LCID	"address of solver stress file" (only needed if not using mapping entry).							

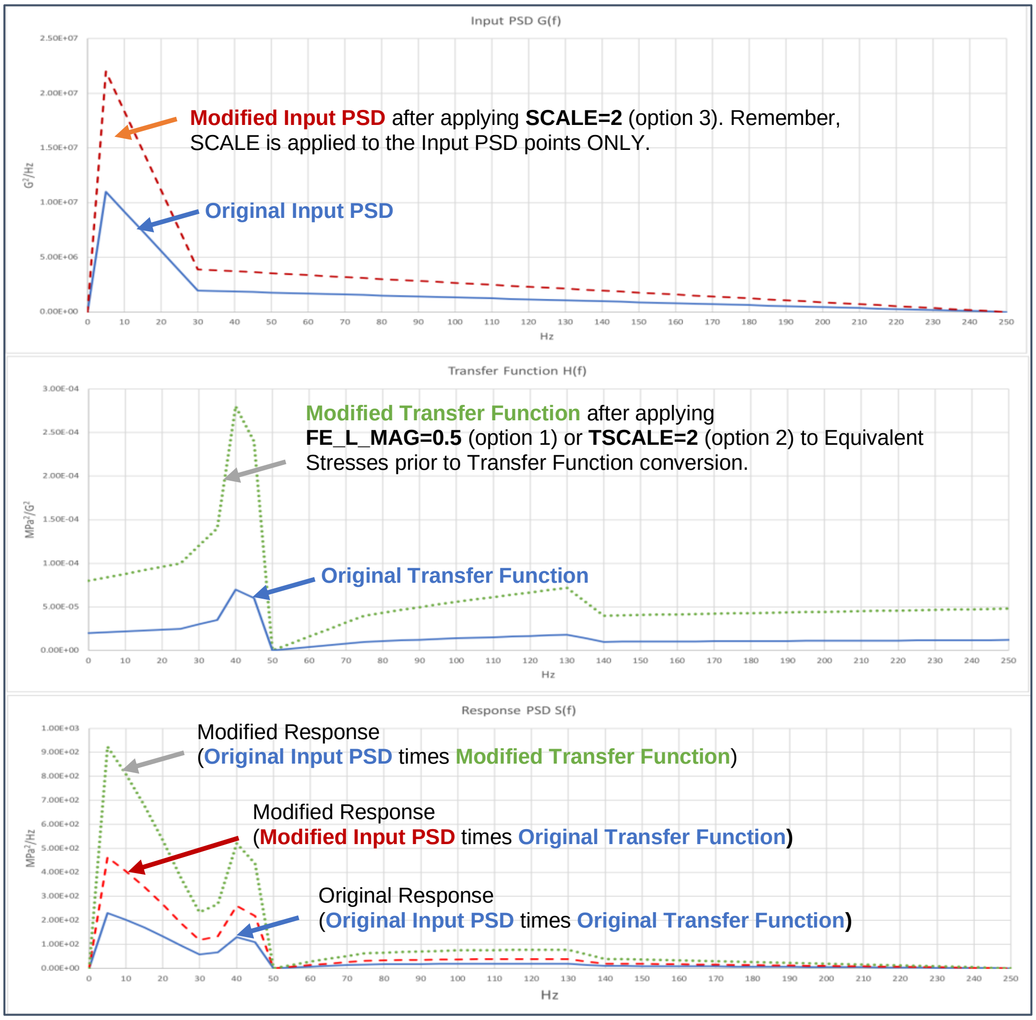
Another Example: A unit Load was used to calculate original FRF stress, but the User is required to used different INPUT PSDs of scaled intensities.

In this example, the FRF calculation was done within the solver using a 1 G unit load, and the INPUT PSD being specified in Cf is also in units of G (gravity). In this case, the units between INPUT PSD and TRANSFER FUNCTION match up and will create the correct units for RESPONSE PSD. No FE_L_MAG or TSCALE is needed in this example. However, the User is given two INPUT PSDs to use in the analysis where one PSD is simply a scaled-up version of the other.

In this case, we could create two separate PSD definitions (using vTABRND entries) along with two vFTGLOAD entries or it may be easier to create one vTABRND entry for the first PSD definition and use SCALE=2 in the second vFTGLOAD entry to simply scale up the PSD described in the vTABRND that defines the first PSD. In this way, if the PSD shape changes for any reason, one change to the vTABRND entry will satisfy the changes for both Input PSD conditions in the example.

The image below is intended to show the differences between using **FE_L_MAG** (option 1), **TSCALE** (option 2), or **SCALE** (option 3). It is vital that the User clearly understands these scaling options and how it will affect their analysis. As can be seen, the OUTPUT RESPONSE varies significantly depending on the scaling used, which will significantly change the fatigue life calculation.

Figure 3-2 Example of Input PSD, Transfer Function, Response PSD and the units for each.



Local Scaling Option – SCALE (in FNOTCH)

SCALING OPTION 4: SCALE entry in the FNOTCH entry

a. SCALE in the FNOTCH entry is a <u>**LOCAL**</u> scaling method use to scale up or down, a section of the Transfer Function.

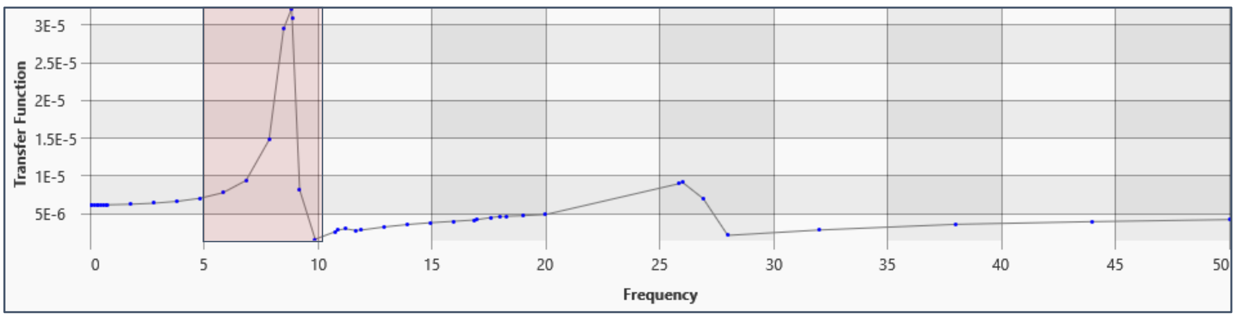
b. If the User provides a starting frequency values (fia) and an ending frequency value (fib), FNOTCH will apply a local scale value (SCALEi) to only that section of the Transfer Function.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FNOTCH	EVID							
	$LCID_i$	$f_i a$	$f_i b$	$SCALE_i$				

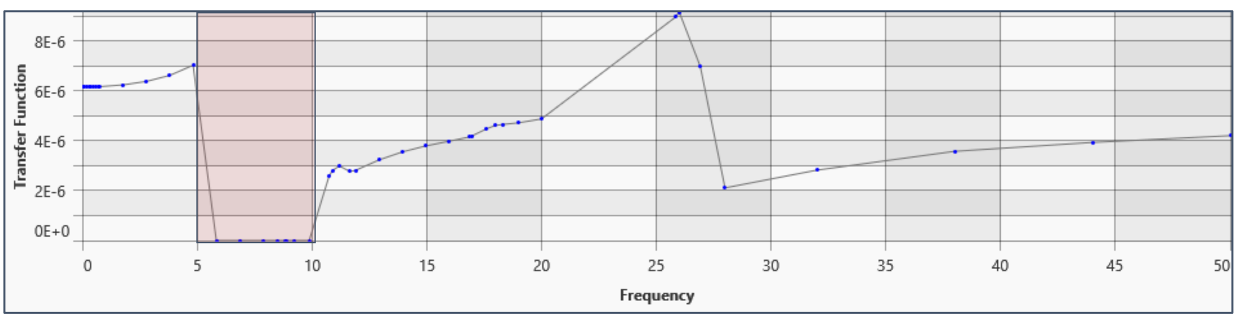
c. NOTE: unlike FE_L_MAG or TSCALE, this FNOTCH SCALE factor is applied directly to the Transfer Function values (MPa^2/G^2) and not just the solver stress values (MPa).

d. Applying a SCALE value of 0.0, can allow a User to remove the influence of a specific frequency range.

Below is the original Transfer Function for TPL109 (see User Guide example).

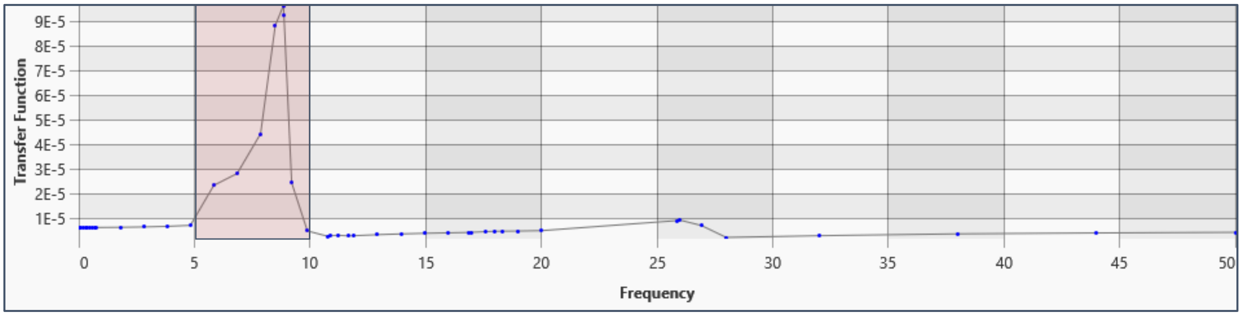


Below is the same Transfer Function with FNOTCH > SCALE=0.0 applied. This means the points in the Transfer Function between 5 Hz and 10 Hz are multiplied by 0.0, which effectively removed this section from the Transfer Function.



Note: FNOTCH scale factor is **only** applied to actual points in the Transfer Function. In the example above, the scale factor was applied to the first point above 5 Hz since no point existed directly at 5 Hz. This function does not interpolate between values to scale at exactly 5 Hz.

Below is the original Transfer Function with **FNOTCH > SCALE=3.0** applied. This means the points in the Transfer Function between 5 Hz and 10 Hz are multiplied by 3.0, which effectively scales up this local section of the Transfer Function.



Why Use FNOTCH?

FNOTCH is a very quick and powerful way for the User to determine the influence on stress, damage, etc. for a very specific frequency range in the analysis. FNOTCH coupled with RESTART, can allow the User to perform sensitive studies to determine the best approach to resolve a frequency based issue with the model.

Post Processing Options

Throughout this document H3D results are post processed with HyperView and FEF results are post processed with Patran; however, any other compatible 3rd party post processor can be used. Results can also be post processed using the included graphical interface supplied within CAEfatigue.

4 | ENTRIES REQUIRED FOR - STRESS FILE SELECTION AND ANALYSIS SETUP

This section describes in detail the "entries and fields" used in the **Control File**. The terms used are similar to the Nastran terminology. Each entry has a number of fields that control the entry behavior during execution of the Control File. Many of the control entries will have default values that will be used in the absence of a data entry for the field. Most control entries are limited 8 characters (unless specified) and must be entered within the appropriate column window.

If using the **Process Flow** interface, the User need not worry about column spacing or ID numbers as the software will handle this without the need for User input.

vIBFAT - Stress Solver Identification and Output Setup

Requests a vibration fatigue analysis using results from a frequency response analysis and (optionally) a static analysis. This must be the first entry in the Cf control file.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vIBFAT	JOBID	OFILTYPE	SOURCE	GIDOUT	LOGLVL	JOBNAME		
	“OPTIONS”		STRLIM			OUTDIR		

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vIBFAT	777	CSV	Nastran	Center	0	Knuckle		
	OPTIONS					Results_TPL1		

Describer	Content
JOBID	ID which references the relevant vFTGSEQ, vFTGPARM, vFTGDEF, FE_UNITS, KTDATA and INCLDIR entries. – Required, Integer>0, no default.
OFILTYPE	Choice of CSV, FEF, CSVFEF, H3D, FEFH3D, CSVH3D, H3D**xx**, CSVH3D**xx**, FEFH3D**xx** (where **xx** = nb/nt/nw), FEF**yy**, CSVFEF**yy** (where **yy** = eb/et/ew/nb/nt/nw). FEF is a flat ASCI Patran neutral (ELS) file. H3D is an Altair binary format and CSV is a comma separated value text file. – Required, Character, Default=CSV. NOTE: n=node, e=element, b=bottom, t=top, w=worst. If selecting H3D, the software will create a single H3D file for every event or event summary. If the User wants to have only a single H3D file for the entire job, please use the Utilities H3D Writer option. If selecting FEF, the software will create a single FEF file for every event or event summary at the element / node bottom, top and worst location. This can result in a number of output FEF files.
SOURCE	Stress solver used. Available options are below – Required, Character, Default=Nastran. **Nastran** – MSC Nastran OP2 file **Nasth5** – MSC Nastran HDF5 file **NX** – NX Nastran OP2 file **Abaqus** – Abaqus ODB file **Ansys** – Ansys RST file **OS** – Optistruct OP2 file **Lsdyna** – LSDYNA d3plot file (LTRANS analysis with center stresses only)

GIDOUT	The type of results to be stored in the Main CSV output file. Note: The solver file must contain the corner results for options CORNER and NODAV. Remaining options are CENTER, CENTUPP, or CENTLOW. -- Required, Character, Default=CENTER.
LOGLVL	Level of messaging sent to the LOG file and output saved from the job execution. Options are 0=Basic output, 1=Basic plus PSD or Time Signal output and 2=Basic plus PSD or Time Signal output plus Damage output. **Warning**: In the Frequency Domain, the amount of output results can change significantly depending on the LOGLVL chosen. LOGLVL=1 or 2 should be used in combination with ELSET/FSET3 to limit the amount of output. See previous section in this document for a detailed explanation of LOGLVL. – Required, Integer, Default=0.
JOBNAME	Used to tag all output files. – Optional, Character, Default=Control File name without *.txt.
"**OPTIONS**"	Optional FLAG indicating that various options for stress recovery are to follow.
STRLIM	STRLIM=1 will read from the solver file or restart file, only the elements defined by ELSETs and use those elements in the analysis. All other elements will be ignored in the analysis. STRLIM=0 will use all elements read from the Solver file or restart file. – Optional, Integer 0 or 1, Default=0, but 1 when ELSET is entry is present.
OUTDIR	Directory location where all output files should be written. Directory must already exist and be part of the same directory structure from where the job was run. In other words, if the file being executed is c:\Documents\TPL\TPL1.txt, then the OUTDIR would need to be within the TPL directory. There is no limit on the length of the name. – Optional, Character, no default.

Remarks:

1. The JOBID points to specific vFTGDEF, vFTGPARM and vFTGSEQ entries that belong to the same analysis. The JOBID in the vIBFAT entry is the job that will be run in the analysis, regardless of other JOBIDs existing in other locations.
2. Specifying H3D in the OFILTYPE entry will produce a separate H3D file for every Event in the analysis. If the User wants to have only a single H3D file for the entire job, please use the Utilities H3D Writer option.

OP2MAP and OP2MAPS – Mapping between LCID's in Cf and Subcases in Nastran

This is a method to map the load case IDs in Cf to the subcase ID's from Nastran. This is used for random (dynamic) OP2 mapping whereas the OP2MAPS is used for static (preload) OP2 mapping. How mapping is used differs depending on it being a time domain or frequency domain analysis. See remarks below for more information.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
OP2MAP (S)	File_name (for complex stress OP2 file)							
	$CFLCID_1$	$OP2LCID_1$						
	$CFLCID_2$	$OP2LCID_2$						
	$CFLCID_n$	$OP2LCID_n$						

Examples:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
OP2MAP	Dynamic_Stress.op2							
	1	101						
	2	102						
	3	103						

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
OP2MAPS	Static_Stress.op2							
	1	1001						

Describer	**Contents**
File_Name	The name of the OP2 file from Nastran. – Required, Character, no default.
$CFLCID_N$	Unique load case ID numbers to be used in the Cf analysis. Numbers must be ascending, i.e., 1, 2, 3, etc. – Required, Integer>0, no default.
$OP2LCID_N$	Subcase ID numbers in the OP2 file. – Required, Integer>0, no default.

Remarks:

1. Using this entry allows flexibility to keep the same Cf control file with a simple change to the mapping entry for different OP2 files and OP2 file subcase IDs.
2. Mapping entry must be placed above the vFTGLOAD entries in the Cf Control File.
3. Mapping and the associated loading definitions work differently between time domain and frequency domain. See information below.

Frequency Domain analysis using a **Nastran SOL111 OP2** file:

Mapping Example	vFTGLOAD Example

`OP2MAP Nastran_SOL111.op2`
`$ LCID OP2_Subcase`
`1 1`
`$ <add more as needed>`
 	
`***`
Notes: Mapping of Cf LCID numbers to Nastran subcases that represent the same **channels** used to create the PSDM file or if no RPC file was used, the same subcases used to create the PSDM inputs.
	`$ FLOAD TYPE SID SCALE OFFSET`
	`vftgload801 PSD 1 1.00`
	`$ LCID FILENAME`
	`multi`
	`$`
	`include TIME2PSD_EV1_PSDM.txt`
	
	`***`
	NOTE: This will apply the PSDM file to **all** the LCID numbers in the OP2MAP entry at the same time. SID refers to the SID number in the vRANDPS entry in the included PSDM file.

Time Domain analysis using a **Nastran SOL101 OP2** file - static superposition method:

Mapping Example	vFTGLOAD Example

`OP2MAP Nastran_SOL101.op2`
`$ Ch_Num OP2_Subcase`
`1 1`
`$ <add more as needed>`
 	
`***`
Notes: Mapping of required vFTGLOAD RPC channel numbers to Nastran subcases that correspond to the same channel numbers.
	`$ FLOAD TYPE SID SCALE OFFSET`
	`vftgload801 LQSTATIC 1.00`
	`$ LCID FILENAME`
	`LQSTATIC_EV1.rsp`
	
	`***`
	NOTE: This will apply mapped channel numbers from the input RPC event file to the appropriate Nastran subcase corresponding to the same channels. These loads will be applied at the same time. The LCID and SID is **not** required.

Time Domain analysis using a **Nastran SOL112 (103) OP2 with PUNCH file output that contains the modal participation factors** – MPF stress recovery method:

Mapping Example	vFTGLOAD Example

`OP2MAP Nastran_SOL112.op2`
`$ LCID OP2_Subcase`
`1 1`
`$ <add more as needed>`
 	
`***`
Notes: Mapping of Cf LCID numbers to Nastran subcases that refer to the **events** applied to the model.
	`$ FLOAD TYPE SID SCALE OFFSET`
	`vftgload801 LMTRANS 1.00`
	`$ LCID FILENAME`
	`1 LMTRANS_EV1.PUNCH`
	
	`***`
	NOTE: This will apply the modal loads in the PUNCH file to the Nastran OP2 event subcase using the LCID number as reference for the OP2MAP entry. The SID is **not** required.

Time Domain analysis using a **Nastran SOL112 OP2 with separate RSP file using another source like MSC Adams** – modal transient stress recovery method:

Mapping Example	vFTGLOAD Example
OP2MAP Nastran_SOL112.op2 **$ LCID OP2_Event** **$ no mapping number are needed** *** Notes: Mapping of Cf LCID numbers to Nastran subcases are not required when using RSPs to describe each event.	**$ FLOAD TYPE SID SCALE OFFSET** **vftgload801 LMTRANS 1.00** **$ LCID FILENAME** **LMTRANS_EV1.RSP** **$** **vftgload802 LMTRANS 1.00** **$ LCID FILENAME** **LMTRANS_EV2.RSP** **$ <add an vFTGLOAD entry and RSP file for each Event>** *** NOTE: This will apply the modal loads in the RSP files for each event to the Nastran OP2 events. The LCID and SID numbers are **not** required.

Time Domain analysis using a **Nastran SOL112 OP2** file – direct stress recovery method:

Mapping Example	vFTGLOAD Example
OP2MAP Nastran_SOL112.op2 **$ LCID OP2_Event** **1 1** **$ <add more as needed>** *** Notes: Mapping of Cf LCID numbers to Nastran subcases that refer to the **events** applied to the model.	**$ FLOAD TYPE SID SCALE OFFSET** **vftgload801 LTRANS 1.00** **$ LCID FILENAME** **1** *** NOTE: This will obtain the stresses directly from the Nastran OP2 event subcase using the LCID number to select the Nastran subcase. The SID is **not** required.

ODBMAP and ODBMAPS – Mapping between LCID's in Cf and STEPS in Abaqus

If reading results from Abaqus, this is an entry to assign the specified STEPs in the Abaqus ODB file to the load case IDs in CF. This is used for random (dynamic) ODB mapping whereas the ODBMAPS is used for static (preload) ODB mapping. How mapping is used differs depending on it being a time domain or frequency domain analysis. See remarks below for more information.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
ODBMAP (S)	File_name (for ODB stress file)							
	$CFLCID_1$	$ODBLCID_1$						
	$CFLCID_2$	$ODBLCID_2$						
	$CFLCID_n$	$ODBLCID_n$						

Examples:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
ODBMAP	XYZ_Dynamic_Stress.odb							
	1	Steady State X						
	2	Steady State Y						
	3	Steady State Z						

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
ODBMAPS	Static_Stress.odb							
	1	Static_Step						

In some cases, the static or preload data (real) and the dynamic or steady state data (complex) stress results are in the same ODB file. In this case, the same file name can be used for both mapping inputs. For example: ***combined.odb***.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
ODBMAP	combined.odb							
	1	Steady State X						
	2	Steady State Y						
	3	Steady State Z						

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
ODBMAPS	combined.odb							
	1	Static_Step						

In some cases, the dynamic or steady state (complex) stress results are in different ODB files. In this case, you would need to list the mapping separately. Example below.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
ODBMAP	X_Dir_Dynamic_Stress.odb							
	1	Steady State X						

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
ODBMAP	Y_Dir_Dynamic_Stress.odb							
	2	Steady State Y						

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
ODBMAP	Z_Dir_Dynamic_Stress.odb							
	3	Steady State Z						

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
ODBMAPS	Static_Stress.odb							
	1	Static_Step						

Describer	**Contents**
File_Name	The name of the ODB file from Abaqus. – Required, Character, no default.
$CFLCID_N$	Unique load case ID numbers to be used in the Cf analysis. Numbers must be ascending but does not need to start at 1 or be consecutive, i.e., 2, 3, 5, etc. – Required, Integer>0, no default.
$ODBLCID_N$	STEP name in Abaqus ODB file. – Required, Integer>0, no default.

.

Remarks:

1. Using this entry allows flexibility to keep the same Cf control file with a simple change to the mapping entry for different ODB files and ODB file subcase IDs.
2. Mapping entry must be placed above the vFTGLOAD entries in the Cf Control File.
3. Mapping and the associated loading definitions work differently between time domain and frequency domain. See information below.

Frequency Domain analysis using an **Abaqus FRF ODB** file:

Mapping Example	vFTGLOAD Example

`ODBMAP   Abaqus_FRF.odb`
`$        LCID     ODB_Step`
`         1        1`
`$        <add more as needed>`
 	
`***`
Notes: Mapping of Cf LCID numbers to Abaqus Steps that represent the same **channels** used to create the PSDM file or if no RPC file was used, the same Steps used to create the PSDM inputs.
	`$        FLOAD    TYPE     SID      SCALE    OFFSET`
	`vftgload801       PSD      1        1.00`
	`$ LCID   FILENAME`
	`multi`
	`$`
	`include TIME2PSD_EV1_PSDM.txt`
	
	`***`
	NOTE: This will apply the PSDM file to **all** the LCID numbers in the ODBMAP entry at the same time. SID refers to the SID number in the vRANDPS entry in the included PSDM file.

Time Domain analysis using an **Abaqus Linear Static ODB** file - static superposition method:

Mapping Example	vFTGLOAD Example

`ODBMAP   Abaqus_Static.odb`
`$        RPC_Ch   ODB_Step`
`         1        1`
`$        <add more as needed>`
 	
`***`
Notes: Mapping of required vFTGLOAD RPC channel numbers to Abaqus Steps that correspond to the same channel numbers.
	`$        FLOAD    TYPE     SID      SCALE    OFFSET`
	`vftgload801       LQSTATIC           1.00`
	`$ LCID   FILENAME`
	`         LQSTATIC_EV1.rsp`
	
	`***`
	NOTE: This will apply mapped channel numbers from the input RPC event file to the appropriate Abaqus Steps corresponding to the same channels. These loads will be applied at the same time. The LCID and SID is **not** required.

Time Domain analysis using an **Abaqus Modal Participation Factor** – MPF stress recovery method:

Mapping Example	vFTGLOAD Example

`ODBMAP   Abaqus_MPF.odb`
`$        LCID     ODB_Step`
`         1        1`
`$        <add more as needed>`
 	
`***`
Notes: Mapping of Cf LCID numbers to Abaqus Steps that refer to the **events** applied to the model.
	`$        FLOAD    TYPE     SID      SCALE    OFFSET`
	`vftgload801       LMTRANS           1.00`
	`$ LCID   FILENAME`
	`1        LMTRANS.odb`
	
	`***`
	NOTE: This will apply the modal loads from Abaqus using the LCID number as reference for the ODBMAP entry. The SID is **not** required.

RSTMAP and RSTMAPS – Mapping between LCID's in Cf and a Subcase in Ansys

This is a method to map the load case IDs in Cf to the subcase IDs from Ansys. This is used for random (dynamic) RST mapping whereas the RSTMAPS is used for static (preload) RST mapping. Note: multiple RSTMAP(S) entries are permitted. Note: for LQSTATIC analysis only, Cf will work with RST files with multiple Steps (subcases). This feature will be extended to all analysis types in a later release.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
RSTMAP (S)	File_name (for complex stress RST file)							
	$CFLCID_1$	$RSTLCID_1$						

Examples:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
RSTMAP	Dynamic_Stress_1.RST							
	1	101						
RSTMAP	Dynamic_Stress_2.RST							
	2	101						
RSTMAPS	Static_Stress_1.RST							
	1	101						

If doing an LQSTATIC (TD linear static analysis):

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
RSTMAP	Dynamic_Stress_3.RST							
	1	101						
	2	102						
	3	103						

Describer	**Contents**
File_Name	The name of the RST file from Ansys. – Required, Character, no default.
$CFLCID_N$	Unique load case ID number to be used in the Cf analysis. – Required, Integer>0, no default.
$RSTLCID_N$	Step ID numbers in the RST file. – Required, Integer>0, no default.

Remarks:

1. Using this entry allows flexibility to keep the same Cf control file with a simple change to the mapping entry for different RST files and RST file subcase IDs.
2. Multiple RSTMAP and RSTMAPS entries are permitted.

3. Mapping entry must be placed above the vFTGLOAD entries in the Cf Control File.
4. Mapping and the associated loading definitions work differently between time domain and frequency domain. See information below.

Frequency Domain input PSD analysis using an **Ansys FRF RST** file:

<table>
<tr><th>Mapping Example</th><th>vFTGLOAD Example</th></tr>
<tr><td>

```
RSTMAP   Ansys_FRF_1.rst
$        LCID     RST_Step
         1        1
RSTMAP   Ansys_FRF_2.rst
$        LCID     RST_Step
         2        1
$        <add more RSTMAP entries as needed>

***
Notes: Mapping of Cf LCID numbers to Ansys
substeps.
```

</td><td>

```
$        FLOAD    TYPE     SID      SCALE    OFFSET
vftgload801       PSD      1        1.00
$ LCID   FILENAME
1
$ or use Multi for multiple input Psd

***
NOTE:  This will apply the RST subcase for Ansys_FRF.rst
to the first (1st) LCID in CAEfatigue.
```

</td></tr>
</table>

Time Domain analysis using an **Ansys Linear Static RST** file - static superposition method:

<table>
<tr><th>Mapping Example</th><th>vFTGLOAD Example</th></tr>
<tr><td>

```
RSTMAP   Ansys_Static.rst
$        RPC_Ch   RST_Step
         1        1
$        <add more as needed>

***
Notes: Mapping of required vFTGLOAD RPC
channel numbers to Ansys substeps that
correspond to the same channel numbers.
```

</td><td>

```
$        FLOAD    TYPE     SID      SCALE    OFFSET
vftgload801       LQSTATIC           1.00
$ LCID   FILENAME
         LQSTATIC_EV1.rsp

***
NOTE:  This will apply mapped channel numbers from the
input RPC event file to the appropriate Ansys substeps
corresponding to the same channels. These loads will be
applied at the same time. The LCID and SID is not
required.
```

</td></tr>
</table>

Time Domain analysis using an **Ansys Modal Participation Factor** – MPF stress recovery method:

<table>
<tr><th>Mapping Example</th><th>vFTGLOAD Example</th></tr>
<tr><td>

```
RSTMAP   Ansys_MPF.odb
$        LCID     RST_Step
         1        1
$        <add more as needed>

***
Notes: Mapping of Cf LCID numbers to Ansys
substeps that refer to the events applied
to the model.
```

</td><td>

```
$        FLOAD    TYPE     SID      SCALE    OFFSET
vftgload801       LMTRANS           1.00
$ LCID   FILENAME
1        LMTRANS.RST

***
NOTE:  This will apply the modal loads from Ansys using
the LCID number as reference for the RSTMAP entry. The
SID is not required.
```

</td></tr>
</table>

CASEMAP and CASEMAPS – Defining MNF or Mapping to Subcases in Nastran H5 file or LSDyna D3PLOT file.

The CASEMAP is used for several inputs:

- The CASEMAP entry provides a method to read in the modal stresses from a Modal Neutral File (MNF) file created from Nastran. The MNF file is typically generated to use in MSC Adams. Hence, CAEfatigue will support a Time Domain modal transient analysis using the Nastran MNF stress field file and the Adams RSP modal loads file.
- The CASEMAP entry can be used to map the load case IDs in Cf to the subcase ID's from a Hierarchical Data Format (HDF5) file created by Nastran. CASEMAP maps the random (dynamic) or nonlinear HDF5 stress file whereas the CASEMAPS maps the static (preload) HDF5 stress file.

  NOTE ON HDF5 LIMITATION: Currently these entries can only be used for a single Input PSD random (D, V, A, F, M) and fatigue analysis (using a Nastran SOL111) or for a non-linear static analysis (NQSTATIC) using a Nastran SOL400 analysis or Marc analysis.
- The CASEMAP entry can be used to map the load case IDs in Cf to the subcase ID's from a LSDyna stress file (typically with the extension d3plot).

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CASEMAP	File_name (for MNF file)							

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CASEMAP (S)	File_name (for dynamic stress file)							
	$CFLCID_1$	$Solver\_LCID_1$						
	$CFLCID_2$	$Solver\_LCID_1$						
	$CFLCID_n$	$Solver\_LCID_1$						

Examples:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CASEMAP	Filename.MNF							

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CASEMAP	Dynamic_Stress.HDF5							
	1	101						
	2	102						
	3	103						

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CASEMAPS	Static_Stress.HDF5							
	1	1001						

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CASEMAP	Dynamic_Stress.d3plot (for LTRANS analysis only)							
	1	101						

NQSTATIC analysis example using MARC Nastran HDF5 file:

Assuming we had HDF5 nonlinear stress results from MARC as shown below. We could analyze any subcase, step, increment result using the following specification within a Cf control file.

```
SC1:, A1:Time=0.
SC1:Step 1:, A1:Time=0.2
SC1:Step 1:, A1:Time=0.4
SC1:Step 1:, A1:Time=0.6
SC1:Step 1:, A1:Time=0.8
SC1:Step 1:, A1:Time=1.
SC1:Step 2:, A1:Time=1.2
SC1:Step 2:, A1:Time=1.4
SC1:Step 2:, A1:Time=1.6
SC1:Step 2:, A1:Time=1.8
SC1:Step 2:, A1:Time=2.
SC1:Step 3:, A1:Time=2.2
SC1:Step 3:, A1:Time=2.4
SC1:Step 3:, A1:Time=2.6
SC1:Step 3:, A1:Time=2.8
SC1:Step 3:, A1:Time=3.
SC1:Step 4:, A1:Time=3.2
SC1:Step 4:, A1:Time=3.4
SC1:Step 4:, A1:Time=3.6
SC1:Step 4:, A1:Time=3.8
SC1:Step 4:, A1:Time=4.
```

Note: CAEfatigue does not support the MARC OP2 file format; only the MARC HDF5 file format.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CASEMAP	nonlinear_Stress.HDF5 (from SOL400 or MARC analysis)							
	1	Subcase 1, step 1, increment 0.2						
	2	Subcase 1, step 2, increment 1.4						
	3	Subcase 1, step 3, increment 2.8						
	4	Subcase 1, step 4, increment 3.8						

The User will see the following in the LOG file information indicating the correct step / increments were selected.

```
Beginning Time Domain Damage Computations
Casemap + h5: H5 domain id is 2 for user-specified subcase 1, step 1, increment 0.2
Casemap + h5: H5 domain id is 8 for user-specified subcase 1, step 2, increment 1.4
Casemap + h5: H5 domain id is 15 for user-specified subcase 1, step 3, increment 2.8
Casemap + h5: H5 domain id is 20 for user-specified subcase 1, step 4, increment 3.8
Number of subcases/stress states read from op2/odb/rst/hf5/API : 4
```

NOTE: Most Users do not use the Increment option. If left out, Cf will read the last time entry for the step. In other words, Cf would analyze Increments = 1.0, 2.0, 3.0., and 4.0 respectively, if INCREMENT was removed from the definitions above.

Describer	Contents
File_Name	The name of the MNF or HDF5 file from Nastran. – Required, Character, no default.
$CFLCID_N$	Unique load case ID numbers to be used in the Cf analysis. Numbers must be ascending, i.e., 1, 2, 3, etc. – Required, Integer>0, no default.
$SOLVER\_LCID_N$	HDF5: Subcase ID numbers for linear analyses or subcase, step and increment numbers for NQSTATIC analyses. – Required, Integer>0 (Real for the time entry shown in example above), no default. D3plot: Step ID number for linear direct transient analysis. - Required, Integer>0, no default.

Remarks:

1. Using this entry allows flexibility to keep the same Cf control file with a simple change to the mapping entry for different HDF5 files and HDF5 file subcase IDs.
2. Mapping entry must be placed above the vFTGLOAD entries in the Cf Control File
3. If required, multiple CASEMAP entries can be used to define subcases from several different Lsdyna d3plot files.

vFTGDEF – Element Identification and Fatigue Analysis Setup

Defines element sets and the job parameters to be considered for fatigue analysis and the output required. Note: omitting a value for both MID and MIDi means that only random response data is calculated (i.e., no fatigue data). This means no material properties are required (i.e., no vMATFTG entry is required) and reduced output is produced (see vIBFAT output options).

The vFTGDEF entry has a very large number of fields that are used in a Frequency Domain and/or Time Domain analysis. The color coding used below is intended to define the uses for each field.

Orange items are only applicable to the Time Domain. Blue items are applicable to the Frequency Domain. Green items are applicable to both Time Domain and Frequency Domain analysis. Note: Items in Grey are not currently supported.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGDEF	JOBID	ATYPE	TOPRMS or TOPSTR	MID	CLIPLEV	MAXFREQ	MAXSTR	STRBINS
	"ELSET"	ELSID1	MID1	ELSID2	MID2	ELSID3	MID3	
		ELSID4	MID4	...	...	...	...	
	"HOTSPOT"	NHS	HSGATE	HSFLAG	STOP			
	"FILTER"	TOPRMS	TOPRMSD	TOPRMSV	TOPRMSA	TOPDMG		
	"DIAGNOS"	*NHSD*	HSSET	*CHSET*	VAR			
	"RCCOUT"	*RCCVAR1*	*RCCID1*	*RCCVAR2*	*RCCID2*	*RCCVAR3*	*RCCID3*	
		RCCVAR4	*RCCID4*	...	...	...	...	
	"PSDOUT"	PSDVAR1	PSDID1	PSDVAR2	PSDID2	PSDVAR3	PSDID3	
		PSDVAR4	PSDID4	...	...	...	...	
	"PSDMOUT"	OUTVAR	G_1	DOF$_j$	G_2	DOF$_2$	G_3	DOF$_3$
		G_4	DOF$_4$	...	...	...	...	
	"TIMEOUT"	TIMEVAR1	TIMEID1 or RUNTIME					
	"HISTRCC"	"ELSET" or "TIMEOUT"	ELSID					
	"CRITOUT"	CRITVAR1	CRITID1					
	"SGATE"	METHOD	*EVOPT*	*MODE*	*TYPE*	*T_ACC*	*PL_LIM*	
	Target_File							
	"USERWHS"	HSSIDi	MIDi	TENSIDi				
	"SPOTW"	SPSID1	MID1	DIAM	T1	T2		
		SPSID2	MID2	DIAM	T1	T2		
	"SEAMW"	SWSID1	MID1	NDSID1	BTHRESH	*RTHICK*	*nTHICK*	WTYPE

		SWSID2	MID2	NDSID2	BTHRESH	*RTHICK*	*nTHICK*	WTYPE
	"SEAMW3DH"	SWSID1	MID	MAXDEPTH	NUM_LAYERS	BTHRESH		
	"SEAM7608"	SWSID1	WeldClass	SCF	Distance	Tref	k	
	"ABSRESP"	ABSVAR1	SETID1	ABSVAR2	SETID2	ABSVAR3	SETID3	
		ABSVAR4	SETID4	...	...	...	...	
	"RELRESP"	RELVAR1	SETID1	PARAM1	PARAM2			
		RELVAR2	SETID2	PARAM1	PARAM2			
	"RELRESP2"	RELVAR	NODEID1	NODEID2				
	"SNXML / ENXML"	SETNAME	SETID1	SETID2	SETID3	…		

Examples:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGDEF	777	Dirlik	U90.0	3	16	99.9	16	64

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGDEF	777	Dirlik						
	ELSET	14	3	15	4			
	HOTSPOT	10	2					
	ABSRESP	DA	480					
	RELRESP	D	485	S0.01				
	PSDOUT	DV	481	S	490	F	495	
		A	500	S	510			
	PSDMOUT	DA	80000	123456	80010	123	80025	456
		80030	123	80040	123	80060	123456	

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGDEF	777	Dirlik						
	ABSRESP	DM						
	PSDOUT	D	481					
	PSDOUT	M	NAME1					
	PSDMOUT	M	NAME1	123456	NAME2	123	NAME3	123456
	NAME4	123	NAME5	1346				

Describer	**Contents**
JOBID	JOB ID used for entries vFTGSEQ vFTGPARM, vFTGDEF, FE_UNITS, KTDATA and INCLDIR entries. – Required, Integer>0, no default.
ATYPE	Fatigue Analysis type (Dirlik, NB, Stein, Sines and Simsine). See table for ATYPE to choose depending on loading condition. -- Required, Character, Default=Dirlik (for Frequency Domain) or RAINFLOW (for Time Domain)

ATYPE	Meaning	Loading Condition
Dirlik	Use Dirlik approach for Rainflow cycle count (RCC).	Applicable for any random PSD load with/without additional deterministic loading applied. Also, applicable for DETLOAD if more than one sinewave is applied with/without additional random loading applied.
NB	Use Narrow Band approach for Rainflow cycle count (RCC).	Applicable for any random PSD load (but best suited for NB PSD) with/without additional deterministic loading applied. Also, applicable for DETLOAD if more than one sinewave is applied with/without additional random loading applied.
Stein	Use Steinberg 3-banded approach for broad band Rainflow cycle count (RCC).	Applicable for any random PSD load with/without additional deterministic loading applied. Not as accurate as DIRLIK method. Also, applicable for DETLOAD if more than one sinewave is applied with/without additional random PSD loading applied.
Sines	Assumes that ONLY sinewaves are passed through the structural system.	Applicable for SINGSINE or SINESW (i.e. only sinewaves), i.e. if NO additional random PSD loading applied. Also, applicable for DETLOAD if ONLY one sinewave is applied i.e. if NO additional random PSD loading applied.
Simsine	Requests a synthesized time history be created of length RCCT, which is then rainflow cycle counted and used for fatigue life evaluation. See detailed notes below.	Applicable for DETLOAD if more than one sinewave applied with/without additional random loading applied.
Rainflow	For Time Domain analysis only.	Applicable for all Time Domain analyses.

TOPRMS

FREQUENCY DOMAIN ONLY:

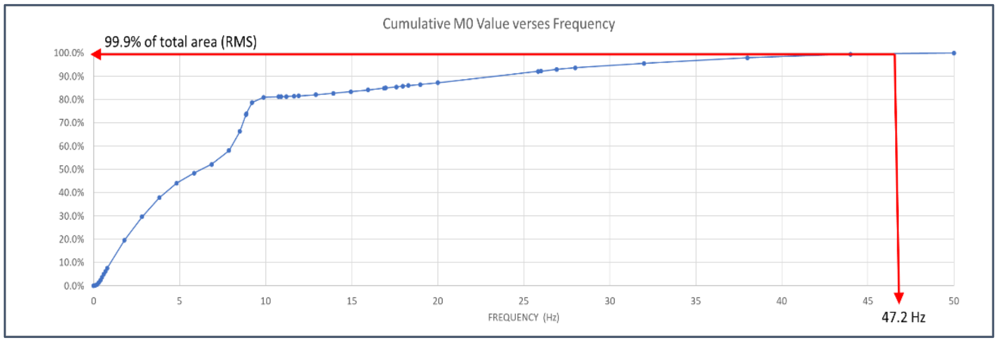
Max Stress Based: Top rms stress percentage to keep in the output results set. Only elements or nodes with rms values within the percentage will be retained and results reported. Example: If the highest calculated RMS stress is 1000 MPa and **TOPRMS=90**, then all elements with an RMS stress from 100 MPa to 1000 MPa will be retain and the lowest 10% will be ignored in the analysis.

This field will filter Stress (element based), Displacement, Velocity and Acceleration (nodal based) results. This field will be ignored if the RELRESP, RELRESP2 or HOTSPOT flags are used. This field will also be overwritten by any values used in the FILTER flag. – Required, 0.0<Real≤100.0, Default=100.0.

UTS Stress Based: If value is preceded by a **U (e.g., U90.0)** then all elements within the top 90% of the element's UTS stress value will be kept. Example: If the UTS is 400 MPa and TOPRMS= U90, then elements with stresses above 40 MPa will be retained for the analysis. The Displacement, Velocity and Acceleration will still

	be filtered at 90% (U is ignored) or the User can choose to use the FILTER flag to enter individual RMS filter values for Displacement, Velocity and Acceleration.
TOPSTR	**TIME DOMAIN ONLY**: **Max Stress Based**: Pass through set of elements from the model based on xx% of the largest stress range. Example: **90** means all elements within 90% of the largest stress range value will be kept and used in the analysis. – Optional, 0.0< Real ≤100.0, no default, i.e., no preceding character applied. **UTS Stress Based**: If value is preceded by a **U (e.g., U90.0)** then all elements within the top 90% of the element's UTS stress value will be kept. Example: If the UTS is 400 MPa and TOPRMS= U90, then elements with stresses above 40 MPa will be retained for the analysis. **Model Size Based**: If the value is preceded by an **M (e.g., M90.0)** then the top 90% of the elements are kept in the analyses based on the highest to lowest **stress range value**. Example: If the model has 100,000 elements, then 90,000 elements (ranked in order from highest to lowest stress range values) will be retained for the analysis. **Simple Stress Range Based**: If the value is preceded by an **S (e.g., S90.0)** then the top 90% of the elements are kept in the analyses based on a **scaled stress range** calculation. Depending on the equivalent stress defined i.e., von Mises or Max Principal, the stress range value is multiplied by the local and/or global scale factors defined in vFTGLOAD and vFTGSEQ respectively. Example: If the model has 100,000 elements, then 90,000 elements (ranked in order from highest to lowest scaled stress range values) will be retained for the analysis.
MID	ID of a vMATFTG entry for associating fatigue properties to all elements of the model. Leave blank if ELSET option is used. <u>Must</u> be left blank for Random Response Only. – Optional, Integer>0, no default. Special case: if **MID = -1**, Cf will NOT read / calculate stress results. This is useful if you are only reading Displacements from the solver.
CLIPLEV	Value of stresses where all stresses are "clipped" (kept at that level) when doing the fatigue life calculation. CLIPLEV is only used for damage calculations so is therefore, ignored for Random Response Only analysis. – Required, Real>0, Default=MAXSTR.
MAXFREQ	Frequency value, as a function of RMS (m0) used to define the maximum frequency used to integrate for m1, m2, and m4. Determined by calculating cumulative m0 curve and where the cumulative total equals the default value; that will be the

frequency used for MAXFREQ. Example below shows how MAXFREQ was determined to be 47.2 Hz using the default of 99.9%. – Required, 0.0<Real≤100.0, Default=99.9%.



MAXSTR

Maximum stress to use, as function of RMS, in the Rainflow cycle count (RCC). This parameter is set based on stress range so a MAXSTR=10 means +/- 5 rms amplitudes. This Maximum Stress parameter will be divided by STRBINS to calculate the BIN width in the RCC output. Example: if RMS = 64 MPa, then MAXSTR = 10 * RMS = 640 MPa. If STRBINS = 32, then each BIN has a width of 20 MPa when plotting RCC histograms. Note: MAXSTR is only used for damage calculations so is therefore, ignored for Random Response Only analysis. – Required, Integer, Default=3.0 for ATYPE=SINES otherwise Default=10.0.

STRBINS

Number of BINS to use in RCC histogram. Note: STRBINS is only used for damage calculations so is therefore, ignored for Random Response Only analysis. – Required, Integer, Default=1280 for ATYPE=SINES otherwise Default=32.

“ELSET“

Optional FLAG indicating that a list of elements and property pairs for consideration in the fatigue analysis will follow. This will restrict the analysis to only the elements listed in the associated FSET3.

ELSIDi

ID of an FSET3 entry containing nodes or elements to be included in the random and/or fatigue analysis. See Remark 3. – Required, Integer>0, no default.

MIDi

ID of a vMATFTG entry for associating fatigue properties to elements within each ELSETi. Specified with “ELSET” flag. MID must either be specified for the whole model on the main vMATFTG entry or as part of the “ELSET” field. The “ELSET” field will be used if both are specified. Must be left blank for Random Response Only. Otherwise, format is – Required, Integer, no default.

NOTE: Special case: if MID = -1, Cf will NOT read / calculate stress results. This is useful if you are only reading Displacements from the solver.

“HOTSPOT”

Optional FLAG indicating that parameters for Hot Spot detection follow.

NOTE: Hotspot may not work from a RESTART run because not all elements may be in the RESTART file(s), so connectivity issues can occur.

Also, User can use H5 file for all Time Domain analyses using Hotspots. **Param, postext, yes** must be present in Nastran run.

NHS Number of Hot Spots to be detected from elements in model. – Required, Integer>0, Default=1.

HSGATE Number of element “rings” around hot spot element to retain in output (e.g. 0 means hot spot element only; 1 means hot spot element and all elements connected to the hot spot element; 2 means expand out another group of elements). – Required, Integer>0, Default=1.

SETID ID given to HOTSPOT set. Must be text based for Abaqus and numeric based for all other solvers. Must be no more than 8 characters or integers. – Optional, Character or Integer, no default; i.e. Set name will be defined as filename_hs_set_SETID.

STOP Terminate the job after writing Hot Spot set (after 1st pass). Options are YES or NO. – Optional, Character, Default=NO.

“FILTER” Optional FLAG indicating that individual RMS based filtering of elements and grids (nodes) will be applied for either stress, displacement, velocity or acceleration. Any entry provided below will overwrite the value in the TOPRMS field in the vFTGDEF entry. NOTE: The FILTER flag entries for nodes (D, V and A) will be ignored if the RELRESP flag is used.

TOPRMS Pass through set of elements based on % maximum RMS stress in the model. Example: 90 means elements within 90% of the top stress value will be shown. Adding a U, i.e. Uxx, means that the UTS stress value will be used instead of the top stress value – Optional, 0.0<Real≤100.0, no default; i.e. no filter applied.

TOPRMSD Pass through set of nodes based on % maximum RMS displacement in the model. Example: 90 means elements within 90% of the top displacement value will be shown. – Optional, 0.0<Real≤100.0, no default; i.e. no filter applied.

TOPRMSV Pass through set of nodes based on % maximum RMS velocity in the model. Example: 90 means elements within 90% of the top velocity value will be shown. – Optional, 0.0<Real≤100.0, no default; i.e. no filter applied.

TOPRMSA Pass through set of nodes based on % maximum RMS acceleration in the model. Example: 90 means elements within 90% of the top acceleration value will be shown. – Optional, 0.0<Real≤100.0, no default; i.e. no filter applied.

TOPDMG **TIME DOMAIN ONLY**: Pass through set of elements based on % maximum Damage in the model. Example: 90 means elements within 90% of the top damage value will be shown – Optional, 0.0<Real≤100.0, no default; i.e. no filter applied.

“DIAGNOS” Optional FLAG indicating that diagnostics results should be written to output. This feature calculates / displays the contribution of each loading “channel” in a frequency domain multiple input PSD analysis. This is not relevant / available in a single input PSD analysis. New output file will be called ***filename_diagnose.CSV***.

NHSD *Number of monitoring locations (hotspots) to use for the diagnostics output. – Required only if HSSET or CHSET are not present, Integer>0, no default*

HSSET ID of FSET3 listing elements to be used for diagnostics output. – Required, Integer>0, no default.

CHSET *ID of FSET3 listing channels to be used for diagnostics output. . – Required only if NHSD or HSSET are not present, Integer>0, no default.*

VAR Options for output include Stress, *Strain and Damage*. Currently, only Stress is an available option. – Required, Character, Default=Stress.

“SGATE” Optional FLAG indicating that parameters for Surrogate Load analysis will follow. (Optional). SGATE will work with multiple input loading Events, where each event will generate a single, surrogate Input PSD to replace the Event loading. The LOG file will also include an “envelope” PSD that will be a shape that encompasses the outer perimeter of the individual PSDs generated from the Events.

METHOD Method used for the optimization. There are 4 options based on non negative least squares profiles, but this initial release only uses Option 4. This option is called to “Rotate Matrix method”. – Required, Integer=4, Default=4.

EVOPT *Method for choosing the event to use for optimization. Options are STRESS, DAMAGE or EV_NUM. – Required, Character, Default=STRESS.*

MODE *SINGLE or VECTOR. If VECTOR, Event entry must contain 3 vFTGLOAD entries with different LCID numbers. – Required, Character, Default=SINGLE.*

TYPE *Type of Surrogate Load to be created. Options are PSD or BLOCK SWEEP. – Required, Character, Default=PSD.*

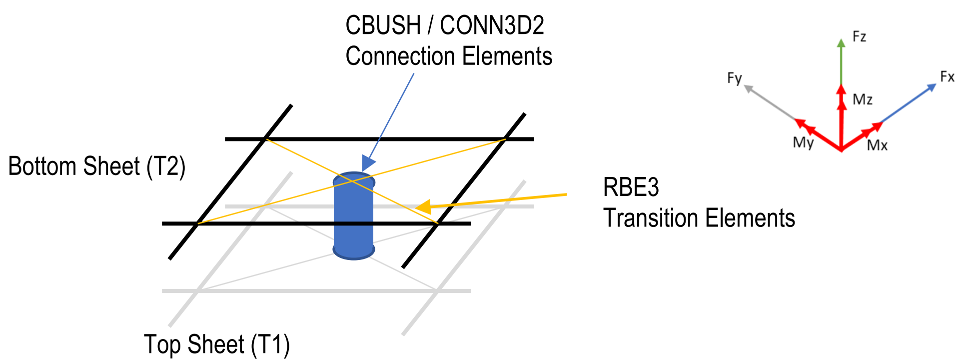
T_ACC *Test acceleration percentage. A value of 100 represents no reduction in test time due to test acceleration. A value of 40 represents a reduced test time of 40%. – Optional, Real between 0 and 100, Default=100 (no test reduction).*

PL_LIM *Limit to be used to define maximum test acceleration. – Optional, Real between 0 and 100, Default=100 (no test reduction).*

Target_File Name of the target results file that will be used as the target to achieve. This is typically a CSV file from a previous Cf analysis although any generated CSV file with the same format (as created by CF) can be used. – Required, Character, NO Default.

"USERWHS" Optional FLAG indicating that a list of elements and property data for User Defined weld analysis will follow. Multiple User Welds can be defined.

SSIDi ID of an FSET3 entry listing the CBUSH (Nastran) or CONN3D2 (Abaqus) entities of the model to be included in the fatigue analysis. The coordinate system should follow the standard right-hand rule as shown below. – Required, Integer>0, no default.



MIDi ID of material definition for CBUSH / CONN3D2 elements. Required, Integer, no default.

TENSIDi ID of vUDNAME entry where the name of the CSV / TXT file is located. This file provides the tensor lines for a User Defined weld that were calculated based on unit force / moments input to an analytical representation or fine mesh representation of the User weld (done as a separate analysis). These stress tensors will be used in the Cf analysis to scale the CBUSH / CONN3D2 stress tensors from the Solver analysis. This step is required to accurately produce stresses from a CBUSH / CONN3D2 that reflect the stress results achieved from the analytical / fine mesh model.

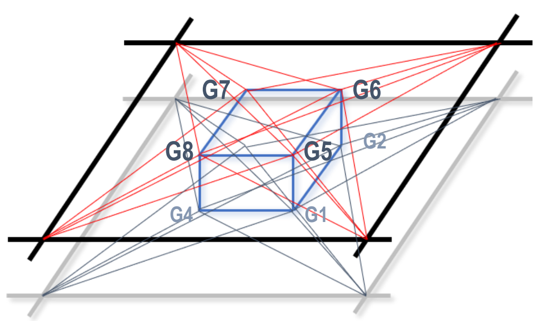
The format is shown below. Any lines in the file that are comment rows must be commented out using "$" at the beginning of the lines. Required, Character, no default.

Format of the vUDNAME File:

$ Format of vUDNAME file for generic User Weld definition																			
$																			
$ First row is the stress tensor multiplier for each stress value column. Use a value of 1.0 if no multiplier is needed.																			
$ Second row is User Defined angle (degrees) followed by the 6 real components of the stress tensor Sx, Sy, Sz, Sxy, Sxz, Syz corresponding to a																			
$ unit Force or Moment input. This is repeated 6 times for Forces Fx, Fy, Fz and Moments Mxy, Mxz, Myz.																			
$																			
$ Add stress tensor multipliers (STM) corressponding to each stress tensor column																			
	STM	STM	STM	STM	STM	STM	STM	STM	STM	STM	STM	STM		STM	STM	STM	STM	STM	STM
$ angle	Stress Tensor Real Components for FX						Stress Tensor Real Components for Fy							Stress Tensor Real Components for Myz					
Angle (Degrees)	Sx	Sy	Sz	Sxy	Sxz	Syz	Sx	Sy	Sz	Sxy	Sxz	Syz	... continue ...	Sx	Sy	Sz	Sxy	Sxz	Syz
Angle (Degrees)	Sx	Sy	Sz	Sxy	Sxz	Syz	Sx	Sy	Sz	Sxy	Sxz	Syz	... continue ...	Sx	Sy	Sz	Sxy	Sxz	Syz
Angle (Degrees)	Sx	Sy	Sz	Sxy	Sxz	Syz	Sx	Sy	Sz	Sxy	Sxz	Syz	... continue ...	Sx	Sy	Sz	Sxy	Sxz	Syz
Angle (Degrees)	Sx	Sy	Sz	Sxy	Sxz	Syz	Sx	Sy	Sz	Sxy	Sxz	Syz	... continue ...	Sx	Sy	Sz	Sxy	Sxz	Syz
Angle (Degrees)	Sx	Sy	Sz	Sxy	Sxz	Syz	Sx	Sy	Sz	Sxy	Sxz	Syz	... continue ...	Sx	Sy	Sz	Sxy	Sxz	Syz
... continue ...	Sx	Sy	Sz	Sxy	Sxz	Syz	Sx	Sy	Sz	Sxy	Sxz	Syz		Sx	Sy	Sz	Sxy	Sxz	Syz

"SPOTW" Optional FLAG indicating that a list of elements and property data for spot weld analysis will follow. Multiple spot welds can be defined.

SPSIDi ID of an FSET3 entry containing the solid, spot weld elements in the model to be included fatigue analysis. Elements used to represent spot welds should be solid elements (Nastran – CHEXA or Abaqus – C3D8). These elements connect the two metal sheets defined by shell elements. For the CHEXA elements, face G1-G2-G3-G4 must have its grids connected to shell elements that define the top sheet (T1) via RBE3 rigid elements and face G5-G6-G7-G8 must have corresponding RBE3 elements connecting the bottom sheet (T2). In Abaqus, the connections are made with DCOUP3D elements. – Required, Integer>0, no default.



The so called, "bottom" face of the blue solid element (G5-G6-G7-G8) is connected to the bottom of sheet (T2) element by the red rigid element spiders.

The so called "top" face of the blue solid element (G1-G2-G3-G4) is connected to the top of sheet (T1) element by the grey rigid element spiders.

MIDi ID of material definition for spot weld elements. – Required, Integer>0, no default.

DIAM, T1, T2 User specified values for nugget diameter, top shell thickness and bottom shell thickness (these are calculated from the model data if not specified). If DIAM is left blank, the following rule is used: The diameter is derived based on the minimum thickness of the two sheets either side of the weld by performing a lookup on the table below. The thicknesses of the top and bottom sheets must be within the range of the lookup table, which is up to 3mm by default; otherwise a fatal error is issued. Also, the diameter is set as a function of the thickness of the thinnest sheet joined by the spot weld. No interpolate between the data points in the table is done; rather, the thickness of the thinnest sheet from each spot weld is compared to the table, and the value of thickness that is nearest to but not greater than the thickness of the sheet is selected. The corresponding diameter from the table is assigned to that spot weld.

For T1 (top sheet) and T2 (bottom sheet) the required format is – Required, 0.0 ≤ Real ≤ 3.0, no default.

For DIAM, it can be left blank and automatically calculated as described above or the format is – Required, 3.5 ≤ Real ≤ 6.0, no default.

SPOT WELD DEFINITION TABLE

Min Sheet T	DIAM
0.0	3.5
0.3	3.5
0.8	4.0
1.2	5.0
2.0	5.5
3.0	6.0

Note that there may be rounding errors in the extraction of sheet thicknesses, so when defining a spotweld.sys file, it may be a good idea to reduce the sheet thickness values by a small tolerance in order to avoid anomalous results.

If a User defined spotweld.sys file is required, it should be placed in the working directory (directory where the control file is running) and then it will be used. Otherwise, the default values above will be used.

As an example, if the top sheet (T1) thickness is 1.1mm and the bottom sheet (T2) is 1.3mm then the lower value (1.1mm) would be used to look in the table. Since 1.1 is between 0.8 and 1.2 a value of 0.8 would be used to obtain DIAM=4.0.

"SEAMW " Optional FLAG indicating that a list of elements and property data for seam weld analysis will follow.

SWSIDi ID of an FSET3 set containing element to be included in the seam weld fatigue analysis. – Required, Integer>0, no default.

MIDi ID of material definition for seam weld elements. – Required, Integer>0, no default.

NDSIDi ID of an FSET3 set containing grids (nodes) associated with the elements defined by SWSIDi. These grids define the seam line of the seam weld. – Required, Integer>0, no default.

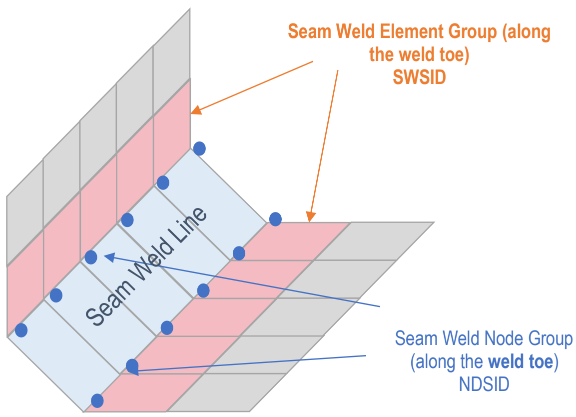
BTHRESH Threshold value of the bending (r) ratio used in interpolation between "stiff" and "flexible" SN curves for fatigue analysis of seam welds. – Required, 0.0 ≤ Real ≤ 0.999, Default=0.5.

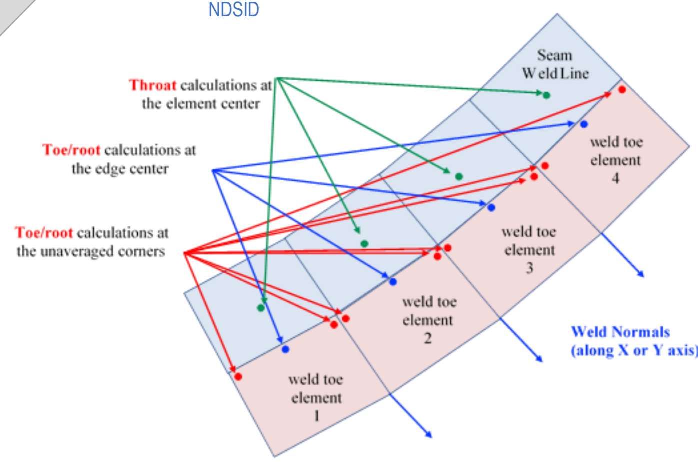
RTHICK Reference thickness / threshold (in consistent model length units) for sheet thickness correction used in fatigue analysis of seam welds. Ignored if THICK=0 on the vFTGPARM entry for "SEAMW". Must be supplied if THICK=1. – Required, Real ≥ 1.0e-9, Default=1.0.

nTHICK Sheet thickness correction exponent used in the fatigue analysis of seam welds. Ignored if THICK=0 on the vFTGPARM entry for “SEAMW”. Must be supplied if THICK=1. – Required, Real>0.0, Default=0.16667.

WTYPE Type of seam weld to use. - Required, Character, Default=Toe.

A later release will have options Root, Toe, ToeG (generic toe weld), and Throat. The following will be done based on this parameter.





	Unaveraged Node		*Edge Mid Point Averaged*	
	Top	*Bottom*	*Top*	*Bottom*
Root	***YES***	*NO*	***YES***	*NO*
Toe	***YES***	*NO*	***YES***	*NO*
ToeG	***YES***	***YES***	***YES***	***YES***
Throat	*NO*	*NO*	***YES (at center)***	*NO*

"SEAMW3DH " **TIME DOMAIN ONLY** Optional FLAG indicating that a list of elements / nodes and property data for seam weld analysis of 3D HEXA elements will follow.

SEAMID ID of an FSET3 set containing element / node information to be included in the HEXA 3D seam weld fatigue analysis. See FSET3 entry in this document for further information on the format of the FSET3 set. – Required, Integer>0, no default.

MID ID of material definition for HEXA 3D seam weld elements. – Required, Integer>0, no default.

MAX_DEPTH Distance from the surface downwards, to use in the seam weld analysis. Any element completely within the distance specified will be used in the analysis – Required, Integer>0, No Default.

NUM_LAYERS The number of element layers from the surface downwards, to use in the seam weld analysis. – Required, Integer>0, Default=1 (top surface only).

BTHRESH Threshold value of the bending (r) ratio used in interpolation between "stiff" and "flexible" SN curves for fatigue analysis of seam welds. – Required, 0.0 ≤ Real ≤ 0.999, Default=0.5.

"SEAM7608 " **TIME DOMAIN ONLY**: Optional FLAG indicating that a list of elements and property data for a BS7608 seam weld analysis will follow.

SWSIDi ID of an FSET3 set containing elements and nodes to be included in the weld fatigue analysis. See FSET3 entry in this document for further information on the format of the FSET3 set. – Required, Integer>0, no default.

WeldClass ID of the weld class to use in the analysis. – Required, Integer>0, no default.

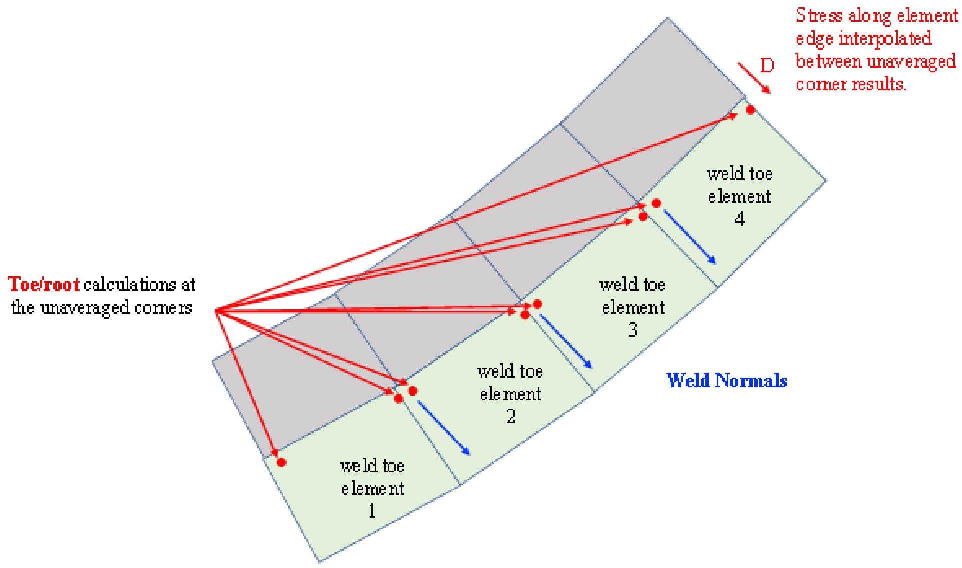
NOTE: In a future release, we will allow the Weld Class SN curves to be modified if desired by the User.

SCF Value of any local stress concentration factors. – Required, Integer>0, Default = 1.0.

Distance (D) Distance along element normal to "move" the stress calculation point by interpolation between unaveraged corner results. Must be specified as an absolute value i.e, 4.0 mm or must be specified as a percentage of the element thickness i.e., T20.0 means 20% of the element thickness. – Required, 0.0 ≤ Real ≤ 0.999, Default=T20.0.

Tref Reference thickness for Thick Correction. Obtained from the Standard for the type of weld class selected. – Required, Real ≥ 0.0, no default.

k Power exponent for Thickness Correction. Obtained from the Standard for the type of weld class selected. – Required, Real ≥ 0.0, Default = 0.0, meaning no thickness correction.



"ABSRESP" Optional FLAG indicating that parameters for absolute random response output at nodes are to follow. If RELRESP is also specified then the PARAM1 value should be used for the value of maximum (M, G, R or S) and all related values. If RELRESP is not specified, or if PARAM1 is not specified, then the PS (MAXPEAK) value from the vFTGPARM entry is used for calculation of the maximum.

ABSVARi Character combination of D, V, and/or A, or F or M for displacement, velocity, acceleration, force or monitor point force (MONPNT3) output, respectively. Example: a designation of DA request's displacement and acceleration. – Required, Character, no default

NOTE: MONPNT3 is used in Nastran to represent a "cutting plane" across a part and the summation of forces on that plane. When "m" is specified, SETID is ignored as the OP2 file will contain a User defined grid (node) SET name for the monitoring part.

SETIDi ID of FSET3 with list of grid IDs (when ABSVAR=D, V and/or A) or element IDs (when ABSVAR=F) on which to output the random response. This is ignored for ABSVAR=M – Required, Integer>0, no Default.

NOTE: You must include a Displacement output request in the Solver to use ABSRESP=D, V or A.

"RELRESP" Optional FLAG indicating that parameters for relative random response output based on node pairs are to follow. Cannot be run alongside with RELRESP2.

RELVAR1 Choice of displacement (D) only. – Required, Character, Default=D.

SETID1 Set of nodes to be used in relative response assessment. DVA results will also be calculated for then nodes in this set. If any nodes are common between the two sets those nodes will not be compared since checking for possible contact cannot be done between identical nodes.

An initial 1st pass filter of 10 x Displacement RMS is used to determine which nodes in the ABSRESP and RELRESP groups are close enough to keep in the relative response (contact) assessment. Hence, Cf will reduce the ABSRESP and RELRESP node sets before passing these nodes along to the 2nd and 3rd pass filtering steps (PARAM2 and PARAM1, respectively). – Required, Integer>0, no default.

PARAM1 PARAM1 has two roles:

First: Parameter used to check collision distance in the relative response assessment. Only nodes defined in the ABSRESP group are used for evaluation. Options are:

Mx.x	number of RMS multiplier to use for peak estimate
Gy.yyy	Gaussian probability used for peak estimate
Ry.yyy	Rayleigh probability used for peak estimate
Sy.yyy	Davenport probability used for peak estimate

Where: X.X is the RMS multiplier, e.g., M3.0 means 3 times the RMS will be used in the clearance calculation. Y.YYY is the Collision Probability percentage selected from the tables, e.g., G.269980 means ~3.0 times the RMS will be used for the clearance calculation. The SY.YYY value is used in the Zmax calculation below along with the number of cycles (N), event duration (T) and the expected zero crossings [0]. - Optional, Character (M G R or S) + 0.0<Real≤100.0, Default: the value from MAXPEAK field in the vFTGPARM entry.

NOTE: If ABSRESP and RELRESP are specified, additional collision probability results are written to the "**filenamePSD.csv**" file and additional scalar field results are written to the "**filename_dva.csv**" and "**filename_d_rel.csv**" files.

The following table contains Collision Probability percentage values and RMS multipliers for the RMS, Gaussian and Rayleigh approaches. A single RMS multiplier is passed through to the calculation based on the MX.X, Gy.yyy or Ry.yyy value provided by the User. If using Davenport, an RMS multiplier is calculated for every output point based on the value for Sy.yyy.

RMS Multiplier	Gaussian Collision Probability %	Rayleigh Collision Probability %		Davenport Method
M0.0	G100.0	R100.0		MAXPEAK is calculated at every output point using the formula:
M0.5	G61.7075	R88.2496		

M1.0	G31.7310	R60.6530		$$Z_{max} = \sqrt{2.\ln\left(\frac{-T.E[0]}{\ln(\rho_N)}\right)} = PS$$ Where: T is the Event duration (EVT) found in vFTGSEQ. E[0] is the expected ZERO CROSSING calculated at every output point. ρ_N is the provided 1-**SY.YYY** value.
M1.5	G13.3614	R32.4652		
M2.0	G4.55002	R13.5335		
M2.5	G1.24193	R4.39369		
M3.0	G.269980	R1.11090		
M3.5	G.046526	R.218749		
M4.0	G.006334	R.033546		
M4.5	G.000680	R.004001		
M5.0	G.000006	R.000372		
From: Gaussian and Rayleigh **Single** Sided Tables. Note: a percentage value of 0.0 for G, R or S is not permitted.				

Second: Parameter used as a 3rd filter to determine the group of nodes for relative clearance calculations. Options are M, G and R only and defaults are noted in (1). If S is used or if PARAM1 is left blank, the default value for the 3rd filter will be the MAXPEAK field in the vFTGPARM entry.

PARAM2 Parameter used as a 2nd filter to determine the group of nodes for relative clearance calculations. Entry will be in units of displacement (D). Example: PARAM2=40 means if the absolute distance between node pairs is greater than 40 units (millimeters for example) than they will be excluded from the calculations. **NOTE: if PARAM2 is not specified, no 2nd stage filtering will be done, and the process will move to 3rd stage filtering with PARAM1.** – Optional, Real>0.0, not default.

"RELRESP2" Optional FLAG indicating that parameters for direct distance output based on a node pair are to follow. Cannot be run alongside with RELRESP.

RELVAR1 Choice of displacement (D) only. – Required, Character, Default=D.

NODEID1 ID of first node – Required, Integer>0, no default.

NODEID2 ID of second node – Required, Integer>0, no default.

"RCCOUT" *Optional FLAG indicating that parameters for Time Domain RCC and damage response output at elements or nodes are to follow.*

RCCVARi *Available option is BOTH, i.e., both rainflow cycle count (RCC) and damage results will be written– Required, Character(s), no default.*

RCCIDi *ID of FSET3 entry with list of grid IDs or element IDs.– Required, Integer>0, no default.*

"PSDOUT" Optional FLAG indicating that parameters for PSD response output at elements or nodes are to follow.

PSDVARi Options are S (stress), F (force), M (MONPNT3 Force) output for an element set or D (displacement), V (velocity) or A (acceleration) output for a grid (node) set. Combinations of output for D, V and/or A are permitted, i.e. PSDVAR=DA is allowed. – Required, Character(s), no default.

NOTE: To request a D, V or A, you must also include an ABSRESP request to capture the random response output for the grids (nodes) of interest from the Solver file and a DISPLACEMENT request must be made in the solver run.

PSDIDi ID of FSET3 entry with list of grid IDs (nodes) for DVA or element IDs for S or F. **Note: if M is used, the MONPNT3 grid set is defined in Nastran with a name and that name must be used instead of an FSET3 number**.– Required, Integer>0, (or Character if PSDVAR=M), no default.

"PSDMOUT" Optional FLAG indicating that parameters for PSDM response output for specified nodes and degrees of freedom are to follow. Data to be written in PSD Matrix format (see TIME2PSD output) with the file name "file name"_"event number"_"output type"_PSDMOUT.txt". This FLAG is typically used to create a cascaded loading input for an additional Cf run at different location. If this is the case, the subcases defined for the new solver run must match the outputs requested in this PSDMOUT entry.

NOTE: You can only make one PSDMOUT request per OUTVAR.

OUTVAR Character combination of D, V and/or A for displacement, velocity and acceleration output, respectively or M for MONPNT3 forces. Example: a designation of DA requests displacement and acceleration is allowed. – Required, Character(s), no default.

NOTE: To use PSDMOUT, you must also include an ABSRESP request to capture the random response output for the grids (nodes) of interest from the Solver file and a DISPLACEMENT request must be made in the solver run.

Gi Grid ID for output location if OUTVAR=D, V or A. – Required, Integer>0, no default. MONPNT3 grid set name (from solver) if OUTVAR=M. – Required, Character, no default.

DOFi Degrees of freedom (DOF) to output at Grid ID. For example, specifying 123 would request output for X, Y and Z degree of freedom. Specifying 123456 would request output for X, Y, Z, RX, RY, RZ. – Required, Integer, no default.

"TIMEOUT" Optional for Time Domain only: FLAG indicating that parameters for stress Time History output at elements are to follow. This option will output a single H5 file that contains stress time histories at the element center and, if available, at the nodes.

NOTE: if a CSV format is desired, the User can set the PARAM TIMEOUT CSV.

TIMEVARi S (stress) is the only option. – Required, Character, no default.

TIMEIDi ID of FSET3 entry with list of Element IDs when User selects "User-Defined" output for the Element Set method. – Required, Integer>0, no default.

RUNTIME Output is based on one of the following options. Used when User selects "Chosen at Runtime" for the Element Set method:

- **TOP** - output for the elements identified using the "MAX Stress Based" filter (vFTGDEF> TOPSTR). The TOPSTR field must be set.
- **TOPxx** – same as TOP but limited to the most highly stressed XX number of elements, where X is set by LIMIT. TOPSTR does not need to be set because Cf will automatically set TOPSTR=100.
- **DAM** – output for the elements identified using the "MAX Damage Based" filter (vFTGDEF> FILTER> TOPDMG). The TOPDMG field must be set.
- **DAMxx** – same as DAM but limited to the most highly damaged XX number of elements, where X is set by LIMIT. TOPDMG does not need to be set because Cf will automatically set TOPDMG=100.
- **HOT** – output based on the number of elements requested in the HOTSPOT box. The HOTSPOT entry (vFTGDEF> HOTSPOT) must be set as part of the analysis.
- **HOTxx** – same as HOT but limited to the most highly damaged X number of elements, where XX is set by LIMIT. The HOTSPOT entry (vFTGDEF> HOTSPOT) must be set as part of the analysis.

Limit Identifies the maximum number of elements to output. This is the XX identified above next to TOPXX, DMGXX and HOTXX.

"HISTRCC" Optional for Time Domain only: FLAG indicating the computation of rainflow cycles and histogram.

"ELSET" Get rainflow cycles and histogram for all elements defined in the elset.

"TIMEOUT" Get rainflow cycles and histogram for the same elements as defined in TIMEOUT.

ELSID	When ELSET flag is used, defines the FSET3 ID.
“CRITOUT”	Optional. FLAG indicating that parameters for 3D Critical Plane output at elements are to follow. This option will output a *filename_CRITOUT*.CSV file listing the damage and RMS stress results for each element and each angle analyzed. NOTE: “Critical Plane” must be set in the vFTGPARM>COMB entry.
CRITVARi	DS (Damage and RMS Stress) is the only option. – Required, Character, no default.
CRITIDi	ID of FSET3 entry with list of Element IDs. – Required, Integer>0, no default.
“SNXML or ENXML”	Optional. FLAG indicating that parameters for material mapping are to follow. SNXML indicates that material mapping will be to SN material data. ENXML indicates that material mapping will be to EN material data. Used with vMATXML entry.
SETNAME	The type of set format containing the Elements. Options are NASTSET (Nastran set) and FSET3 (CF set). There can be multiple rows of SETNAMEs. – Required, Character, no default.
SETIDi	ID of NASTSET or FSET3 entry with list of Element IDs. There can be multiple set ID in the same row. – Required, Integer>0, no default.

Remarks:

1. Starting on the second row, multiple sets of ELSIDi and MIDi in columns 3-8 are allowed and continued in columns 2-9 of the next row until the required list of values is specified. The occurrence of a blank column or a field in column 1 (the start of a new entry) signifies the end of the list.
2. Where no MIDi is specified for an ELSETi, it is assumed that only random response calculations are needed for this set.
3. If the ELSET references a node set, the User must also specify the ABSRESP entry. Use of ABSRESP flag results in an additional file being created, **filename_dva.csv.** If ABSRESP ‘m” is specified, an additional **force.csv** file is created**.**
4. Use of RELRESP flag results in an additional file being created, **filename_d_rel.csv.**
5. Additional RELRESP requests can be made directly under the first request.

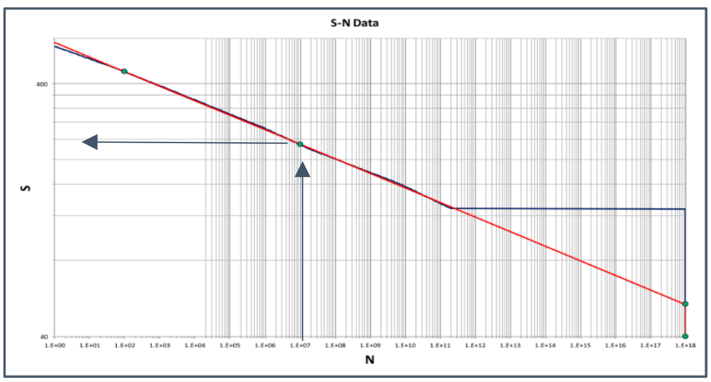
DETAILED NOTES ON PROCEDURE TO USE IN CASE OF ATYPE=SIMSINE

SINSINE is applicable for DETLOAD if more than one sinewave is applied with/without additional random loading applied. If a random entry is present the NBLOAD method is used to calculate an equivalent sinewave, which is then added with all other sinewaves before the time history synthesis.

The DETLOAD moment calculations (for each DETLOAD component) is calculated and kept as a separate m_0 and frequency value fk for each DETLOAD component. Plus, the m_0 and the f_k=(E[0]=sqrt[m_2/m_0]) is calculated using the narrow band method (NBLOAD) for the remainder (random parts).

So, for example, a loading with a PSD + DETLOAD with 4 sines would result in 5 pairs of m_0 and f_k being utilized. The following steps are used:

1. The process for calculating an equivalent sine input from the random component uses a linearization of the S-N (or E-N) data as shown below. A straight line is fixed between the S,N values at N=10^2 and N=10^7. The appropriate axes (log-log, lin-log, log-lin, lin-lin) are used to draw the straight line.



So, the procedure for converting the random m_o into an equivalent sine amplitude will be as follows:

I. For a particular event calculate the damage for the random (including any NB contribution) part as normal. Call this D.
II. Calculate N=E[0]*T / D where E[0] is expected zero crossings, T is event time and D is damage from above.
III. Calculate the highest value of S for which there is a corresponding value of N=1.0E18. Call this $S_{N=18}$.
IV. Calculate the lowest value of N which has the same S as $S_{N=18}$. Call this N_{end}. If N being checked is less than N_{end}. Then use SN_{orig} otherwise use SN_{lin}.
V. Using the relevant SN data, for the calculated N read from the corresponding S as shown below. This will be the sine wave range. Divide by 2 to get the amplitude.

2. Create a synthesized time history with all sines set as cosines. Note the value of the highest sine wave frequency being added (including the random part), call this fsinmax. Time spacing (dt) is set to 1/(20*fsinmax)). Synthesized time signal duration is set to RCCT (default 60 seconds).

3. Close the end of the time sequence by adding a point to the end equal to the value of the time history at time=0. Using the time history calculate the following values for use in the output files m_0, m_1, m_2, m_4, rms, E[0], E[P], MAX and MIN.

4. Reduce to turning points TP's (peaks and troughs). Call these TP^+ and TP^-.

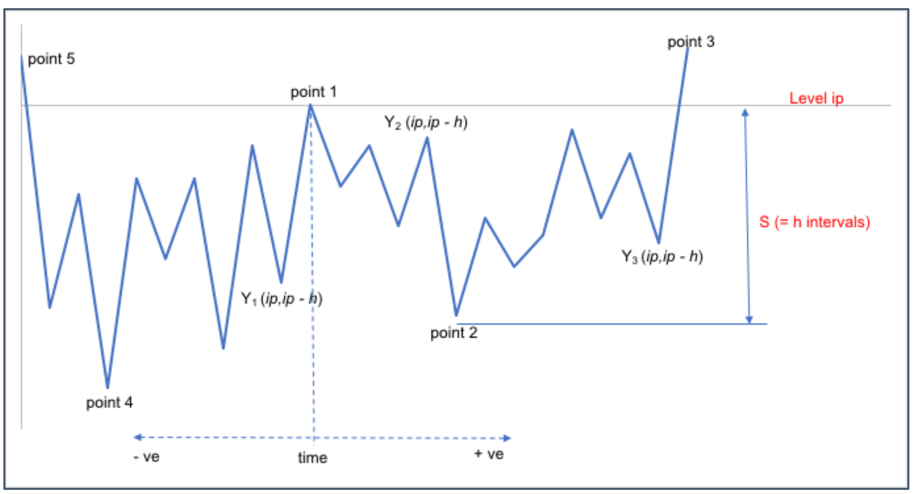
5. Reorder so maximum is both the start and the end (this step is redundant because cosines were added in Step 2).

6. Perform Rainflow Cycle Count using Rycklik method shown below. Assume that every positive peak (TP^+) has a Rainflow cycle associated with it (including the first point in the sequence).

At each TP^+ perform the following evaluation,

TP_3 is the first TP which occurs above TP_1 in a positive time direction – store a set with all negative turning points (TP^-) between TP_1 and TP_3. Call this TP_{set3}. Evaluate minimum in the set and call this $SET3_{min}$. TP_5 is the first TP^+ which occurs above TP_1 in a negative time direction – store a set with all negative turning points (TP^-) between TP_5 and TP_3. Call this TP_{set5}. Evaluate minimum – $SET5_{min}$.

Evaluate smaller of TP_3-$SET3^{min}$ and TP_3-$SET5_{min}$. This is the RC associated with this TP.



FE_UNITS - FE Stress Units

Defines the units of the FE stresses and what load magnitude was used.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FE_UNIT	JOBID	CNVRTS	FE_L_MAG	CONJCON	CNVRTF	CNVRTL		

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FE_UNIT	777		10					

Describer	Contents
JOBID	JOB ID used for entries vFTGSEQ vFTGPARM, vFTGDEF, FE_UNITS, KTDATA and INCLDIR entries. – Required, Integer>0, no default.
CNVRTS	CNVRTS (convert stress) should be set to MPA, PA, KSI, PSI or a User defined real number with the conversion from the Solver FE stresses to MPa. For example, to convert from FE stresses in KSI specifying “KSI” or “6.89476” would have the same effect. This entry is used internally within the software to convert the FRF stresses in the User defined units to MPa, which the default unit used by CF. – Optional, Character or Real>0.0, Default=MPa.
FE_L_MAG	FE_L_MAG is a scale value applied to equivalent stresses before Transfer Functions are calculated. For example, if the frequency domain FRF results were caused by 10G input loading within the Solver analysis, then FE_L_MAG should be set to 10.0 to adjust the equivalent stress calculation. If FE_L_MAG=10.0 then the equivalent stresses will be divided by 10.0 before they are converted to transfer functions This will provide the stresses as if the input loading was Unit loading. NOTE: This field is also available for Time Domain analysis in order to scale the equivalent stresses as required. – Optional, Real>0.0, Default=1.0.
CONJCON	Used to decide how the cross-PSD terms are calculated in the response PSD calculation and/or the input PSD calculation. Options are method A or method B. This field is not applicable for Time Domain analysis. – Required, Character, Default = B. CPSDxy = conj(X)*Y Method A Or CPSDxy = X*conj(Y) Method B
CNVRTF	CNVRTF (convert force) should be set to one of the following. Note: this entry is used for spot welds ONLY. – Optional, Character, Default=N.

N – Newton – Default Entry	**LBF** – pounds (1 LBF = 4.44822 N)
KN – kilonewton (1 KN = 1.0 E+3 N)	**KLBF** – kilo pounds (1 KLBF = 4448.22 N)
MN – millinewton (1 MN = 1.0 E-3 N)	**OZF** – once (1 OZF = 0.27801 N)
UN – micronewton (1 UN = 1.0 E-6 N)	**KGF** – kilogram (1 KGF = 9.80665 N)
NN – nanonewton (1 UN = 1.0 E-9 N)	**DYNE** – dyne (1 DYNE = 1.0E-5 N)

CNVRTL CNVRTL (convert length) should be set to one of the following. – Optional, Character, Default=mm

mm – millimeter – Default Entry	**inch** – inch (1 inch = 25.4 mm)
cm – centimeter (1 cm = 10 mm)	**foot** – foot (1 foot = 304.8 mm)
m – meter (1 m = 1000 mm)	

Remarks:

none

vMATFTG - Fatigue Material Properties

Defines fatigue material properties. This entry is not required for a Random Response (only) analysis and the contents of this entry will be ignored if present.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vMATFTG	MID	CNVRTM	AMP_RNG	SN_TYPE				
	"STATIC"	YS	UTS	E	CODE		SE	
	"CYCLIC"	K'	n'					
	"SN"	SRI1	b1	Nc1	b2	Nfc	SE	
		M1	*M2*	*M3*	*M4*			
	"KADJ"	KU	KT	KR / KF	KRDESC			
	"SN0" **"SN1"** **"SN2"**	SRI1	b1	Nc1	b2	Nfc	MSS	SE
		SF-FXY	DE-FXY	TE-FXY	SF-MXY	DE-MXY	TE-MXY	
		SF-FZ	DE-FZ	TE-FZ	SF-MZ	DE-MZ	TE-MZ	
	"SN_FKM"	M1	M2	M3	M4			
	"SNBR0" **"SNBR1"**	SRI1	b1	Nc1	b2	Nfc	SE	
	"SEAM_FKM"	M1	M2	M3	M4	MSS		
	"EN"	σ_f'	b	ε_f'	c	*K'*	*n'*	*Y* (0.5)
		SEe	SEp	SEc				
	"AUTOSN" or "AUTOEN"							
	"MMPDS"	A1	A2	A3	A4			
	"TABLE"	TID_1	T_1	SE				
	"FILE"	UDID	Type	XML_file_reference				
	"DIGIMAT"	TYPE	File_Location					

Items in Grey are not currently support.

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vMATFTG	9	MPa	Range					
	STATIC		430	69000	99			
	SN	3095	-0.1339	1.0E6	0.0	1.0E9		
	TABLE	415						

Describer	Contents
MID	Unique material ID used in vFTGDEF entry. – Required, Integer>0, no default.
CNVRTM	CF assumes that the material property stresses are always in MPA units. If not, CNVRTM (convert material) should be set to units of the provided material properties, such as MPA, PA, KSI, PSI or a User defined real number. This will allow Cf to convert the material curve stresses to MPa stresses. Note that this User defined value has to be real. CNVRTM does not affect MMPDS data which must always be specified in KSI. – Optional, Character or Real>0.0, Default=MPa.
AMP_RNG	Definition of whether stress units in material curve are in amplitude (AMP) or range (RANGE). – Required, Character, Default=RANGE.
SN_TYPE	For use with **Multiple SN Curve**: Defines the type of Multiple SN curve. Options are Life (Haigh Life), Mean (Mean Stress) and Rratio (R-Ratio). The SN curves are entered via a vMATFTG> TABLE and vTABRND entry. – Required if using Multi-SN, Character, Default=blank.
"**STATIC**"	Required FLAG indicating that common material parameters are to follow.
YS	Yield strength. Required for some Mean Stress Correction options when a Mean stress load is applied. – Required, Real > 0.0 (for MPA), no default.
UTS	Ultimate tensile strength. Required for Mean Stress Correction options when a Mean stress load is applied. – Required, 100.0 ≤ Real ≤ 4000 (for MPA), no default.
E	Youngs Modulus. Required to do cyclic stress-strain conversions when CYCLIC data or EN data is specified. Required (when CYCLIC or EN data is present), Real>0.0, no default.
CODE	Numeric reference numbers defining the type of material to use when SN, SN0, SN1 or SN2 is not provided. Required if using the AUTOSN or AUTOEN flags along with User Defined value for UTS. Note: This is called Material Type in the Process Flow Material box. Ferrous = 99, Aluminum = 100, Titanium = 300 and User Defined are the codes show below. Optional, Preset names or Integers from table below, Default=99 (Ferrous steel).

1	Flake cast iron (FCI)		99	Steel of unknown heat treatment (STEEL)
2	Ferritic cast iron with compacted graphite (FCICG)		100	Wrought aluminum (WA)
3	Pearlitic cast iron with compacted graphite (PCICG)		101	Wrought aluminum-copper alloy (WACA)
4	Bainitic cast iron with compacted graphite (BCICG)		102	Wrought aluminum-manganese alloy (WAMNA)
5	Ferritic cast iron with spheroidal graphite (FCISG)		103	Wrought aluminum-magnesium alloy (WAMGA)

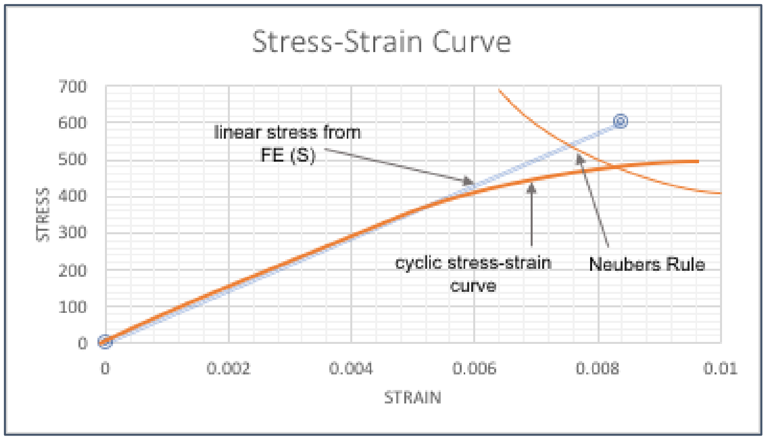
6	Ferrite/pearlite cast iron with spheroidal graphite (FPCISG)		104	Wrought aluminum-magnesium-silicon alloy (WAMGSA)
7	Pearlitic cast iron with spheroidal graphite (PCISG)		105	Wrought aluminum-zinc alloy (WAZA)
8	Bainitic cast iron with spheroidal graphite (BCISG)		106	Cast aluminum alloy (CAA)
9	Cast steel with less than 0.2% carbon (CSL2C)		107	Wrought complex special purpose aluminum alloys (WCSPAA)
10	Normalized cast steel with 0.2-0.4% carbon (NCS24C)		200	Wrought copper (WCU)
11	Quenched & tempered cast steel with 0.2-0.4% carbon (QTCS24)		201	Wrought brass (WBR)
12	Normalized cast steel with 0.4-0.7% carbon (NCS47)		202	Wrought aluminum bronze (WABR)
13	Plain carbon wrought steel with < 0.2% carbon (PCWS)		203	Cupronickel (CUPNI)
14	Hot rolled/normalized plain carbon wrought steel, 0.2-0.4% carbon (HNPCWS24)		204	Nickel silver (NIAG)
15	Quenched & tempered cast steel with 0.4-0.7% carbon (QTCS47)		205	Wrought phosphor bronze (WPHBR)
16	Quenched & tempered plain carbon wrought steel, 0.2-0.4% carbon (QTPCWS24)		206	Wrought copper beryllium (WCUBE)
17	Hot rolled/normalized plain carbon wrought steel, 0.4-0.7% carbon (HNPCWS47)		207	Cast copper alloys (CCUA)
18	Quenched & tempered plain carbon wrought steel, 0.4-0.7% carbon (QTPCWS47)		300	Titanium alloy (TA)
19	Normalized low alloy wrought steel (NLAWS)		400	Wrought magnesium alloys (WMGA)
20	Quenched & tempered low alloy wrought steel (QTHSLAWS)		401	Cast magnesium alloys (CMGA)
21	Normalized Ni/Cr/Mo wrought steel (NNCMWS)		500	Fusible alloys, solders (FUSSOL)
22	Quenched & tempered Ni/Cr/Mo wrought steel (QTNCMWS)		600	Cast zinc alloys (CZINCA)

23	Austenitic stainless steel (ASS)		700	Wrought nickel alloys (WNIA)
24	Ferritic stainless steel (FSS)		701	Cast nickel alloys (CNIA)
25	Martensitic stainless steel (MSS)		800	Precious metals (PRECMET)
26	Annealed plain carbon wrought steel, 0.2-0.4% carbon (APCWS24)		900	Clad materials (CLADMAT)
27	Annealed plain carbon wrought steel, 0.4-0.7% carbon (APCWS47)		1000	Thermoplastics (THERPLAS)
28	Normalized carbon/manganese steel (MCMS)		1001	Thermosetting plastics (TSETPLAS)
29	Quenched and tempered carbon/manganese steel (QTCMS)			
30	Hardened chromium steel (HCS)			
31	Quenched and tempered chromium steel (QTCS)			

SE Standard error of $\log_{10}(N)$. This is used to calculate the fatigue life adjusted to a certain probability of failure / survival. Optional, *0.0 ≤ Real ≤10.0, Default=0.1 if CERTNTY Flag is used in vFTGPARM entry*.

“**CYCLIC**” Optional FLAG indicating the definition of a cyclic stress strain curve follows.

K' and n' Cyclic strength coefficient (K') and strain hardening exponent (n'). Only required if SN material data is used for the Cf analysis and stresses are high enough to cause local plasticity, hence, a need to convert FEA stress-strain values from the linear line to real Stress-Strain values on the curved line using the Neuber Rule. Cf will then use these real values and the vFTGPARM > MAXPEAK value to calculate the ***mean +/- MAXPEAK * rms strain*** values reported in main CSV output file. The CYCLIC flag is not needed if EN material data is used because these parameters are part of the EN material properties. – Required, Real>0.0, no default.



Cyclic Stress-Strain Curve

$$\varepsilon = \frac{\sigma}{E} + \left(\frac{\sigma}{K'}\right)^{\frac{1}{n'}}$$

Neuber Rule

$$\left[\frac{\sigma_{max}}{2E} + \left(\frac{\sigma_{max}}{2K'}\right)^{1/n'}\right]\sigma_{max} = \frac{(S_{max})^2}{2E}$$

"SN" Optional FLAG indicating the definition of an S-N curve follows using the nCode material definition.

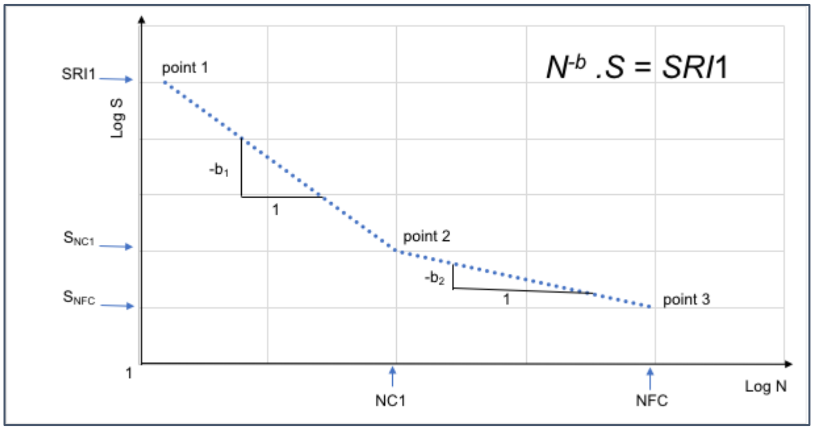
SRI1 Stress range intercept. – Required, 1.0 ≤ Real ≤2.5e4 (for MPa), no Default.

b1 First fatigue strength exponent. – Required, -1.0 < Real< -0.02, no Default.

NC1 In a 1-segment S-N curve, the cycles limit of endurance. In a 2-segment S-N curve, this is the fatigue transition point (point 2, see below). Both are defined in cycles. – Required, 1.0 ≤ Real ≤1.0E25, no Default.

b2 Second fatigue strength exponent. It is zero when defining 1-segment S-N curve. -- Optional, -0.5 < Real ≤ 0.0, Default=0.0.

Nfc Fatigue cut-off. – Required, 1.0E9 < Real ≤ 1.0E30, Default=1.0E30.

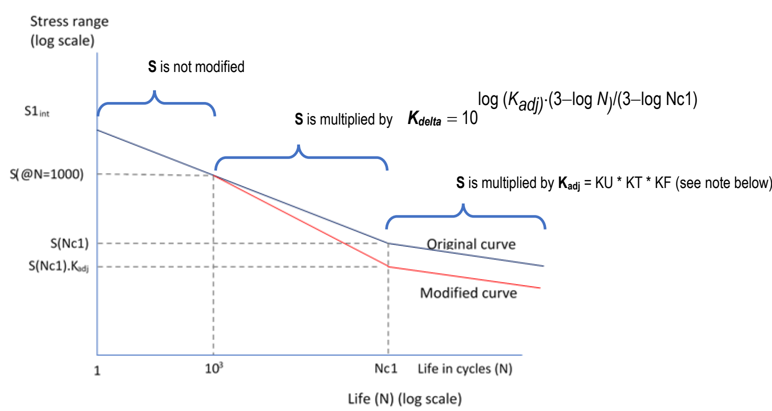


SE Standard error of $\log_{10}(N)$. This is used to calculate the fatigue life adjusted to a certain probability of failure / survival. *Optional, 0.0 ≤ Real ≤10.0, Default=0.1 if CERTNTY Flag is used in vFTGPARM entry.*

"**KADJ**" Optional FLAG indicating that a surface finish / treatment correction follows that will alter the SN curve as described below.

- If **N ≤ 10E3**, then the stress values (S) are not modified by the surface finish / treatment correction.
- If **N ≥ Nc1**, then the stress values (S) are multiplied by a constant value called KADJ.
- If **N** is **between 10E3** and **Nc1**, then the stress values (S) are multiplied the correction factor KDELTA, which is derived using the KADJ value.

NOTE: KADJ can only be used when the material is specified using the **SN** option.



NOTE: The value for the **Finish Factor**, **KF** is calculated by the formula below:

$KF = 1 - a_R.\log(KR).\log(2.UTS / R_f)$ UTS in MPa

Where, **KR** is specified by the User, **UTS** is specified in the STATIC flag (in MPa), and R_f / a_R are selected from the table below based on the CODE value specified in the STATIC flag. If the CODE value is outside the range shown below, Cf will terminate with an error message.

Material	*Steel*	*Cast Steel*	*Nodular Cast Iron*	*Malleable Cast Iron*	*Gray Cast Iron*	*Wrought Al Alloys*	*Cast Al Alloys*
CODE	13,14, 16-22, 25-99	9-12, 15	5-8	2-4	1	100-105	106
a_R	0.22	0.20	0.16	0.12	0.06	0.22	0.20
R_f	400	400	400	350	100	133	133

Hence, **Kadj** = User Factor (KU) * Surface Treatment (KT) * Finish Factor (KF)

KU A User specified **fatigue strength reduction** factor. Required, Real>0.0, Default=1.0. This is called Kf in NEF.

KT A User specified **surface treatment correction** factor. Required, Real≥0.0, Default=1.0. This is called KTREAT in NEF.

KR or KF A User specified **surface roughness** factor (KR) in units of micrometer (**μm**). Optional, Real>0.0, no Default. This is called FINISH in NEF. Only used when KRDESC=KSURFC.

A User specified **finish (roughness)** factor (KF). Optional, 0.0<Real<1.0, no Default. This is called KFINISH in NEF. Only used when KRDESC=KROUGH.

KRDESC A User specified **surface finish** description. Optional, character per table below, Optional, Character, Default=Polished. This is called FINISH in NEF.

KRDESC	***KR*** *(μm) that will be used*
Polished	0.0
Ground	12.5
Machined	100.0
PoorMach	200.0
Asrolled	200.0
Ascast	200.0
KSURFC	User specified KR
KROUGH	User specified KF

“SN0, SN1, SN2” Optional FLAG indicated that material properties for SPOT WELD are to follow.

- The SN0 row is used for the nugget SN data. The SN1 and SN2 rows are used for the top and bottom sheet SN data. No data is required for a middle sheet if it exists in the analysis.
- If any of the flags are missing, the parameters will be based on generic SN curves for steel or aluminum per the material CODE supplied in the “STATIC” flag.
- If no CODE is supplied in the “STATIC” flag, the parameters for CODE=99 (generic steel) will be used.

SRI1, b1, Nc1, b2, Nfc Same parameter definitions and defaults as noted under SN flag.

MSS Mean stress sensitivity factor, used only for fatigue analysis of spot welds with CORR=SIMPLE on the vFTGPARM entry. This mean stress correction method is a simplified version of the FKM method where M1=M2=M3=M4=-MSS. – Optional, 0.0 ≤ Real ≤ 1.0, no default.

SE — Standard error of $\log_{10}$(N). This is used to calculate the fatigue life adjusted to a certain probability of failure / survival. *Optional, 0.0 ≤ Real ≤10.0, Default=0.334 for steel and 0.33 for aluminum, only if CERTNTY Flag is used in vFTGPARM entry*.

SF-, DE-, TE- — Scale factors that can be used to scale up forces and moments. The default values shown in the table below are for STEEL. Different values for SF, DE, TE will exist for different materials. – Optional, Real≥0.0, Default=values shown below for Steel.

Component	Factor	Diameter Exponent	Thickness Exponent
FX, FY	SFFXY = 1.0	DEFXY = 0.0	TEFXY = 0.0
MX, MY	SFMXY = 0.6	DEMXY = 0.0	TEMXY = 0.5
FZ	SFFZ = 0.6	DEFZ = 0.0	TEFZ = 0.5

SN_FKM — Optional FLAG. Applicable to SN, SN0, SN1, and SN2. Example: you can set SN_FKM, SN0_FKM, SN1_FKM and/or SN2_FKM.

M1, M2, M3, M4 — Mean stress slope parameters M1 through M4 representing sensitivity to mean stress in 4 regimes of R-ratio as plotted on a constant life Haigh diagram and used in FKM mean stress correction. Mean stress sensitivity: M1 for R>1; M2 for $-\infty < R < 0$; M3 for 0<R<0.5; M4 for 0.5<R<1.

If M values are undefined, and the material type (CODE) is given, all the parameters will be estimated using empirically defined rules for the FKM mean stress correction method.

If only M2 is defined, then M3 is set to M2 and M1 / M4 will be set to zero. – Required, -0.99 ≤ Real ≤ 0.0, no default.

“SNBR1”, “SNBR0” — Optional FLAG. The SNBR1 and SNBR0 lines are used for the flexible and stiff seam weld SN data. Same parameter definitions and defaults as noted under SN Flag. NOTE: if parameters are not entered than defaults will be used as listed in Appendix 10 - Required if seam weld analysis is being done.

SEAM_FKM — Optional FLAG. Applicable to seam welds and will automatically be used if seam welds are defined.

M1, M2, M3, M4 — Mean stress slope parameters M1 through M4 representing sensitivity to mean stress in 4 regimes of R-ratio as plotted on a constant life Haigh diagram and used in FKM mean stress correction. Mean stress sensitivity: M1 for R>1; M2 for $-\infty < R < 0$; M3 for 0<R<0.5; M4 for 0.5<R<1.

If M values are undefined, and the material type (CODE) is given, all the parameters will be estimated using empirically defined rules for the FKM mean stress correction method.

If only M2 is defined, then M3 is set to M2 and M1 / M4 will be set to zero. – Required, -0.99 ≤ Real ≤ 0.0, no default.

MSS — Mean stress sensitivity factor, used only for fatigue analysis of seam welds with CORR=SIMPLE on the vFTGPARM entry. This mean stress correction method is a simplified version of the FKM method where M1=M2=M3=M4=-MSS. – Optional, 0.0 ≤ Real ≤ 1.0, Default=0.1.

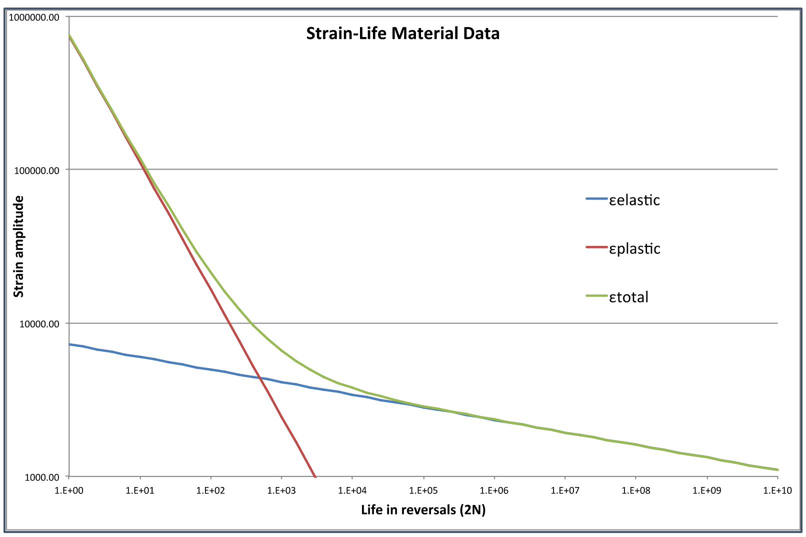
"EN" — Optional FLAG indicating the definition of an E-N curve is to follow.

σ_f' and b — Elastic fatigue strength coefficient and exponent. – Required, σ_f' = Real > 0.0 and b = -0.3 < Real < -0.2, no defaults.

ε_f' and c — Plastic fatigue ductility coefficient and exponent. – Required, ε_f' = 0.001 < Real < 20.0 and c = -2.0 < Real < -0.1, no defaults.

K' and n' — Cyclic strength coefficient and strain hardening exponent. – Required, K' = 100.0 < Real < 20000.0 and n' = 0.1 < Real < 0.5, no defaults.

ϒ — Additional coefficient needed for the Walker mean stress correction equation. – Required, Real > 0.0, Default = 0.5.



$$\epsilon_a = \frac{\sigma_f'}{E}\left(2N_f\right)^b + \varepsilon_f'\left(2N_f\right)^c$$

(E, σ_f' and K' can be entered in any "stress" units and converted using CNVRTS field in FE_UNITS entry)

SEe, SEp, SEc — Standard error of $\log_{10}$(N) for elastic component, plastic, component and cyclic (total) component, respectively. This is used to calculate the fatigue life adjusted to a certain probability of failure / survival. Optional, *0.0 ≤ Real ≤10.0, Default=0.1, only if CERTNTY Flag is used in vFTGPARM entry*.

"AUTOSN" OR "AUTOEN" — Optional FLAG indicating that the User wants Cf to generate the SN or EN curve automatically based on the data provided in the STATIC flag entry. This FLAG cannot be used if SN, SN0/SN1/SN2 or EN flags are also present. See the Appendix section for a further explanation of AutoSN / AutoEN.

“**MMPDS**” Optional FLAG indicating that an S-N material data set based on the MMPDS specification (Metallic Materials Properties Development and Standardization – MMPDS-01, Jan 2013) is to be used.

$$\epsilon_a = \frac{\sigma_f'}{E}(2N_f)^b + \varepsilon_f'(2N_f)^c$$

NOTE: CAEfatigue will automatically set the mean stress correction to MMPDS for any material defined as MMPDS i.e., vFTGPARM>CORR will be set to MMPDS.

A1-A4 Coefficients of the standard MMPDS-01 material equation

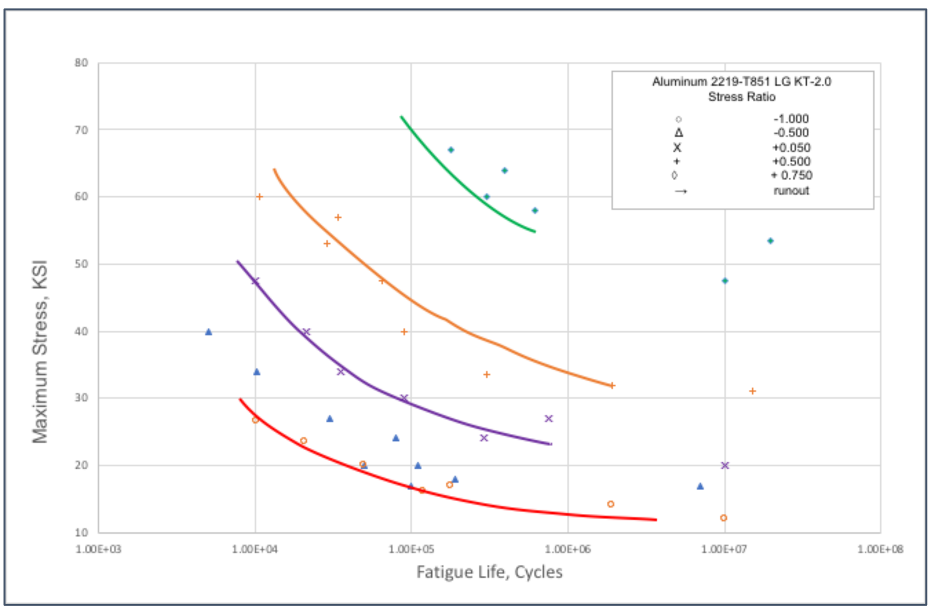
$$\log N = A_1 + A_2 \log(S_{\max}(1 - R)^{A_3} - A_4)$$

where,

$$S_{eq1} = S_{\max}(1 - R)^{A_3}$$

MMPDS data must always be specified in KSI.

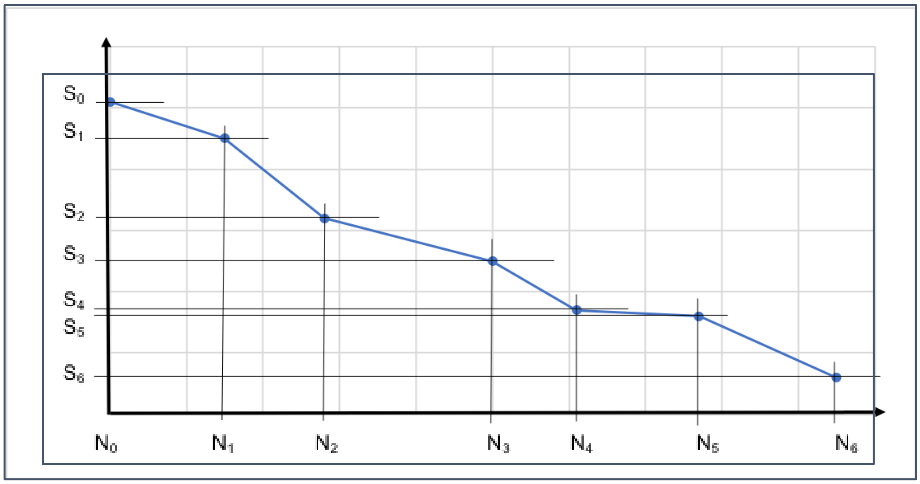
Coefficients of the standard MMPDS-01 material equation. – Required, Real>0.0, no defaults.



“**TABLE**” Optional Flag indicating that an S-N material data set is to be specified as a series of Ni,Si points.

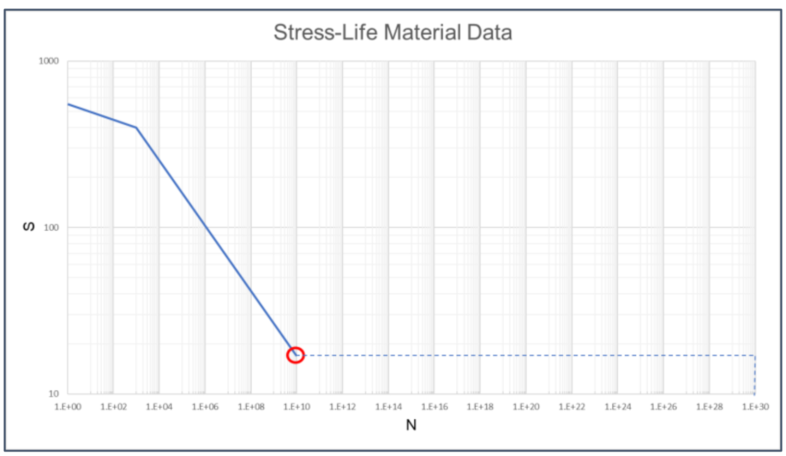
Note: In the case where multiple SN curves are being used (set with vMATFTG> SN_TYPE), the SN curves are defined as Haigh Life, Mean Stress or RRatio curves via a vTABRND entry.

TID_1 A vTABRND TID defining the S-N curve of life in cycles (N) versus stress range (S) for this particular S-N curve and multiple SN parameter T_i.



For S-N values between defined points, a table look-up is performed using linear interpolation within the data table. At the last point (red circle to the right), Cf assumes a horizontal endurance limit from that point to N=1E-30. Shown as a dotted blue line. – Required, Real>0.0, no defaults

Note: Any N value beyond 1E+30 cycles will be assessed as if the N value equaled 1E+30 cycles.



Note: In the case of a multiple SN analysis, this field is populated with a numeric ID that corresponds to a vTABRND entry.

T_i Used for Multiple SN input. This entry will reference the ID of the Haigh Life curve, Mean Stress curve or R-Ratio curve. Optional, Real.

Note: In the Process Flow, the User can provide a multiple SN CSV file or enter the data manually. Examples are below:

For Haigh Life option, the first column would be a Life value for each SN curve followed by Mean Stress in the 2nd column and Stress Range in the 3rd column (see below). **The first column ID is the T_i entry.**

	A	B	C
1	LIFE	Mean Stress (Sm)	Stress Range (Sr)
2	1.00E+03	0	5000
3		500	0
4			
5	LIFE	Mean Stress (Sm)	Stress Range (Sr)
6	1.00E+04	0	4000
7		300	0
8			
9	LIFE	Mean Stress (Sm)	Stress Range (Sr)
10	1.00E+05	0	3000
11		290	0

For Mean Stress option, the first column would be a mean stress value for each SN curve followed by Cycles to Failure in the 2nd column and Stress Range in the 3rd column (see below). **The first column ID is the T_i entry.**

	A	B	C
1	Mean Stress	Cycles to Failure (N)	Stress Range (Sr)
2	-1.00E+00	1	20000
3		1.00E+08	500
4		1.00E+16	500
5			
6	Mean Stress	Cycles to Failure (N)	Stress Range (Sr)
7	0.00E+00	1	19000
8		1.00E+08	400
9		1.00E+16	500
10			
11	Mean Stress	Cycles to Failure (N)	Stress Range (Sr)
12	1.00E+00	1	15000
13		1.00E+08	300
14		1.00E+16	500

For RRatio option, the first column would be a RRatio value for each SN curve followed by Cycles to Failure in the 2nd column and Stress Range in the 3rd column (see below). **The first column ID is the T_i entry.**

	A	B	C
1	R-Ratio	Cycles to Failure (N)	Stress Range (Sr)
2	1.00E+00	1	20000
3		1.00E+08	500
4		1.00E+16	500
5			
6	R-Ratio	Cycles to Failure (N)	Stress Range (Sr)
7	-1.00E+00	1	19000
8		1.00E+08	400
9		1.00E+16	500
10			
11	R-Ratio	Cycles to Failure (N)	Stress Range (Sr)
12	5.00E-01	1	15000
13		1.00E+08	300
14		1.00E+16	500

SE — Standard error of log_{10}(N). This is used to calculate the fatigue life adjusted to a certain probability of failure / survival. Optional, *0.0 ≤ Real ≤10.0, Default=0.1 if CERTNTY Flag is used in vFTGPARM entry*.

"**FILE**" — Optional FLAG indicating that the material data will be referenced in an external XML file. See Appendix section for detailed information about the XML file available in this version of the CAEfatigue software.

UDID — ID of a UDNAME entry that references an XML file containing the required material data. – Required, Character, no default. In the case of a multiple SN curve analysis, a numeric ID is entered in this field which corresponds to the vMATFTG> TABLE entry.

Type — Type of data to be plotted from the XML file. Options are SN, EN. – Required, Character, Default=SN. In the case of a multiple SN analysis, the Haigh Life, Mean Stress or R-Ratio value corresponding to the curve is entered in this field.

Support for SPOTW and SEAMW will be added in a later revision.

XML_File_Reference — Reference to a unique material entry in an XML file using ID="name1"ParentID="name2". Example: *ID="strain-life (E-N) ParentID="test-1"*. – Required, Character, no default.

"**DIGIMAT**" — Optional: FLAG indicating that the material data will come from DIGIMAT.

Note: When using Digimat SN curve data, the Cf mean stress correction is <u>ignored</u> in favor of the mean stress correction method used within Digimat.

Type — Type of Digimat file that will be referenced in File_Location field. Options are *digimat* and *digidof*. – Required, Character, no default.

File_Location — Path to file location. These files should be in the default working directory of DIGIMAT unless this location is change by the User within Digimat.

Remarks:

1. If the User wishes to do a fatigue damage calculation, the User must provide one of the following information:
   a. SN or EN material properties (and SN0, SN1, SN2 properties if dealing with spot welds).
   b. OR, a CODE entry in the STATIC line that specifies a generic material to use in an AUTOSN or AUTOEN calculation. This cannot be used if SN or EN properties are specified.
   c. OR, a FILE flag entry that specifies an XML file of generic material properties.

vMATSTAT – Random Response Material Properties

Defines material properties used for random response elastic-plastic conversion peak estimation. NOTE: vMATSTAT is currently not support in Time Domain analysis.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vMATSTAT	MID	CNVRTM						
	"STATIC"		UTS	E				
	"CYCLIC"	K'	n'					

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vMATSTAT	9							
	STATIC		430	69000				
	CYCLIC	461.7	0.12					

Describer		Contents
MID		Unique material ID used in vFTGDEF entry. – Required, Integer>0, no default.
CNVRTM		CNVRTM should be set to MPA, PA, KSI, PSI or a User defined real number with the conversion from the FE stresses to MPa. Note that this User defined value has to be real. This has the effect of scaling the following parameters. – Required, Character of Real>0.0, Default=MPa.
"STATIC"		Optional FLAG indicating that common material parameters are to follow.
	UTS	Ultimate tensile strength. Required to do Mean Stress Correction when a Mean stress load is applied. – Required, 100.0 ≤ Real ≤ 4000 (for MPA), no default.
	E	Youngs Modulus. Required to convert stresses to strains when EN Material data is specified. - Required (when EN data is present), Real>0.0, no default.
"CYCLIC"		Optional FLAG indicating the definition of a cyclic stress strain curve follows.
	K' and n'	Cyclic strength coefficient and strain hardening exponent. Only required if SN material data is used for the Cf analysis and stresses are high enough to cause local plasticity, hence, a need to convert FE stress-strain (linear line) to Local Stress-Strain (curved line). Cf will then use this value and MAXPEAK to calculate the MAX strain value reported in main CSV output file. The CYCLIC flag is not needed if EN material data is used because these parameters are part of the EN material properties. – Required, Real>0.0, no default.

Remarks:

1. Note: *E*, and *K′* can be entered in any "stress" units and converted using ***CNVRTS*** field in FE_UNITS entry.
2. Strain response data will be calculated in the following circumstances:
   - Where a "CYCLIC" row is provided in a vMATSTAT entry.
   - Where a "CYCLIC" row is provided in a vMATFTG entry (with "SN", "EN", "MMPDS" or "TABLE").
   - Using the K' and n' values on the "EN" field ONLY IF there is no "CYCLIC" line for that material.
3. In other words, if an EN material is specified which also has a "CYCLIC" field included, then the K' and n' values on the CYCLIC line take priority when calculating random response. If they are not specified, then the K' and n' values on the "EN" field are used. The K' and n' values on the "EN" line are required to calculate fatigue results and so must be specified.

vMATXML – Mapping Fatigue Material Properties from XML File to Nastran OP2 File

This entry allows the User to cross reference a Material ID in Nastran with a Material ID from an XML database. Using this entry allow the material mapping to happen automatically, i.e., material data from XML file will be assigned to the elements in a Nastran OP2 file that have a matched MAT ID as defined in the crossover file.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vMATXML	JOBID							
	XML filename							
	Crossover Filename							

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vMATXML	777							
	Matdb.xml							
	Matdb_xover.csv							

Describer	Contents
JOBID	JOB ID used for entries vFTGSEQ vFTGPARM, vFTGDEF, FE_UNITS, KTDATA and INCLDIR entries. – Required, Integer>0, no default.
XML Filename	This is the material database file that contains the fatigue material properties.
Crossover Filename	This is the crossover file that tells CAEfatigue what Solver material ID should be associated to a material within the XML database.

Remarks:

1. The format of the XML file is that same as that described in vUDNAME.
2. The format of the crossover file is CSV containing 2 columns separated by a comma. The first column is the material ID or MAT1 entry value found in the Nastran BDF/OP2 file, and the second column is the OBJECT ID found in the XML file. See examples below.

   NOTE: The use of **SNXML** or **ENXML** in **vFTGDEF** tells us which material to use from the XML file.

Example of crossover file format:

```
10135,10135__Steel_SS_ASTM A1011_Grade 50_v03
```

Example of MAT1 entry in Nastran BDF file:

```
$Steel_SS_ASTM A1011_Grade 50_v03
MAT1        10135 206000.            0.3  7.85-9
```

Example of XML file format for EN material, which would be used if **ENXML** is specified in **vFTGDEF**:

```
<Object ID="Strain-life (E-N)" ParentID="10135__Steel_SS_ASTM A1011_Grade 50_v03"
Type="nCodeENMatData">
      <property Name="Sf'" Units="MPA" Value="672.24"/>
      <property Name="b" Value="-0.087"/>
      <property Name="c" Value="-0.58"/>
      <property Name="Ef'" Value="0.59"/>
      <property Name="n'" Value="0.15"/>
      <property Name="K'" Units="MPA" Value="739.46"/>
      <property Name="K'90" Value=""/>
      <property Name="Nc" Value="200000000.0"/>
      <property Name="S" Value="1"/>
      <property Name="SEe" Value="0.1"/>
      <property Name="SEp" Value="0.05"/>
      <property Name="SEc" Value="0.0"/>
      <property Name="E" Units="MPA" Value="206000.0"/>
      <property Name="UTS" Units="MPA" Value="448.2"/>
      <property Name="YS" Units="MPA" Value="344.7"/>
      <property Name="me" Value="0.3"/>
      <property Name="mp" Value="0.3"/>
      <property Name="MaterialType" Value="0"/>
      <property Name="Reference" Value=""/>
      <property Name="Comments" Value="Reserved for future use"/>
```

vFTGPARM – Fatigue Analysis Parameters

Defines parameters needed to do a fatigue analysis.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGPARM	JOBID							
	"STRESS"	COMB	CORR	NCALC	OPTIONAL	TOLER	MAXPEAK	RCCT
	"CYCPROC"	TRSTIN	*EVALL*	HYST	TRSTOUT			
	"SPOTW"	COMB	CORR	NANGLE	SWLOC	ZCOMP	MIDDLE	
	"SEAMW"	COMB	CORR	THICK	WELDTOP			
	"SEAM7608"	COMB	CORR					
	"CERTNTY"	CERTSV						
	"USERWHS"	COMB	CORR	NANGLE	SWLOC			
	"FOS"	LIFE	BACKACC	MAXFAC	MINFAC			
	"MULTIAX"	METHOD	GATE					
	ZERO_PER	NPF_LOW	NPF_UP	BIA_LOW	BIA_MID	BIA_UP		

Examples:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGPARM	777							

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGPARM	777							
	STRESS	SGVON	NONE					

Describer **Contents**

JOBID JOB ID used for entries vFTGSEQ vFTGPARM, vFTGDEF, FE_UNITS, KTDATA and INCLDIR entries. – Required, Integer>0, no default.

"STRESS" Optional FLAG indicating that stress is used in the fatigue calculation.

COMB Equivalent Stress to use for converting stress tensors from solver results. Acceptable values are listed in the table below. – Required, Character, Default=SGVON.

Equivalent Stress	Meaning
MAXPREST	Frequency Domain ONLY: Fast Maximum Principal calculation using approximate algorithm.

ABSMAXPR	Time Domain and Frequency Domain: Absolute Maximum Principal using accurate phase scanning. Will always be positive and represent the highest principal stress value.
MAXPRINC	Time Domain ONLY: Maximum Principal from the largest positive principal stress.
SGMAXSHR	Time Domain ONLY: Signed Max Shear
SGVON	Time Domain and Frequency Domain: “Equivalent” Signed von Mises Stress. The sign is determined from the first principal stress value.
COMPX, COMPY, COMPZ, COMXY, COMPXZ, COMPYZ	Time Domain and Frequency Domain: Component stress – one of the following – X, Y, Z, XY, XZ, YZ.
CRITXXX	Time Domain and Frequency Domain: Critical Plane analysis - XXX is an integer that represents the number of calculation points. Example: CRIT120 means calculate at every 3 degrees i.e., 360/120 or CRIT72 means calculate at every 5 degrees i.e. 360/72. = 0<Integer≤360, no default NOTE: Critical Plane (CP) analysis can require a **large** amount of memory, especially in the Frequency Domain (FD). When running CP in FD, you must use ELSETs, and/or TOPSTR and/or HOTSPOT, to reduce the number of elements analyzed. If this is not done the software will terminate with an error message.

CORR Mean stress correction to use in the fatigue analysis. Acceptable options are listed in the table below. This option is not needed for Random Response Only. Otherwise, the format is -- Required, Character, Default=None.

Note: When using Digimat SN curve data, the Cf mean stress correction is ignored in favor of the mean stress correction method used within Digimat.

Mean Stress Correction	Meaning
NONE	No mean stress correction (default)
FKM	Uses factors M1, M2, M3, M4 to define the sensitivity to mean stress in 4 stress ratio (R) regions of the loading cycle.
GOODMAN	Goodman mean stress correction using mean stress and UTS.

MODGOOD	Converts compressive stress to tensile stress before applying GOODMAN mean stress correction
GDMANT	Tension only Goodman mean stress correction flattens off the constant life curve when mean stress is compressive
GERBER	Gerber mean stress correction using mean stress and UTS
GRBERT	Tension only Gerber mean stress correction flattens off the constant life curve when mean stress is compressive.
INTERP– or INTERP/ or INTERP\	Interpolate between multiple SN curves. INTERP- means do not extrapolate beyond the range of the curves. Use the Max Curve values for a data point that falls outside the range of the curves. Default is INTERP-. INTERP/ or INTERP\ means extrapolate beyond the last (max) curve using the last 2 curves. NOTE: Can only be entered via Control File view.
SOD	Soderberg mean stress correction using σ_y instead of UTS.
SWT	Smith Watson Topper mean stress correction for tension only.
SWTIC	Smith Watson Topper mean stress correction for both tension and compression. Used for EN data only. Currently, available for **Time Domain** analysis only.
MORROW	Morrow mean stress correction for EN data only.
WALKER	Walker mean stress correction

For MMPDS Material ONLY:

MMPDS	SET AUTOMATICALLY FOR MMPDS MATERIAL: Walker type mean stress correction built into the MMPDS-01 material curves. Used on Tensile mean loads and ignored for Compression mean loads (i.e., Compressive mean loads are converted to zero mean loads or R-Ratio = -1).

NCALC Alternative options for the way "N" is calculated for a given stress BIN (see table below). This option is not needed for Random Response Only. – Required, Character, Default=NAVER.

NCALC option	Method for calculating "N".
NAVER	Calculation of "***N***" is done by adding up all the values of ***N*** within the BIN and then dividing through by the number of ***N*** values used. In this context the average value of ***N*** is calculated over the BIN.
NMID	"***N***" is calculated at the mid (stress) point of the BIN.
NUPPER	"***N***" is calculated at the upper (stress) point of the BIN.

OPTIONAL Additional output options (see table below). – Required, Character, Default=NONE.

DEBUG option	Effect of Option
NONE	No additional output is required.
UNITTF	When this option is used all equivalent stresses read from the FE model output stress file are set to unity (1.0).
MATOUT	When this option is used all detailed SN materials data (fine mesh SN data) will be written out to a txt file called Jobname_vmatftg_MID.txt (not available for Random Response). If EN or CYCLIC are specified, the detailed SN curve derived from the EN curve is written and in addition the Neuber FE_stress to local strain curve is written to another output file. <u>NOTE: the material curve is written out in RANGE format</u>.
NOMATLOG	When this option is used all material data output to the log file is suppressed.

TOLER Tolerance used when performing Neuber correction. – Required, real>0.0, Default=1.0e-5.

MAXPEAK User defined value used in the calculation of maximum (or peak) stress, where peak stress = MAXPEAK * rms stress. This is **<u>ONLY</u>** used for the maximum elastic-plastic peak strain calculation (Plasticity Index) and is exported for reference to the CSV file.

If a mean stress (load) is applied to the model, the maximum (or peak) stress is calculated as the sum of mean stress + (MAXPEAK * rms stress) and the minimum stress is calculated as the sum of mean stress – (MAXPEAK * rms stress). This is also exported for reference to the CSV file.

If no value is specified for MAXPEAK and ATYPE=SINES, the default value is 1.415 * rms stress. – Required, Real=1.415, Default= 1.415.

Otherwise, if no value is specified for MAXPEAK, the default will be CLIPLEV / 2 from the vFTGDEF entry. If CLIPLEV is not specified, the default will be MAXSTR / 2. This typically means a default for MAXPEAK of **5 * RMS Stress**. – Required, Character and/or Real>0.0, Default= CLIPLEV / 2.

Alternative options for MAXPEAK definition are:

Mx.x number of RMS levels to use for peak estimate

Gy.yyy Gaussian probability used for peak estimate

Ry.yyy Rayleigh probability used for peak estimate

Sy.yyy Davenport probability used for peak estimate

where x.x is a peak factor number e.g. **M**3.0 (is the same as MAXPEAK=3.0) and y.yyy is a Collision Probability percentage, e.g. **G**.00068 means approximately a 4.5 RMS Multiplier. The Davenport MAXPEAK value is calculated from the formula using the provided Sy.yyy value, number of cycles (N), event duration (T) and expected number of zero crossings [0]. - Optional, Character (M G R or S) + 0.0<Real≤100.0, Default: the value from MAXPEAK field in the vFTGPARM entry.

<table>
<tr><th>RMS Multiplier</th><th>Gaussian
Collision Probability %</th><th>Rayleigh
Collision Probability %</th><th></th><th>Davenport Method</th></tr>
<tr><td>M0.0</td><td>G100.0</td><td>R100.0</td><td rowspan="12"></td><td rowspan="12">MAXPEAK is calculated at every output point using the formula:
$$Z_{max} = \sqrt{2.\ln\left(\frac{-T.E[0]}{\ln(\rho_N)}\right)} = PS$$
Where:
T is the Event duration (EVT) found in vFTGSEQ.
E[0] is the expected ZERO CROSSING calculated at every output point.
ρ_N is the provided 1-SY.YYY value.</td></tr>
<tr><td>M.50</td><td>G61.7075</td><td>R88.2496</td></tr>
<tr><td>M1.0</td><td>G31.7310</td><td>R60.6530</td></tr>
<tr><td>M1.5</td><td>G13.3614</td><td>R32.4652</td></tr>
<tr><td>M2.0</td><td>G4.55002</td><td>R13.5335</td></tr>
<tr><td>M2.5</td><td>G1.24193</td><td>R4.39369</td></tr>
<tr><td>M3.0</td><td>G.269980</td><td>R1.11090</td></tr>
<tr><td>M3.5</td><td>G.046526</td><td>R.218749</td></tr>
<tr><td>M4.0</td><td>G.006334</td><td>R.033546</td></tr>
<tr><td>M4.5</td><td>G.000680</td><td>R.004001</td></tr>
<tr><td>M5.0</td><td>G.000006</td><td>R.000372</td></tr>
<tr><td colspan="3">From: Gaussian and Rayleigh Single Sided Tables.
Note: a percentage value of 0.0 for G, R or S is not permitted.</td></tr>
</table>

RCCT Used with ATYPE=SIMSINE (on vFTGDEF entry). Duration of synthesized time history in User defined (DUR_UNITS) time units. – Required (for ATYPE=SIMSINE), Real>0.0, Default=60.0.

“CYCPROC” Optional FLAG indicating that parameters for the way S-N and E-N rainflow cycles are processed for an analysis.

TRSTIN Time Domain: Options available are YES or NO. Specifying YES indicates that TRUE STRESS (σ) is coming from the Solver file. In this case the material data is adjusted into a σ-N form instead of the normal FE stress form (S-N). Note: this also applies if the material data is in EN form or if the cyclic data (n', k') is specified along with the SN data. In these 2 cases, the material data is converted to SN form first and then converted to σ-N form. – Optional, Character, Default=NO.

EVALL Options available are YES or NO. Specifying YES will add all events together to calculate mean stress and largest rainflow cycle. Specifying NO will use individual events to calculate mean stress and largest rainflow cycle. – Optional, Character, Default=NO.

HYST Time Domain: Options available are CORR, HANG and STAN. Specifying CORR means all hysteresis loops are placed correctly as hanging or standing cycles. Specifying HANG means all hysteresis loops are placed as hanging cycles. Specifying STAN means all hysteresis loops are placed as standing cycles. – Optional, Character, Default=CORR.

TRSTOUT Frequency Domain: Options available are YES or NO. Specifying YES indicates that NEUBER STRESS (σ) is written to the output files **but only for MAX or MIN STRESS. A future release will have RMS and Mean also converted to Neuber Stress**. – Optional, Character, Default=NO.

"SPOTW" Optional FLAG indicating that parameters for spot weld calculation will follow. See NOTES regarding 3 sheet spot welds.

COMB Stress/strain combination to use in the spot weld fatigue analysis. Only option is Critical Plane. – Required, Character, Default=CPlane.

CORR Mean stress correction to use in the spot weld fatigue analysis. Acceptable values are None, Simple, FKM. FKM will not be implemented in this release but Simple (simple version of FKM) is available. If Simple is selected, the MSS field in the vMATFTG entry will be used. – Required, Character, Default=NONE.

NANGLE The number of calculation angles in 360 degrees around the spot weld. – Required, 10≤Integer≤360, Default=18; i.e., every 20 degrees).

SWLOC Location on the spot welds to report fatigue life. Options are:

0 = worst case damage considering all angles and all layers i.e., Top, Nugget, Bottom) – 1 output only

1 = worst case damage considering all angles with output for each layer – 3 outputs, one for each layer

2 = worst case damage at all angles for the worst layer at each angle – N angles * 1 outputs

3 = worst case damage at all angles and for all layers – N angles * 3 outputs

– Required, Integer 0,1, 2 or 3, Default=1.

ZCOMP Whether to include the compressive part of the axial force steady state response. Options are 0 = NO and 1 = YES. – Required, Integer 0 or 1, Default=1.

MIDDLE Whether to process middle sheets. Note: The Rupp spot weld method has not been validated for the prediction of fatigue damage occurring at the middle sheets for joining more than two sheets and such failures are relatively rare, difficult to reproduce in the laboratory, and difficult to detect in practice. – Required, Integer 0 or 1, Default=0.

“SEAMW” Optional FLAG indicating that parameters for 2D or 3D seam weld calculation will follow.

COMB Equivalent stress to use in the seam weld fatigue analysis. Options are ABSMAXPR and CRITXX, where XX is the number of increments to assess (see Stress>COMB above for further details). – Required, Character, Default=ABSMAXPR.

CORR Mean stress correction to use in the seam weld fatigue analysis. Options are None, FKM (Simple), and FKM. Selecting FKM (simple) will automatically add the entry vFTGMAT>SEAMW_FMK with MSS=0.1. – Required, Character, Default=NONE.

THICK For 2D Seam Weld Only: Thickness correction to be applied. Options are No = no correction. – Default=No. Future revisions will have an option for Yes.

WELDTOP For 2D Seam Weld Only: Defines which side of the seam weld is the top. Options are Lower or Upper. – Required, Character, Default=Upper.

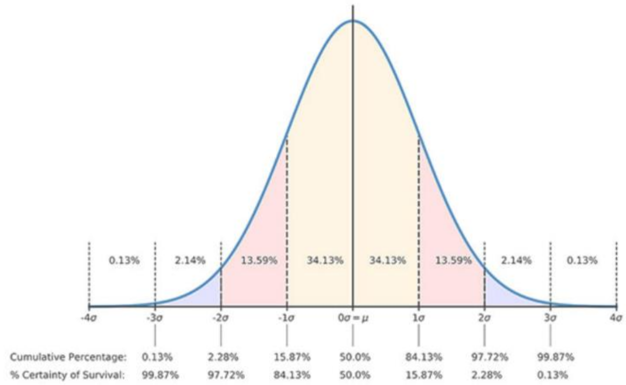
“SEAM7608” **TIME DOMAIN ONLY**: Optional FLAG indicating that parameters for a BS7608 weld calculation will follow.

COMB Equivalent stress to use in the seam weld fatigue analysis. Options are Normal, ABSMAXPR or CRITXX, where XX is the number of increments to assess (see Stress>COMB above for further details). – Required, Character, Default=NORMAL.

CORR Mean stress correction to use in the seam weld fatigue analysis. Options are None, FKM (Simple) and FKM. Selecting FKM(simple) will automatically add the entry vFTGMAT>SEAMW_FMK with MSS=0.1.– Required, Character, Default=NONE.

“CERTNTY” Optional FLAG indicating that a confidence level will be used to adjust damage results. This flag will trigger the use of defaults for fields CERTSV and SE, SEe, SEp, SEc in the vMATFTG entry.

CERTSV Confidence Level supplied by the User to revise the material data due to scatter. – *Optional, 0.1 ≤ REAL ≤99.9, Default=50.0 (if CERTNTY flag is used).*



Number of SD's from the mean (n)	***% Certainty Of Survival (CERTSV)***
-5.00	99.99997
-4.00	99.997
-3.00	99.87
-2.00	97.72
-1.00	84.13
0	50
1.00	15.87
2.00	2.28
3.00	0.13
4.00	0.003
5.00	0.00003

Using the n value from the table above, the formula for strain (below) gets adjusted with the SEe and SEp terms for the elastic and plastic regions of the curves.

Original formula (below) gets modified using n and SE values.

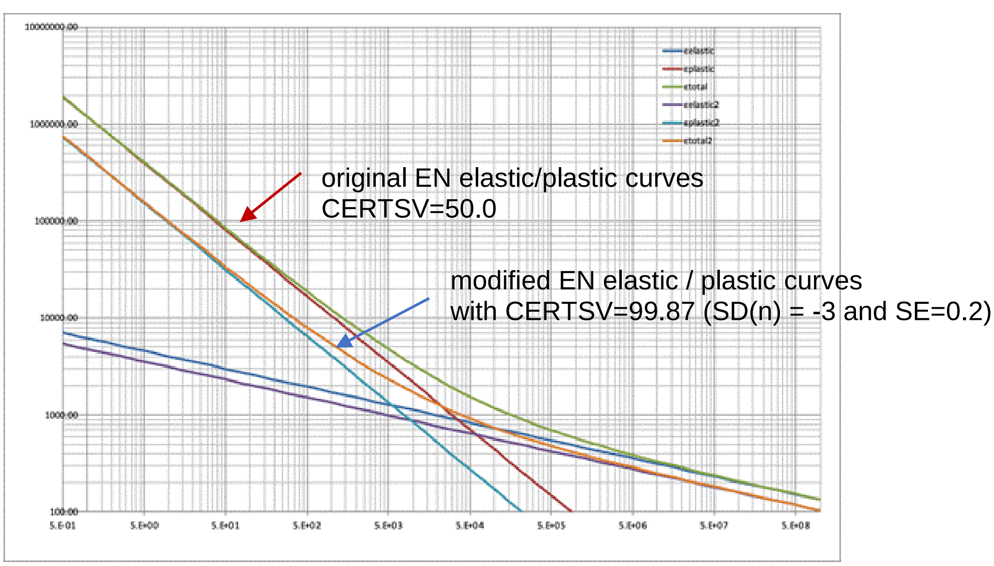
$$\epsilon_a = \frac{\sigma_f'}{E}\left(2N_f\right)^b + \varepsilon_f'\left(2N_f\right)^c$$

$modified\ \sigma_f' = original\ \sigma_f'.10^{n*SEe}$ elastic part

$modified\ \varepsilon_f' R = original\ \varepsilon_f'.10^{n*SEp}$ plastic part

Where: n is the number of Standard Deviations from the mean (see table above).

Example of shift to EN curve when CERTNTY is used.



"USERWHS" Optional FLAG indicating that parameters for User Weld analysis will follow.

COMB Stress/strain combination to use in the User Weld analysis. Only option is SGVON (signed von Mises). – Required, Character, Default=SGVON.

CORR Mean stress correction to use in the User Weld analysis. Current option is None. – Required, Character, Default=NONE.

NANGLE The number of calculation angles in 360 degrees around the User Weld tensor line. – Required, 10≤Integer≤360, Default=18; i.e., every 20 degrees)

SWLOC Location on the tensor line to report fatigue life. Options are 0 = reports worst case angle based on **damage** and 1 = reports all angles. – Required, Integer 0 or 1, Default=0.

"FOS" Optional FLAG indicating that parameters for a factor of safety calculation will follow. Note: If FOS is requested, the output will overwrite the MOS column in the CSV. Also, requesting FOS can significantly increase the processing time for the Cf analysis.

NOTE: FOS is not implemented for LTRANS or analyses involving Critical Plane and spotwelds / user welds.

LIFE Total time duration required for factor of safety calculation in time units of duty cycles or units specified by EQUIV field on FTGSEQ entry, if present. – Required, Real>0.0, no default.

BACKACC The back calculation accuracy as a percentage (%) used to control back calculation iterations that determine the scale factor on the applied stress level to achieve the target design life. – Required, 1.0≤Real≤100.0, Default=5.0.

MAXFAC The maximum safety factor to calculate and report. When this threshold is exceeded, the analysis will go on to the next element and report the maximum for the exceeded element. – Required, 2.0≤Real≤5.0E6, Default=5.0.

MINFAC The minimum safety factor to calculate and report. If the result is below this threshold, the analysis will report MINFAC as the safety factor for this element and go on to process the next element. If 0.0 is entered by the User, Cf will use the default. – Required, 0.0<Real≤0.5, Default=0.2.

"MULTIAX" **TIME DOMAIN ONLY**: Optional FLAG indicating a multiaxial stress assessment is required.

METHOD The method that will be used for the assessment. Options are None, Simple, Stand (for standard) and Auto. See the User Guide "**Introduction to Multiaxial Assessment**" for a full description of each method. – Required, Character, Default=None.

GATE Gate percentage to be use in analysis. - Required, Real>0.0, Default=20.

AUTO Params Six parameters needed if using METHOD=AUTO.

- ZERO_PER – Zero Damage Percent - Required, Real>0.0, Default=10.
- NPFT_LOW - Non Proportional Factor Threshold Lower - Required, Real>0.0, Default=0.25

- NPFT_UP – Non Proportional Factor Threshold Upper - - Required, Real>0.0, Default=0.5.
- BIA_LOW – Biaxiality Threshold Lower - Required, Real, Default=-0.6
- BIA_MID – Biaxiality Threshold Middle - Required, Real>0.0, Default=0.25
- BIA_UP – Biaxiality Threshold Upper - Required, Real>0.0, Default=0.6

Remarks:

1. CF does not support 3 sheet spot welds. However, if a 3 sheet spot weld exists in the model, Cf will treat this modeling as 2 spot welds. One spot weld (using one HEXA element) between the upper sheet and middle sheet, and a second spot weld (using another HEXA element) between the middle sheet and lower sheet.
2. NOTE: The only output that should be used for the above configuration is the TOP FACE of the upper sheet and the BOTTOM FACE of the lower sheet. Output data connected to the middle sheet should be considered unreliable.

DSP – Peak Valley Extraction.

This entry will allow the User to run Peak-Valley extraction on a time history.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
DSP	TYPE	NAME						

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
DSP	FILTER	PEAKVALY						

Describer	Contents
Name	Name of the operation. Only option is FILTER. – Required, Character, Default = FILTER
Type	Type of operation to execute. Only option is PEAKVALY - Required, Character, Default = PEAKVALY

Remarks:

1. N/A

SGAUGE – Software Strain Gauge.

This entry will allow the User to define Software Strain Gauge in a time domain run.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
SGAUGE	ID	TYPE						
	“NODE”	NODEID						
	“GLOBDIR”	COORDX	COORDY	COORDZ				
	“NORMAL”	COORDX	COORDY	COORDZ				

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
SGAUGE	101	SINGLE						
	“NODE”	10						
	“GLOBDIR”	0.0	1.0	0.0				
	“NORMAL”	0.0	0.0	1.0				

Describer	**Contents**
ID	Unique ID of the strain gauge. – Required, Integer, No Default
Type	Type of the strain gauge. Options are SINGLE, TEE, RECT, DELTA. - Required, Character, No Default
“NODE”	Required. Flag Indicating the strain gauge is defined on a node.
NODEID	ID of the node where the strain gauge is defined. – Required, Integer, No Default
“GLOBDIR”	Required. Flag indicating the definition of the strain gauge direction in global coordinate system.
“NORMAL”	Required. Flag indicating the definition of the strain gauge normal vector.
COORDi	Vector components of the direction or normal vector in global coordinate system. – Required, Real, No Default

Remarks:

1. Type SINGLE means 1 strain gauge leg in 0 degree; TEE means 2 strain gauge legs in 0 and 90 degrees; RECT means 3 strain gauge legs in 0, 45 and 90 degrees; DELTA means 3 strain gauge legs in 0, 60 and 120 degrees.

5 | ENTRIES REQUIRED FOR – INPUT LOADING SETUP

The following control file entries are required to identify the input loads both random and deterministic. Once the loads are created, they can be grouped into separate loading events (vFTGEVNT entries) and applied in a particular sequence and time duration (vFTGSEQ entry).

vFTGSEQ – Loading Event Sequence

Defines the loading sequence of events that are applied one after the other. Note: the loads within each event are applied simultaneously.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGSEQ	JOBID	EVNTOUT	DURATION UNIT	MOS_DUR	TSCALE	NREP		
	EVID1	EVT1	EVID2	EVT2	EVID3	EVT3	EVID4	EVT4
	“UNITS”	EQUIV	EQNAME					

Examples:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGSEQ	777							
	100	1.0						
	UNITS	20.0	REPEATS					

Describer	Contents
JOBID	JOB ID used for entries vFTGSEQ vFTGPARM, vFTGDEF, FE_UNITS, KTDATA and INCLDIR entries. – Required, Integer>0, no default.
EVNTOUT	Flag to request output for each individual event. Options are 0 = Summed Data or 1 = Data for All Events. – Required, Integer; 0 or 1, Default=0. When EVENTOUT=0, • Event Plotter will show the “worst” output results for each Element ID / Grid ID / Layer ID combination by adding up the individual contributions from all loading events at the worst results (inputs including PSD loads, Mean loads and Deterministic loads). • Fringe Plotter will show the “worst” output results as Event 0 for each Layer ID by adding up the individual contributions from all loading events (inputs including PSD loads, Mean loads and Deterministic loads).
DURATION UNIT	Frequency Domain: Duration units (seconds, minutes, hours, days). Defines the units used for LIFE fringe plot, for EVTi entry in vFTGEVNT or in vRANT entry. Ignored for Random Response Only analysis. -- Required, Character, Default=Seconds. Time Domain: The only option is Seconds. Any other selection will be ignored. -- Required, Character, Default=Seconds.
MOS_ DUR	Required for Margin of Safety (MOS) calculation only. This is the maximum desired duration of the sequence to cause failure. This desired duration will be compared to actual time to failure to generate MOS output that will tell the User how much additional stress can be applied before the structure fails at the

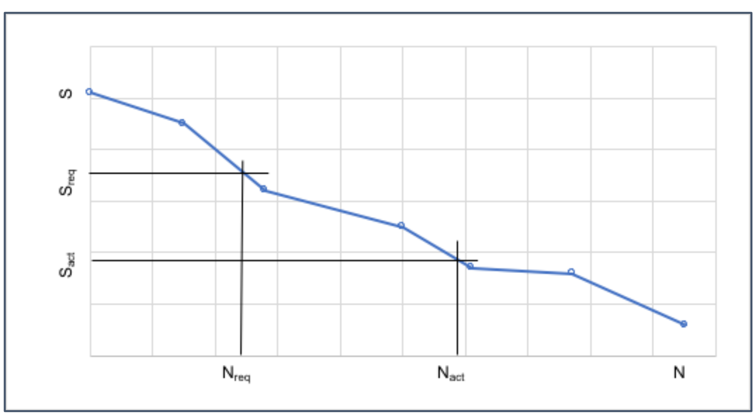
	MOS_DUR. Ignored for Random Response Only analysis, otherwise format is -- Required, Real>0.0, Default=Sum of EVT's.
TSCALE	Global scale factor that is applied to the equivalent stress values. This scales the equivalent stress values prior to the calculation of the Transfer Function, so TSCALE = 3 will results in a 3^2 change to the Transfer Function value. – Optional, Real>0.0, Default=1.0.
NREP	Options are YES or NO. If YES, EVTi values will represent Number of Repeats and not an amount of time. DURATION UNIT now represents the units of the vRANDT entry. – Required, Character, Default=NO. NOTE the following rules: • If NREP=YES but no EVT value is specified for EVID, then give an error because number of repeats of EVID cannot be determined. • If NREP=YES and EVT values are specified, then multiply EVT value by T value from vRANDT entry to determine the duration of EVID. • If NREP=YES and EVT values are specified, but there is no T field specified in vRANDT entry, then give an error as duration of EVID cannot be determined. • If NREP=NO and EVT values are specified, then use EVT value as duration of event (EVID). • If NREP=NO and no EVT values are specified, then use the T values from the vRANDT entry. IF T values do not exist, then give error as duration of EVID cannot be determined. For Time Domain analysis: NREP=YES is Default and cannot be changed.
$EVID_i$	ID of an event entry, vFTGEVNT. – Required, Integer>0, no default.
EVT_i	Duration of each event (EVIDi) or Number of Repeats for event (EVIDi). In the case of multi input, the durations are automatically read in from the TIME2PSD * _PSDM.txt files. EVT_i is ignored for Random Response Only analysis. Values for EVT_i are not needed (will be overwritten) if values for SWRATE and N_SWEEPS are provided on SINESW entry. – Required, Real>0.0, Default=1.0.
"UNITS"	Optional FLAG indicating that a User defined "fatigue equivalent unit" is to be assigned to this loading. This will provide output for LIFE in duration units and LIFE in EQNAME units.
EQUIV	Number of "EQNAME" units in a complete duty cycle. Only the Life and Log of Life results use this entry to calculate life in equivalent units. Life (in duration units) is divided by EVT and then multiplied by EQUIV before outputting to results files in EQNAME units to the main CSV file. – Optional, Real>0.0, no default.
EQNAME	Equivalent name of this loading specification. Example: Laps. – Optional, Character, no default.

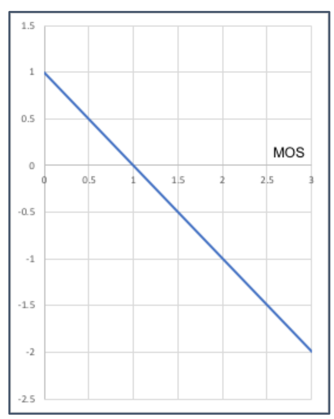
Remarks:

1. Starting on the second row, multiple sets of EVIDi and EVTi entries are allowed in columns 2-9, (with continuation onto the next row) until the required list of values is specified. The occurrence of a blank column or a field in column 1 (the start of a new entry) signifies the end of the list.
2. Where an vFTGSEQ includes an $EVID_i$ which refers to an event containing a sine sweep (SINESW), then the SINESW entry will be used to expand the vFTGSEQ entry to N number of $EVID_i$ entries (N defined on that entry as SWNUM+1). See SINESW entry for more details. EVT_i values will be overwritten if SRATE and N_SWEEPS are provided.
3. Where a swept sine (SINESW) is specified EVT_i is the total duration of the sweep.
4. MOS_DUR is needed for the Margin of Safety results provided in the output.
5. Below is the process for calculating the Margin of Safety (MOS). This is done for each event and event (sum). See the User Guide for a further explanation of MOS and vFTGPARM>FOS (Factory of Safety).
   - Calculate number of cycles to failure for actual loads – call this N_{act}
   - Look at S-N curve and read off equivalent value for S_{act}
   - Use N_{req} (Required Duration) from Control File (this could also be called N_{target})
   - Convert to seconds and multiply by E[P] to get N_{req} in cycles
   - Look at S-N curve and read off equivalent value for S_{req} corresponding to N_{target}
   - MOS is then obtained using the equation below and expressed as a percentage

$$MOS = \left[1 - \frac{S_{act}}{S_{req}}\right] \qquad E[P]_{sum} = \sum \frac{E[P]_i . N_i}{\sum N_i}$$

To calculate E[P] for the summed events use





Both Sact and Sreq are always positive so according to the MOS equation the result can vary between 100.0% and minus infinity. A value above 0.0 would indicate that that result corresponds with a damage less than 1.0.

6. NREP with EVT refers to the number of times to repeat a SINGLE Event. This type of specification can be made for any number of Events in the vFTGSEQ entry.
7. The EQUIV field is the number of EQNAME units make up the Duty Cycle. So, if the total duty cycle is 100 seconds and it is specified to be EQUIV=2 and EQNAME=LAPS, then each “LAP” is assumed to be 50 seconds and that is used to change the numbers for output of Life and Log of Life, specified in the EQNAME units. NOTE: One pass through the vFTGSEQ loading is considered a DUTY CYCLE.

vFTGEVNT – Loading Event Definition

Gathers simultaneously applied random or deterministic loads into a single loading event by referencing the ID's of vFTGLOAD or NBLOAD entries for random PSD loading and the DETLOAD, SINGSINE or SINESW entries for deterministic loading.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGEVNT	EVID	FLOAD1	FLOAD2	FLOAD3	FLOAD4	FLOAD5	FLOAD6	FLOAD7
	FLOAD8	FLOAD9	Continue …					
	"NAME"	EVNTNAME						

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGEVNT	100	401	402	403				
	NAME	Rough_road						

Describer	Contents
EVID	Unique ID of each event which is referenced by the vFTGSEQ entry. – Required, Integer>0, no default.
FLOADi	ID of vFTGLOAD or NBLOAD entries for random PSD loading or DETLOAD, SINGSINE or SINESW entries for deterministic loading. Also, can be ID of FNOTCH local scaling entry or ID of Time Domain vFTGLOAD entry. – Required, Integer>0, no default.
"NAME"	Optional FLAG indicating that a name is to be associated to this event.
EVNTNAM	Event name associated with this event (no spaces allowed). The names must be unique between events. – Optional, Character, no default.

Remarks:

1. All EVID's must be unique.
2. Multiple FLOADi values in columns 3-9 are allowed, then columns 2-9 on continuation rows, until the required list of values is specified. The occurrence of a blank column or a field in column1 (i.e. start of a new entry), signifies the end of the list.
3. For **TIME DOMAIN ANALYSIS**: Multiple vFTGLOAD of TYPE=STATIC is permitted per event and MUST BE COMBINED with a vFTGLOAD of TYPE=LQSTATIC or LMTRANS or LTRANS.

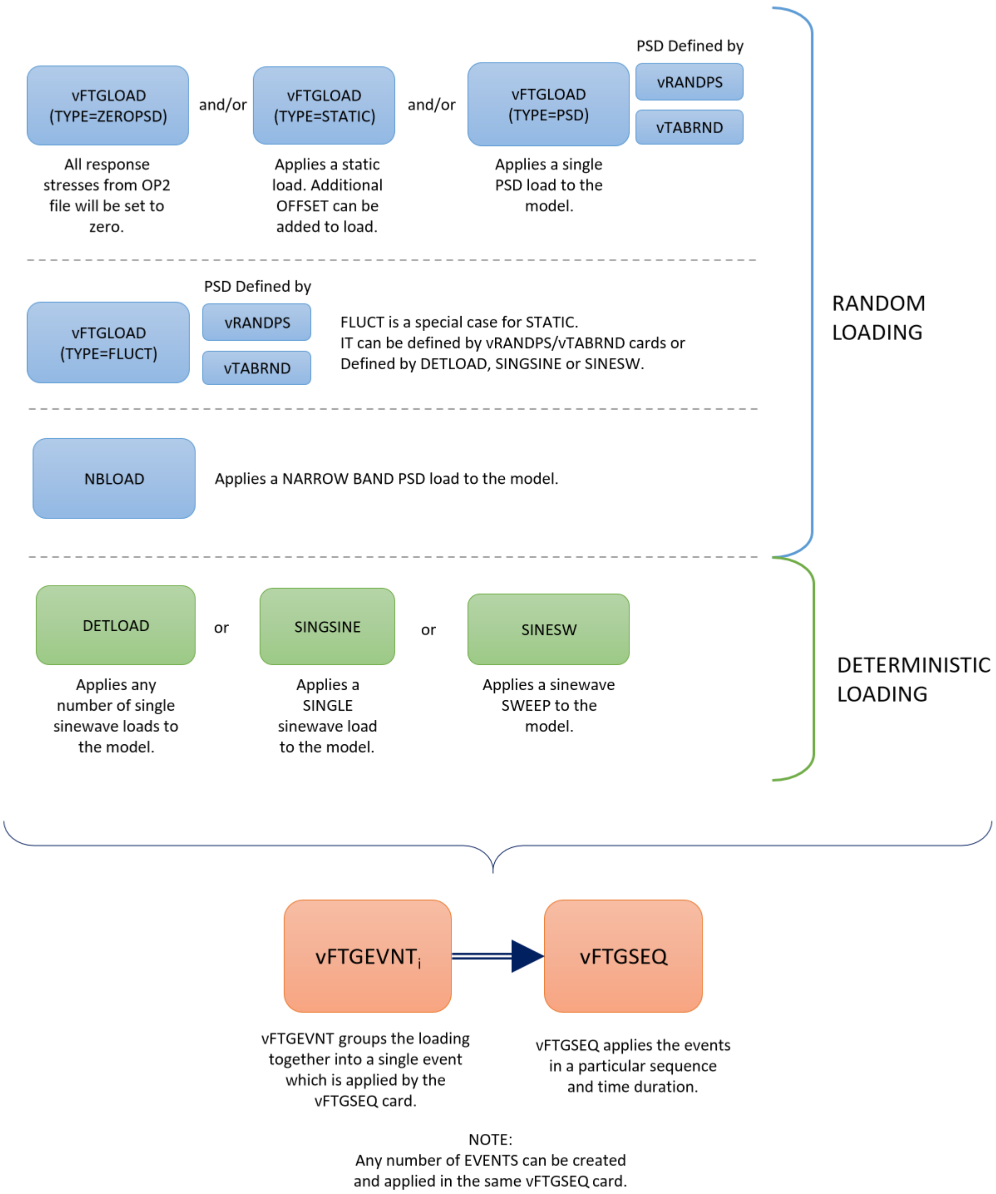
Remaining remarks are for a **Frequency Domain analysis**:

4. Only 1 **DETLOAD** or **NBLOAD** or **SINGSINE** or **SINESW** entry is allowed per event and MUST BE COMBINED with a vFTGLOAD of TYPE=PSD or ZEROPSD.
5. Only 1 **FNOTCH** is allowed per event but can be combined with other loads.
6. Only 1 vFTGLOAD (TYPE=**PSD**) is allowed per event but can be combined with other loads.

7. Multiple vFTGLOAD (TYPE=**STATIC**) are allowed per event but must be combined with a random or deterministic load.
8. Only 1 vFTGLOAD (TYPE=**ZEROPSD**) is allowed per event but can be combined with other loads.

   NOTE: If desired, a PSD, STATIC and ZEROPSD load can be in the same event with FNOTCH and/or an NBLOAD or DETLOAD or SINGSINE or SINESW. Images on the following pages provide examples of how random and deterministic loads can be combined and applied in a single event.
9. Only 1 vFTGLOAD (TYPE=**FLUCT**) is allowed per event and cannot be combined with PSD, STATIC or ZEROPSD. If the FLUCT PSD is not defined by vRANDPS and VTABRND entries than it must be combined with a deterministic load i.e. a DETLOAD, SINGSINE or SINESW load.
10. The image below describes the types of loading that can be applied in a single event. See further information within the individual loading entries further below in this section. NOTE: Any number of events can be applied in the loading sequence vFTGSEQ entry.

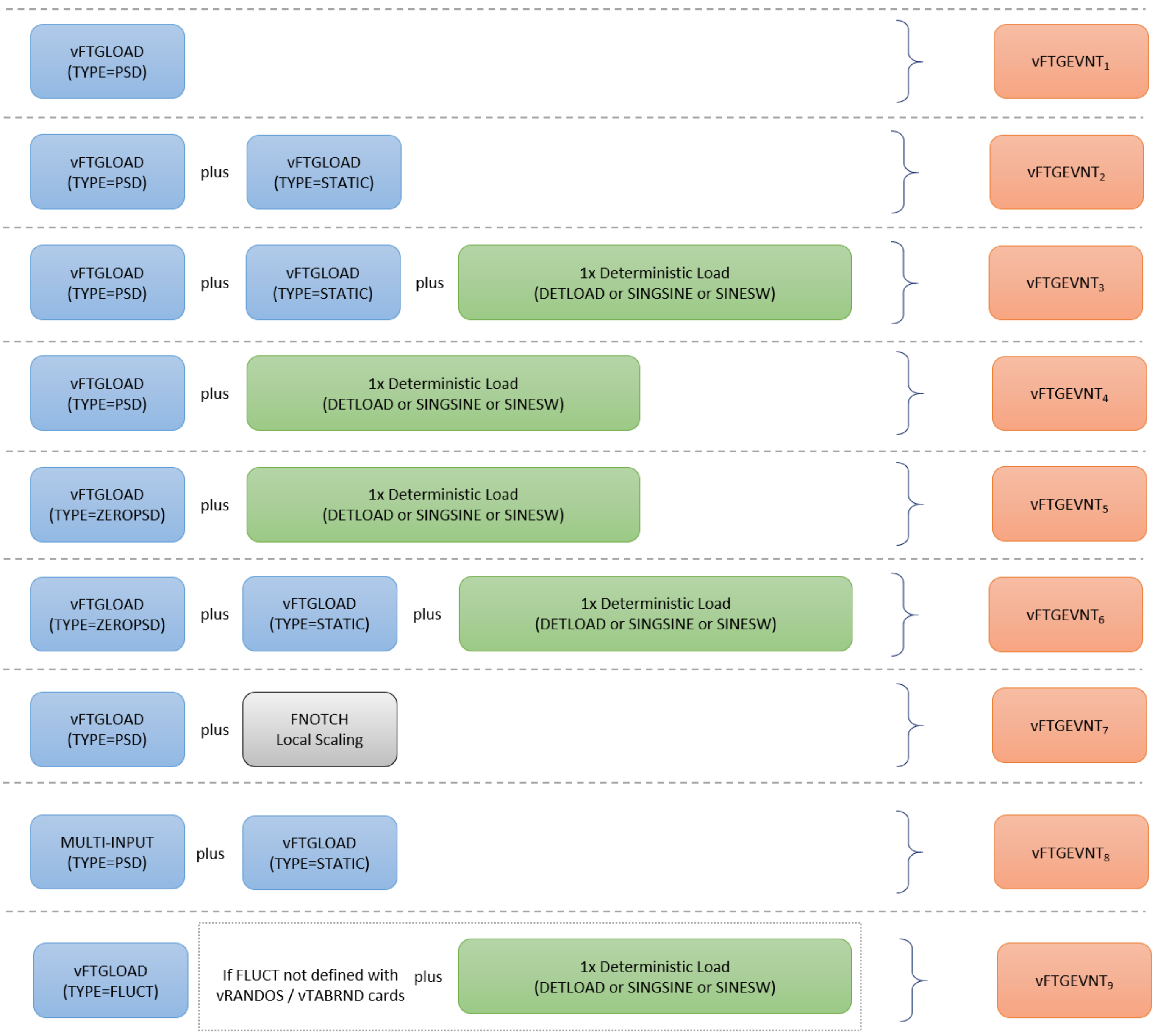
    NOTE: that deterministic loads are not supported with multiple random loads (MULTI).



For **FREQUENCY DOMAIN ANALYSIS**: Below are a few examples of load combinations that can be used in an Event

NOTE:

- Deterministic loads cannot currently be applied with multi input random loads (LCID=MULTI).
- You cannot have an Event that has a random PSD loading followed by a separate Event with a deterministic loading. The reason for this is that a random PSD load requires a vFTGDEF > ATYPE of Dirlik, NB or Stein and a deterministic load requires a vFTGDEF > ATYPE of SINES. Cf only allows one ATYPE to be specified per control file.



vFTGLOAD – Input Load Definition

This entry is used to define the input loading. The input can be a Random PSD load, a Static (Mean) load, a fluctuating Static (Mean) load or a linear / nonlinear time domain based load.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	FLOAD	TYPE	SID	SCALE	OFFSET			
LCID	address of solver or loading file							

Examples for **FREQUENCY DOMAIN**:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	**STATIC**		1.0				
1	(no entry in this cell because OP2MAPS was used to define Nastran subcase)							

Above is a **STATIC** NASTRAN example where the OP2MAPS entry is used. Hence, LCID = Cf load case number from the STATIC OP2 and corresponds to an Event in the Cf analysis.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	**MEANLDS**	**401**	1.0	0.0			
No entry is required for LCID								

Above is a **MEANLDS** example where the OP2MAPS entry is used in conjunction with a PSDM file. An SID matching the PSDM file SID is required. Note: To ensure the MEANLDS section will be read, the PSDM file must have been made using Cf v2021.4 or later.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	**PSD**	500	1.0				
1	(no entry in this cell because ODBMAP was used to define Abaqus subcase)							

Above a **single input PSD** example where the required ABAQUS mapping entry (ODBMAP) must be used. LCID = Cf load case number from ODBMAP entry.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	**PSD**	500	1.0				
multi	OP2_files/randvib.op2							

Above is a **multi-input PSD** example where the optional NASTRAN mapping entry (OP2MAP) was not used. Hence, LCID = NASTRAN subcase number from stress file.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	**PSD**	500	1.0				
vector	(no entry in this cell because OP2MAP was used to define the X, Y and Z subcases)							

Above is a **single input PSD** example where a VECTOR entry was used to combine the X, Y and Z Solver FRF subcase results into a single vector. Hence, LCID = vector to apply the PSD loading to the vector and not a subcase.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	**FLUCT**	500	1.0				
1-3	(no entry in this cell because OP2MAP was used to define the X, Y and Z subcases)							

Above is a **FLUCT** NASTRAN example where the OP2MAP entry was used. Hence, LCID = Cf load case number from OP2MAP entry.

Examples for **TIME DOMAIN**:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	**LQSTATIC**		5.0	10000			
	LOADING_FILE.RSP or CSV							

Above is a **LQSTATIC** NASTRAN example for a linear static stress recovery analysis. Reference to a loading file is required to conduct the analysis (RSP or CSV format). The loading file must have the same number of channels as the defined in the Mapping entry and the time sequence must start at zero (0). Scaling is applied to the Stress Tensor specified in the mapping entry. LCID is not required because the Loading File is applied to all subcases defined in the Solver file which is referenced in the mapping entry.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	**NQSTATIC**		5.0	10000			
	LOADING_FILE.RSP or CSV							

Above is a **NQSTATIC** NASTRAN example for a non-linear static stress recovery analysis. Reference to a loading file is required to conduct the analysis (RSP or CSV format). Scaling is applied to the Stress Tensor specified in the OP2MAP entry. LCID is not required because the Loading File is applied to all subcases defined in the Solver file which is referenced in the mapping entry. Currently only applicable to SOL400 and MARC analysis.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	**LTRANS**		5.0				
1	(no entry in this cell because OP2MAP was used to provide OP2 with direct stresses)							

Above is a **LTRANS** NASTRAN example for a linear dynamic direct stress recovery analysis (SOL112). Direct stresses are recovered for each Nastran subcase through the LCID reference in the mapping. Scaling is applied to the Stress Tensor in the OP2 file.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	**LMTRANS**		5.0				
1	Output.PCH							

Above is a **LMTRANS** NASTRAN example for a linear dynamic external stress recovery analysis using Modal Participation Factors (example: SOL112 with PUNCH output). Reference to the modal loads via the punch file is required along with the modal stress field specified via the OP2 file in OP2MAPS. Scaling is applied to the Stress Tensor in the OP2 file.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	LMTRANS		5.0				
	Output.RSP							

Above is a **LMTRANS** NASTRAN example where the MPFs are coming from a separate RSP file per event. A separate vFTGLOAD entry would need to be used for each event. The modal stresses must come from an OP2 file specified via the OP2MAP entry, but no mapping numbers are needed. Scaling is applied to the Stress Tensor in the OP2 file.

Examples for **applying Static (Mean) offset in the TIME DOMAIN**:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	STATIC		1.0	1000			
1	(no entry in this cell because OP2MAPS was used to define Nastran subcase)							

Above is a **STATIC** NASTRAN example where the OP2MAPS entry is used. Hence, LCID = Cf load case number from OP2MAPS entry. Scaling is applied to the static stress tensor.

SPECIAL CASE: **Time Domain**: Applying multiple Static (Mean) offsets to a Single Event

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	STATIC		1.0	10000			
1	*Specify the 1st **STATIC** OP2 file name here.*							
vFTGLOAD	402	STATIC		2.0	5000			
2	*Specify the 2nd **STATIC** OP2 file name here.*							
vFTGLOAD	403	STATIC		10.0	1000			
3	*Specify the 3rd **STATIC** OP2 file name here.*							
vFTGLOAD	404	STATIC		5.0	20000			
4	*Specify the 4th **STATIC** OP2 file name here.*							

To apply **multiple Static (Mean)** loads to a single event, you must specify the individual STATIC OP2 files in the "address of solver file" field. The LCID now refers to the actual subcase numbers from the STATIC OP2 file. The OP2MAPS entry is not used for this case. Scaling is applied to the OP2 static stresses. OFFSET is adjusted by FE_UNIT entries (if applicable) then applied to the OP2 static stresses.

Examples for **PSEUDO** Damage:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vFTGLOAD	401	PSEUDO	n/a	5.0	n/a			
	LOADING_FILE.RSP or CSV							

Above is a **PSEUDO** Damage analysis for predicting the damage change between two different acceleration load sets. No stress file or geometry file is required for this analysis.

Describer	Contents
FLOAD	Unique ID, which is referenced by the vFTGEVNT entry, FLOAD field. – Required, Integer>0, no default.
TYPE	Flag indicating the type of load being defined. For Frequency Domain analysis: Values can be PSD, STATIC, ZEROPSD, FLUCT and MEANLDS. If STATIC, the SID field will be ignored. Needed to add mean offsets to analysis. If ZEROPSD, all equivalent stresses calculated from Solver stress tensors will be set to zero. Needed when using deterministic loading only. If FLUCT, a deterministic load must be included in the event that contains the FLUCT loading, which will provide the frequency to fluctuate the static load. If MEANLDS, the SID field should be the SID in the PSDM file. Needed to add mean offsets from a PSDM file. Easier to use than adding separate Static loads for each channel in the PSDM file. Required, Character, Default=PSD. For Time Domain Analysis: Values can be LQSTATIC, NQSTATIC, LTRANS or LMTRANS using Nastran Solver files. For **LQSTATIC** or **NQSTATIC**, the LCID is ignored but an RSP or CSV file containing the load time histories must be entered via the “address of solver file” field in the vFTGLOAD entry. For **LTRANS**, the LCID field will point to the event number in the OP2 file. The OP2 file is added using the OP2MAP entry or added via the “address of solver file” field in the vFTGLOAD entry. For **LMTRANS**, the LCID field will point to the event number in the PCH file. The PCH file name must be added via the “address of solver file” field in the vFTGLOAD entry. NOTE: LQSTATIC and LMTRANS analyses are also available for **ABAQUS** and **Ansys**. Required, Character, Default=LQSTATIC. For PSEUDO Analysis: Value is **PSEUDO**. Required, Character, Default=PSEUDO.
SID	CF set ID of a vRANDPS or NBLOAD field that defines the applied random PSD loading. If loads are applied separately (i.e., separate events) than the SID’s must be unique along with the LCIDs for each load. If the loads are applied at the same time (i.e., within the same event) than the SIDs must be the same for each load and the LCID must be set to MULTI. Not required for TYPE=STATIC or TYPE=ZEROPSD, otherwise the format is - Required, Integer>0, no default. NOTE: For **Time Domain** analysis of TYPE=LQSTATIC, NQSTATIC, LMTRANS, LTRANS, SID is not required.
SCALE	Scale factor applied individually to the vFTGLOAD entries. – Optional, Real>0.0, Default=1.0.

OFFSET	Only valid for TYPE=STATIC. OFFSET is adjusted by the parameters in FE_UNITS, if applicable, and then applied to the STATIC stress in the solver file but only after the SCALE value is applied to the static stress first. If a solver stress file is not provided than the total static stress is equal to the offset value only. – Optional, Real>0.0, no default.
LCID	CF load case ID. **See Remark 2, 3 & 4.** In the case of a multiple input loading analysis, use “multi” or “multiuc” for LCID when working in the Frequency Domain. MultiUC allows for the use of direct (diagonal) terms from the PSDM file, without the off-diagonal (cross) PSD terms For type = FLUCT with multiple load case ID’s the format is $LCID_1$-$LCID_3$, e.g. “1-3”. Also, see SPECIAL CASE under remarks. – Required, Character=MULTI, VECTOR or Integer>0, no default.
address of stress or loading file	Name and location of a solver files including stress, PCH, RSP or CSV as needed by the type of analysis. NOTE: For the special **Time Domain** case of applying multiple Static loads, the name of the solver file is permitted to change.

Remarks:

1. All SID’s must be unique.
2. For Nastran/OptiStruct solver with OP2 results: It is MANDATORY that the Cf load case ID numbers come from the OP2MAP entry. This is done automatically in the Process Flow view.
3. For Nastran solver with HDF5 results: It is MANDATORY that the Cf load case ID numbers come from the CASEMAP entry. This is done automatically in the Process Flow view.
4. For Abaqus solver: It is MANDATORY that the Cf load case ID numbers come from the ODBMAP entry, which maps to the Abaqus STEP names.
5. For Ansys solver: It is optional that the Cf load case ID numbers will come from the RSTMAP entry for frequency domain analysis. However, this will become mandatory in future releases. If RSTMAP entry is not used, the subcase ID numbers in the RST files should be used as the LCID numbers in CF. The subcase ID numbers in the RST file should be used as the LCID numbers in CF. For time domain analysis, it is mandatory that the RSTMAP entry be used.
6. If TYPE=STATIC and a non-zero value is specified for OFFSET, the specification of a static load file is optional. If not specified, the static stress will be the value of “OFFSET”. Where a static file is specified, the static stress will be the sum of the stress in the file plus the stress in the OFFSET field.
7. If an OFFSET is specified this must be specified in the same vFTGLOAD where the static file address is specified (if used).
8. Frequency Domain Comments:
    a. All loads (of any kind) are ignored if they are below the lowest FRF (subcase ID) or above the highest FRF (subcase ID) contained within the solver file.
    b. A vFTGLOAD entry is required for an input PSD load. The PSD definition is then found in the vRANDPS entry – which then refers to a vTABRND entry.
    c. A vFTGLOAD entry is required to add a STATIC load (mean stress or preload field). But in this case, no SID is needed since the LCID and the associated file on the second line of the vFTGLOAD entry provides all the required information.

d. To use TYPE=STATIC, the User must also apply a Time Based Loading, Random Loading or a Deterministic Loading. A Static loading cannot be applied by itself.

e. A vFTGLOAD entry is required if the loading is only Deterministic. In this case, TYPE is set to ZEROPSD and the LCID field is still required. However, the Response PSD will be set to zero, i.e. there will NO contribution from a random loading.

f. If TYPE=STATIC or TYPE=ZEROPSD, the SID field will be ignored.

g. If LCID=MULTI, then multiple simultaneous PSD input loads are being specified for the load. No additional NBLOAD, DETLOAD, SINGSINE or SINESW are allowed in this analysis. Deterministic loading can only be added to a single input (Base Shake) analysis.

h. SPECIAL CASE: If LCID= -1, this is the same as specifying LCID=MULTI.

i. SPECIAL CASE: If LCID= -2 or MultiUC, this is the same as specifying LCID=MULTI, but with no cross-correlation terms (only the diagonal terms are used).

j. Type=FLUCT refers to a static loading file for the stress transfer function which is then used as a transfer function over all frequencies.

k. A Type=FLUCT can have a SID that refers to a vRANDPS. Or, if no SID is specified, then a deterministic load must be included in the same event (i.e., DETLOAD, SINGSINE, or SINESW) to provide the frequency at which to fluctuate the load.

l. SURROGATE LOAD: When using the Surrogate Load feature (vFTGDEF > SGATE), you must enter an initial "guess" at the single input PSD load that will be iterated to calculate a Surrogate Load (and Vector direction if requested) that will produce nearly the same output results as found in the vFTGDEF > SGATE > Target_File. Below is an example from TPL177 of how this may be done:

```
$-----------------------------------------------------------------
vftgevnt101     401
vftgload401     psd     501     1.0
3 $Surrogate load applied in Z direction ONLY as single input PSD
vrandps 501     3       3       1.0     0.0     4001
$ INITIAL Surrogate Load PSD description. Cf will start with these
$ frequency points and adjust the amplitudes to match stress output
to
$ the TARGET stress defined in TPL175.CSV.
TABRND1 4001
$       FREQ    AMPLITUDE
        1.0     1.0
        10.0    1.0
        20.0    1.0
        30.0    1.0
        40.0    1.0
        50.0    1.0
        endt
```

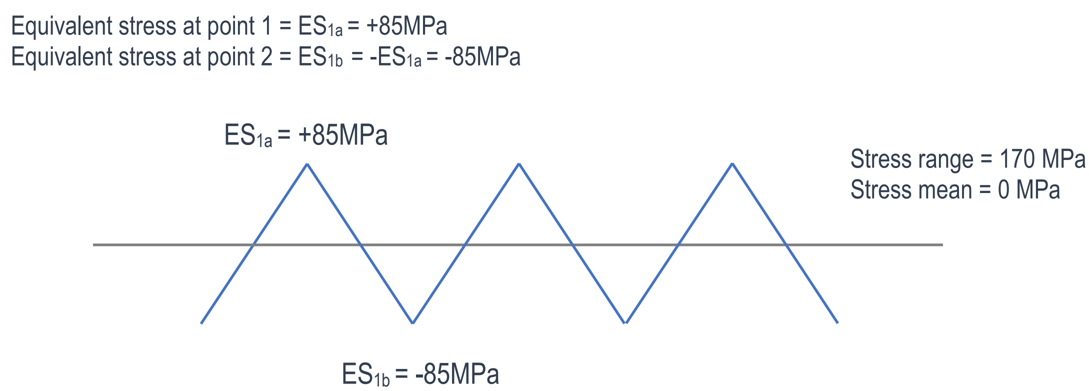
ADDITIONAL NOTES FOR TYPE = FLUCT (FLUCTUATING LOAD)

If TYPE=FLUCT, (typically used to simulate engine roll), the response will be calculated at the following frequencies:

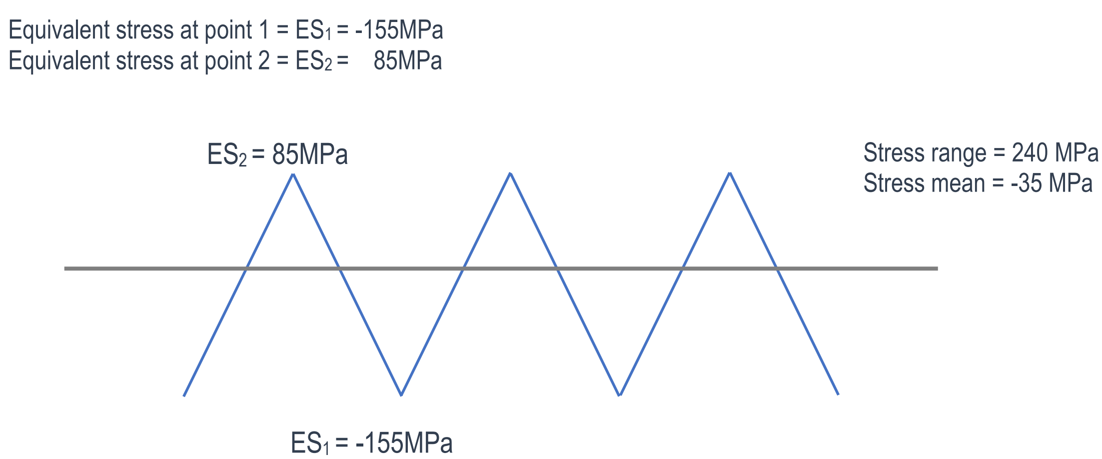
If PSD is specified (via a vRANDPS entry or NBLOAD entry) along with a deterministic load, then 100 FRF's (99 intervals) will be created from the lowest frequency of any specified load (including deterministic loads) to the highest frequency of any specified load (including deterministic loads).

If a PSD is not specified (i.e., the loading only contains deterministic loads such as DETLOAD, SINGSINE, SINESW) then 2 FRF's will be used to define the transfer function curve at the lowest frequency in the deterministic load (minus 0.1Hz) and at the highest frequency (plus 0.1Hz).

TYPICAL EXAMPLE FOR TYPE=FLUCT WITH A SINGLE LCID (STRESS IN SUBCASE IS ASSUMED TO FLUCTUATE FROM PEAK TO TROUGH).



TYPICAL EXAMPLE FOR TYPE=FLUCT WITH MULTIPLE LCID'S (STRESSES IN SUBCASES ARE ASSUMED TO FLUCTUATE FROM PEAK TO TROUGH).



vRANDPS – Random Input Load (PSD) Specification

Defines random PSD that will be referenced by the vFTGLOAD entry.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vRANDPS	SID	J	K	X	Y	TID		

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vRANDPS	500	1	1	1.0	0.0	300		

Describer	**Contents**
SID	CF set ID which is referenced by the vFTGLOAD entry. – Required, Integer>0, no default.
J	CF stress file load case ID to apply to PSD defined in vTABRND. See Remark 1, 2 and 3. – Required, Integer>0, no default.
K	CF stress file load case ID to apply to PSD defined in vTABRND. K must be greater to or equal to J. See Remark 1, 2 and 3. – Required, Integer≥1, no default.
X	Does stress file contain Real components of the complex number? Options are 1 = YES or 0 = NO. – Required, Integer 0 or 1, Default=1.
Y	Does stress file contain Imaginary components of the complex number? Options are 1 = YES or 0 = NO; NOTE: cannot be the same as X. – Required, Integer ≠ X, Default=0.
TID	Identification number of a vTABRNDi entry that defines PSD table. – Required, Integer>0, no default.

Remarks:

1. For Abaqus solver: The J and K Cf load case ID numbers will come from the ODBMAP entry.
2. For Nastran/OptiStruct solver: The J and K Cf load case ID numbers will come from the OP2MAP entry, if used. If OP2MAP entry is not used, the stress file subcase ID numbers must be used.
3. For Ansys solver: The J and K Cf load case ID will be the same as the subcase IDs in the stress file.
4. If a single input PSD is defined in the vTABRND entry than this means the PSD is direct (i.e., only has diagonal or real terms) so J = K and X must be 1.0. Y must be left blank or set to 0.0 meaning there is no imaginary (off diagonal) terms.
5. If a multi input PSD is defined in the vTABRND entry than this means the PSD has direct and cross correlation terms (i.e., diagonal and off diagonal terms). Hence, J = K for the direct (diagonal or real) PSD

loading terms (and X=1.0, Y=0.0) and J ≠ K for the cross correlation (off diagonal or imaginary) PSD loading terms (and X=0.0, Y=1.0). Note: there are always n^2-n cross correlation PSDs for every n direct PSDs.

6. vRANDPS may only reference Cf subcases included within a single stress file.
7. If using the VECTOR entry, J=K=1.0 and X=1, Y=0

vTABRND – PSD Definition Table or Material S-N Curve Definition Table

Defines power spectral density as a tabular function of frequency. Referenced by the vRANDPS entry. Can also be used to specify the points on a material property S-N curve in cycles (N) versus stress range (S) or used to specify multiple SN Haigh Life, Mean Stress or R-Ratio curves. See vMATFTG entry definition.

NOTE: Extrapolation beyond the ends of the data in the table is treated differently when the table is used for a PSD entry versus a material property entry. Please refer to remarks section below.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vTABRND	TID	XAXIS	YAXIS	UDID				
	f1	g1	f2	g2	f3	g3	endt	

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vTABRND	300	LINEAR	LINEAR					
	2.0	0.014	40.0	0.014	51.7	0.024	500.0	0.024
	2000.0	.002	3000.0	.002	ENDT			

Describer	Contents
TID	Unique ID which is referenced by the vRANDPS entry or vMATFTG entry, TID field. – Required, Integer>0, no default.
XAXIS	Specifies a linear or logarithmic interpolation for the x-axis. Options are “LINEAR” or “LOG”. – Required, Character, Default=LINEAR.
YAXIS	Specifies a linear or logarithmic interpolation for the y-axis Options are “LINEAR” or “LOG”. – Required, Character, Default=LINEAR.
UDID	ID of a UDNAME entry that references a text file containing the X, Y values for a PSD or Material curve definition in the following format (#DATA, will indicate that data values will follow): #DATA, f_1 , g_1 (note the comma between f and g) f_2 , g_2 f_3 , g_3 etc. for any number of lines. – Optional, Integer, no default. NOTE: this file can also be in CSV format where each item is entered in a cell (no commas required).
f_i , g_i,	X , Y pair combination separated by a comma (,) and on separate rows (when entered via a text file).

For PSD definition: the frequency value (f) is in cycles (Hz).

For single Material SN/EN curve definition: f is Cycles to Failure (N) and g is stress or strain values.

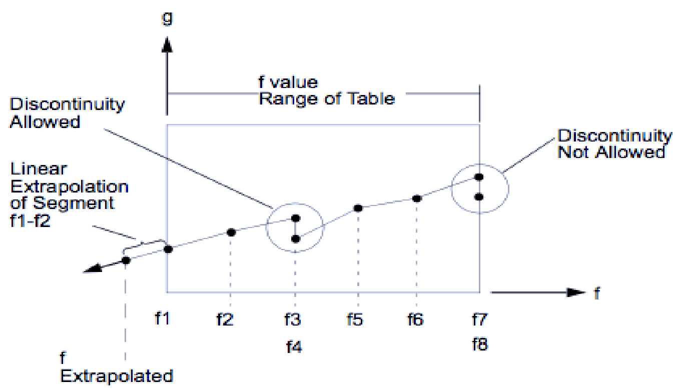
For Multiple SN curve definition:

- Haigh Life: f is mean stress and g is stress range value.
- Mean Stress: f is Cycles to Failure and g is stress range value.
- RRatio: f is Cycles to Failure (N) and g is stress range value.

Note: This is ignored if UDID is specified, otherwise format is – Required, Real>0.0, no default.

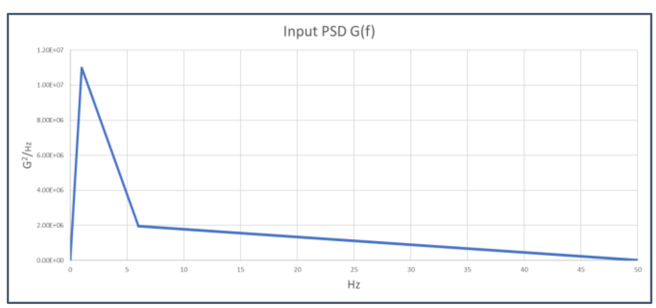
Remarks:

1. The f_i must be in either ascending or descending order, but not both.
2. Discontinuities may be specified between any two points except the two starting points or two ending points. For example, in the figure to the right, discontinuities are allowed only between points f_2 through f_7. Also, if g is evaluated at a discontinuity, then the average value of g is used. So, the value of g at f_3 is g = $(g_3+g_4)/2$. If the y-axis is a LOG axis, then the jump at the discontinuity is evaluated as *g* = sqrt(g*3*g4*).



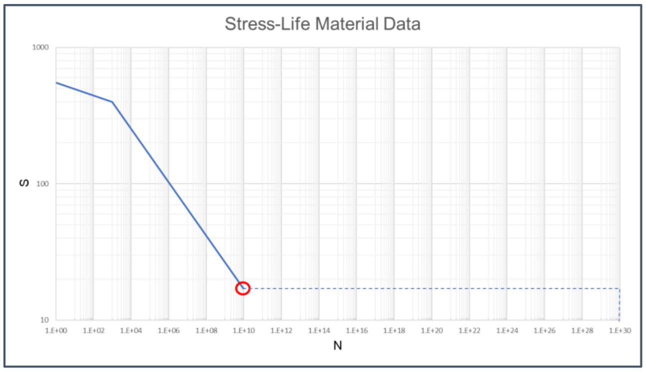
3. At least two entries pairs must be present (i.e., f_1, g_1 and f_2, g_2) to complete a table.
4. The end of the table is indicated by the existence of "ENDT" in either of the two fields following the last entry.
5. **<u>When using the table for PSD data entry:</u>** The table look-up is performed using linear / log interpolation within the curve and extrapolation outside curve using the two starting or two end points. For PSD data, the extrapolated value must be greater than or equal to zero.

   Note: This means that if an extrapolated value is negative, IT WILL BE SET TO ZERO or near zero if LOG scale is used.



6. **When using the table for SN data entry:**
The table look-up is performed using linear / log interpolation within the table by no extrapolation outside the range of the curve. At the last point (red circle to the right), Cf assumes a horizontal endurance limit from that point to N=1E-30. Shown as a dotted blue line.

   Note: Any N value beyond 1E+30 cycles will be assessed as if the N value equaled 1E+30 cycles.



7. **When using the table for multiple SN data entry:**
The table look-up is performed using linear or log interpolation within the range of the curves and if desired, extrapolation outside the max curve. This option is set as a flag called Extrapolate in the vFTGPARM> COMB> INTERPOLATION entry. At the last point (red circle to the right), Cf assumes a horizontal endurance limit from that point to N=1E-30. Shown as a dotted blue line.

   Note: Any N value beyond 1E+30 cycles will be assessed as if the N value equaled 1E+30 cycles.

8. Tabular values on an axis if XAXIS or YAXIS = LOG must be positive.

9. A free format (double precision) option is available for the values of f and g.

10. If using Abaqus as the solver, you must start your input PSD definitions at f_1=0, g_1=0 to eliminate the influence of the stress output by Abaqus at 0 Hz. This is a meaningless output that is used in the transfer function and will cause errors in your response results if the input PSD is not set to zero as the initial point. You should also set the second point to amplitude 0.

    Example: If your first actual input PSD point is at, say 8 Hz, 15 G^2/Hz, make the first two points f_1=0, g_1=0 and f_2=7.999, g_2=0. Make the third point f_3=8.0, g_3=15.0 and continue with your remaining PSD data points. This will make sure that the 0 Hz stress output point provided by Abaqus (and used in the transfer function) does not influence the response output.

vUDNAME – User Defined File Name

Provides the name of a file that can be referenced from other entries such as vTABRND, vMATFTG. and/or USERWHS. The file format is either a PSD description, material description or stress tensor description.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vUDNAME	UDID							
	NAME							

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vUDNAME								
	file.csv							

Describer	Contents
UDID	Unique UDID. – Required, Integer>0, no default.
NAME	Name of a file (with or without path) that includes required data. Format can be CSV or XML. – Required, Character, no default.

Remarks:

1. Example: An acceleration PSD loading in CSV format would look like below. It would be called in the Cf file through the vTABRND entry.

```
vtabrnd 300     Linear  Linear  23
vudname 23
        loading/300_PSDload.csv
```

```
#AXES,
linear,linear
#DATA,
0.00E+00,0.00E+00
4.30E-01,1.12E+07
5.77E+00,1.88E+06
5.00E+01,1.00E+03
```

#AXES options are LOG or LINEAR

#DATA options are X (frequency column) and Y (PSD height column).

2. Example: A material definition in XML format would look like below. It would be called in the Cf file through the vFTGMAT entry.

```
vmatftg 60
        FILE    22      SN      ID="2014_HV_O" ParentID=""
vudname 22
        materials/material_db.xml
```

Content of material_db.xml

```
<Object ID="2014_HV_O" ParentID="" Type="GenericMatData" Category="Aluminum">
<property Name="Comment" Value="2nd Edition, 1988, John Wiley &amp; Sons."/>
<property Name="E" Units="MPA" Value="7.17E4"/>
<property Name="K" Units="MPA" Value=""/>
<property Name="K1C" Units="MPASQRTM" Value=""/>
<property Name="MaterialType" Value="101"/>
<property Name="Nc1" Value="1E6"/>
<property Name="RR" Value="-1"/>
<property Name="Reference" Value="Vibration Analysis for Electronic Equipment, D S Steinberg:"/>
<property Name="SE" Value="0"/>
<property Name="SRI1" Units="MPA" Value="645.5"/>
<property Name="UTS" Units="MPA" Value="200"/>
<property Name="YS" Units="MPA" Value="135"/>
<property Name="b1" Value="-0.064300000667572"/>
<property Name="b2" Value="-0.064300000667572"/>
<property Name="me" Value=""/>
<property Name="mp" Value=""/>
<property Name="n" Value=""/>
</Object>
```

vRANDT – Power Spectral Density Time Specification

Defines random PSD duration. Used in conjunction with EVT field in vFTGSEQ entry to define duration of repeats.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vRANDT	SID	T	Units					

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
vRANDT	500	405	seconds					

Describer	Contents
SID	Random analysis set identification number. – Required, Integer>0, no default.
T	Time of event. – Required, Real>0.0, no default.
Units	Units of T. Options are seconds, minutes, hours or days. – Required, Character, Default=Seconds.

Remarks:

1. The SID number used in vRANDT must correspond to the SID number in the vRANDPS entry.

NBLOAD - Narrow Band Random Load (PSD) Definition

Defines a narrow band PSD input in frequency dependent form including signal width, i.e. frequency (with width) versus amplitude.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
NBLOAD	SID	LCID	f_1	b_1	h_1	f_2	b_2	h_2
	f_3	b_3	h_3	f_4	b_4	h_4		
	f_k	b_k	h_k					

Items in Grey are not currently support.

Example:

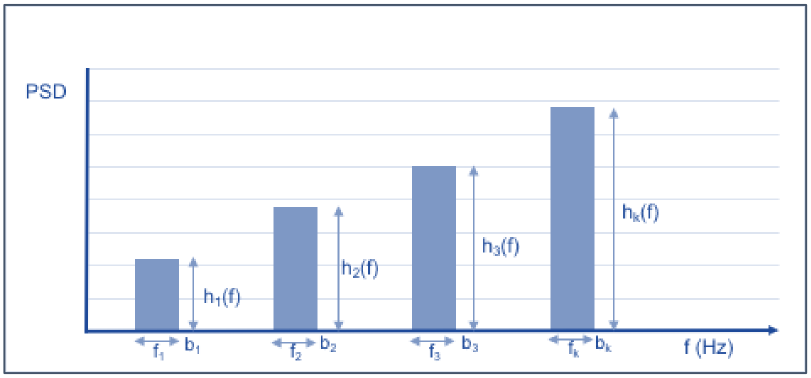
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
NBLOAD	404		10	2	2000	20	3	3000

Describer	Contents
SID	Unique ID, which is referenced by the vFTGEVNT entry, FLOAD field. – Required, Integer>0, no default.
LCID	CF load case ID. – Required, Integer>0, no default.
f_k	Center frequency of narrow band frequency block (Hz). – Required, Real>0.0, no default.
b_k	Width of narrow band frequency block. – Required, Real>0.0, no default.
h_k	Height of narrow band PSD block in units of stress^2 / Hz. – Required, Real>0.0, no default.

Remarks:

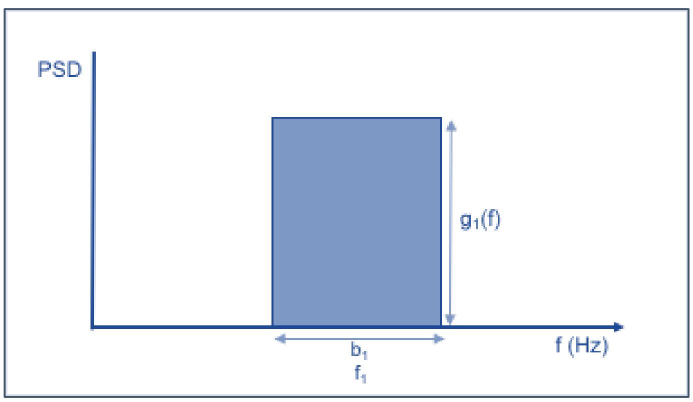
1. Moments are calculated using one frequency per block (each strip pure narrow band).
2. Multiple sets of 3 values in columns 4-9 are allowed, then columns 2-7 on continuation rows until the required list of values is specified. The occurrence of a blank column or an field in column1 (i.e. start of a new entry), signifies the end of the list.
3. Values of h_k in the NBLOAD entry are in normal PSD units.
4. If FRF(f_k) is the value of the FRF (transfer function) calculated (by interpolation) at f_k then the relevant moments can be calculated using:

$$m_n(NBLOAD) = \sum f_k^n * h_k(f) * b_k(f) * FRF(f_k)$$



LOAD SPECIFICATION FOR A NARROW BAND PSD WITH ONLY ONE STRIP

For the special case when only one narrow band strip is specified, Cf will do additional calculations by splitting up the strip to determine the spectral moment more accurately.



$$
\begin{aligned}
m_n(NBLOAD) = {} & f_{k-4}^{n} * g_k(f) * \frac{b_k(f)}{8} * FRF(f_{k-4}) \\
& + f_{k-3}^{n} * g_k(f) * \frac{b_k(f)}{8} * FRF(f_{k-3}) \\
& + f_{k-2}^{n} * g_k(f) * \frac{b_k(f)}{8} * FRF(f_{k-2}) \\
& + f_{k-1}^{n} * g_k(f) * \frac{b_k(f)}{8} * FRF(f_{k-1}) \\
& + f_{k+1}^{n} * g_k(f) * \frac{b_k(f)}{8} * FRF(f_{k+1}) \\
& + f_{k+2}^{n} * g_k(f) * \frac{b_k(f)}{8} * FRF(f_{k+2}) \\
& + f_{k+3}^{n} * g_k(f) * \frac{b_k(f)}{8} * FRF(f_{k+3}) \\
& + f_{k+4}^{n} * g_k(f) * \frac{b_k(f)}{8} * FRF(f_{k+4})
\end{aligned}
$$

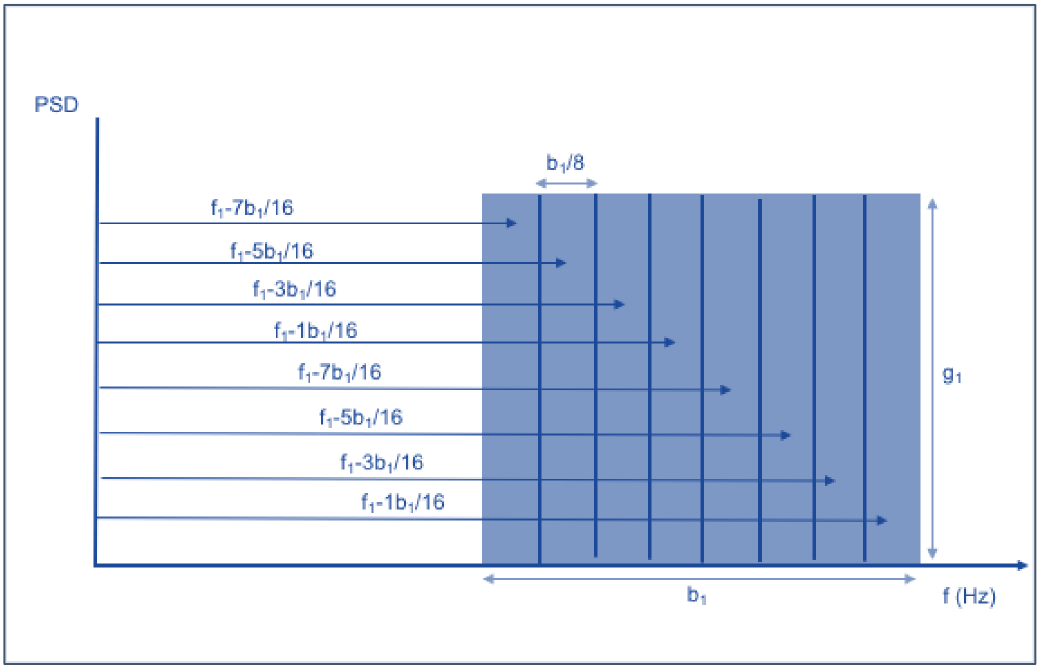
The specification for this type of special narrow band PSD is:

NBLOAD	SID	LCID	f_1	b_1	h_1			

In order to create a more accurate moment calculation this will (internally to the software) be converted into:

Format:

NBLOAD	SID	LCID	f_1-7b_1 / 16	b_1 / 8	h_1	f_1-5b_1 / 16	b_1 / 8	h_1
	f_1-3b_1 / 16	b_1/8	h_1	f_1-1b_1 / 16	b_1 / 8	h_1		
	f_1+1b_1 / 16	b_1/8	h_1	f_1+3b_1 / 16	b_1 / 8	h_1		
	f_1+5b_1 / 16	b_1/8	h_1	f_1+7b_1 / 16	b_1 / 8	h_1		


PSD
b1/8
f1-7b1/16
f1-5b1/16
f1-3b1/16
f1-1b1/16
f1-7b1/16
f1-5b1/16
f1-3b1/16
f1-1b1/16
g1
b1
f (Hz)

DETLOAD – Multi Sinewave Deterministic Load Definition

Defines any number of single sinewave inputs in a frequency dependent form, i.e., frequency versus amplitude.

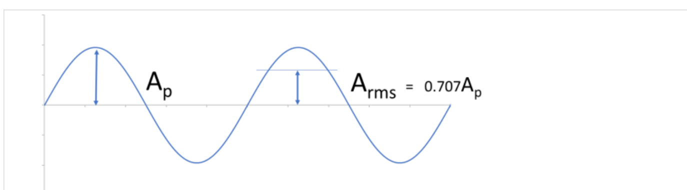
Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
DETLOAD	SID	LCID	f_1	g_1	f_2	g_2	f_3	g_3
	f_4	g_4	f_5	g_5	f_6	g_6	f_7	g_7
	f_k	g_k						

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
DETLOAD	402		10	1200	20	2400	30	3600
	40	4800						

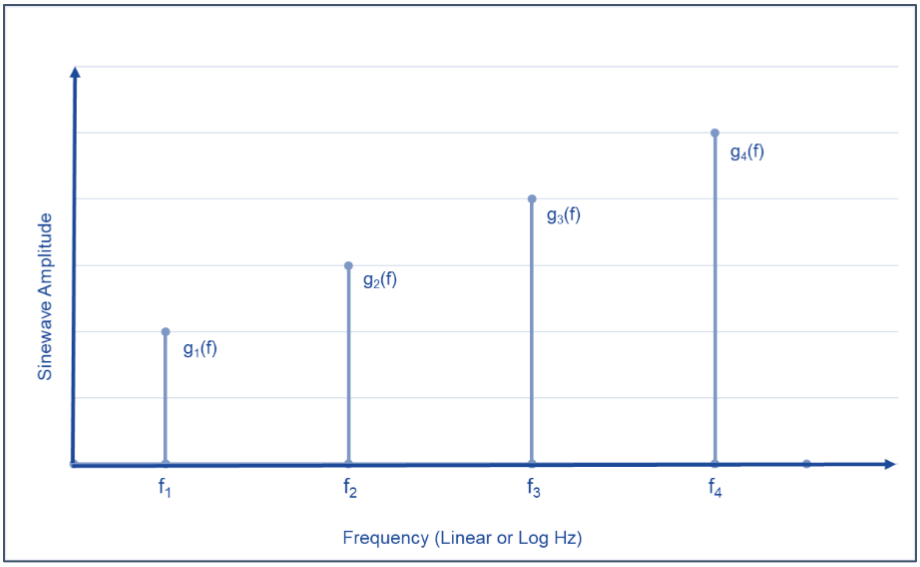
Describer	Contents
SID	Unique ID which is referenced by the vFTGEVNT entry, FLOAD field. – Required, Integer>0, no default.
LCID	CF load case ID. – Required, Integer>0, no default.
f_k	Frequency of sinewave (Hz). – Required, Real>0.0, no default.
g_k	Peak value (amplitude) of sine wave in units that match the solver FRF units. Example G for acceleration sine wave. Shown as Ap below. – Required, Real>0.0, no default.



Remarks:

1. Values of g_k in the DETLOAD entry are in units of peak amplitude.
2. Multiple sets of 2 values in columns 4-9 are allowed, then columns 2-9 on continuation rows until the required list of values is specified. The occurrence of a blank column or a field in column1 (i.e. start of a new entry), signifies the end of the list.
3. If FRF(f_k) is the value of the FRF (transfer function) calculated (by interpolation) at f_k then the relevant moments can be calculated using:

$$m_n(DETLOAD) = \sum f_k^n * 0.5 * g_k(f)^2 * FRF(f_k)$$



SINGSINE - Single Sinewave Deterministic Load Definition

SINGSINE is a special case of DETLOAD where we are only defining a single sinewave input in a frequency dependent form, i.e. frequency versus amplitude.

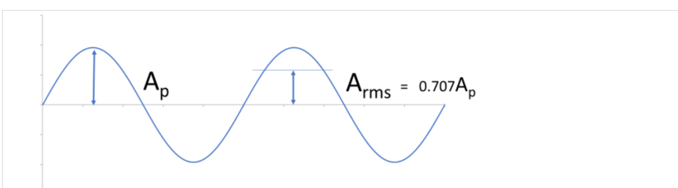
Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
SINGSINE	SID	LCID	f_1	g_1				

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
SINGSINE	601		10	100				

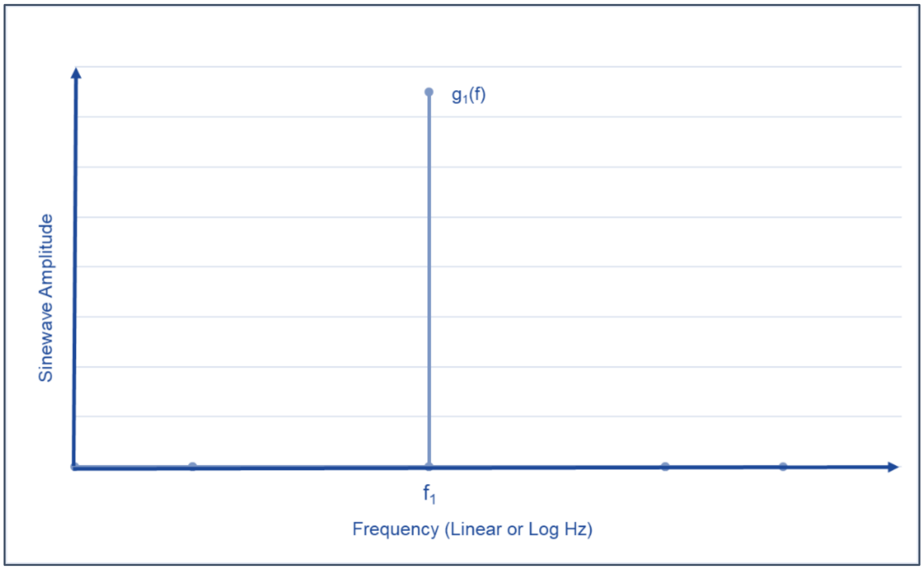
Describer	Contents
SID	Unique ID, which is referenced by the vFTGEVNT entry, FLOAD field. – Required, Integer>0, no default.
LCID	CF load case ID. – Required, Integer>0, no default.
f_1	Frequency of sine wave (Hz). – Required, Real>0.0, no default.
g_1	Peak value (amplitude) of sine wave in units that match the solver FRF units. Example G for acceleration sine wave. Shown as Ap below. – Required, Real>0.0, no default.



Remarks:

1. Values of g_1 in the SINGSINE entry are in units of peak amplitude. RMS of a sine wave is 0.7071 * (sine wave amplitude).
2. If FRF(f_1) is the value of the FRF (transfer function) calculated (by interpolation) at f_1 then the relevant moments can be calculated using,

$$m_n(SINGSINE) = f_1^n * 0.5 * g_1(f)^2 * FRF(f_1)$$



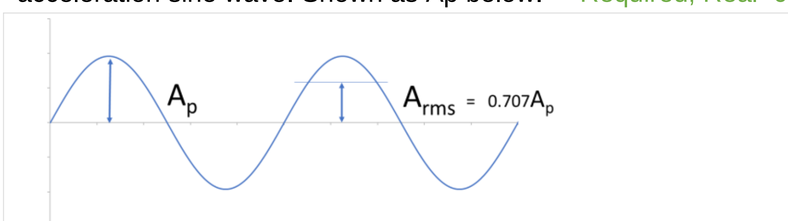
SINESW - Swept Sinewave Deterministic Load Definition

Defines a sinewave swept input in frequency dependent form, i.e., frequency versus amplitude.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
SINESW	SID	LCID	f_1	g1	f_N	g_N	SWTYPE	SWNUM
	"PARAMS"	SWRATE	N_SWEEPS	FRF_UNIT	LD_UNIT			

Describer	Contents
SID	Unique ID, which is referenced by the vFTGEVNT entry, FLOAD field. – Required, Integer>0, no default.
LCID	CF load case ID. – Required, Integer>0, no default.
f_1	Frequency of first sine wave. – Required, Real>0.0, no default.
g_1	Peak value (amplitude) of sine wave in units that match the solver FRF units. Example G for acceleration sine wave. Shown as Ap below. – Required, Real>0.0, no default.



Describer	Contents
f_N	Frequency of last sine wave. – Required, Real>0.0, no default
g_N	Peak value (amplitude) of last sine wave. – Required, Real>0.0, no default
SWTYPE	The sweep types. Options are Decibel (LOG/DB), Octave (OCT) or Linear (Hz). – Required, Character, Default=Linear (Hz).
SWNUM	Number of sine bands to use in the sweep. Note: Make sure to use enough sine bands to match the peak response points in the Transfer Function. – Required, 0<Integer<1000, Default=50.
"PARAMS"	Optional FLAG indicating that additional sweep parameters will be provided.
SWRATE	Sweep rate per <u>second</u> in Hz, DB or OCT. – Optional, Real>0.0, no default.
N_SWEEPS	Number of times the sine is swept through the frequency range (a sweep up and back down the frequency range is 2 sweeps). – Optional, Integer>0, Default=1.

FRF_UNIT Type of loading used to create FRF - can be acceleration (A), velocity (V), displacement (D), or force in N (FN) or Force in KN (FKN). – Optional, Character, no default.

LD_UNIT Type of loading used to define sweep - can be acceleration (A), velocity (V), displacement (D), force in N (FN) or Force in KN (FKN). – Optional, Character, no default.

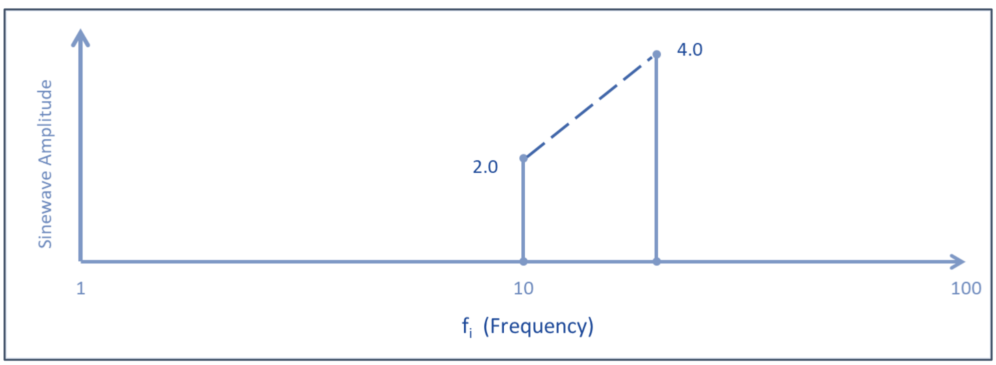
Remarks:

1. Values of g_1 and g_2 are in units of peak amplitude. RMS of a sine wave is 0.7071 * (sine wave amplitude).
2. Default for N_SWEEPS is 1 but can be overwritten in the PARAMS line.
3. Specifying SWRATE will override the EVTi entry in the vFTGSEQ by multiplying SWRATE * N_SWEEPS.
4. Each SINESW entry in the vFTGSEQ command will be converted into SINGSINE entries (internally within CF) that total N events (where, N=SWNUM+1). Each SINGSINE event will be given a new event number.

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
SINESW	601		10	2	20	4	LOG	10
SINESW	701		10	2	20	4	LOG	10
SINESW	801		10	2	20	4	LOG	10

3 SINESW events with each having 10 sweep bands (i.e. 11 individual sweep sinewaves). Below is an image of sine sweep.



Original vFTGSEQ Entry in Control File:

vFTGSEQ	JOBID	EVNTOUT	DURATION UNIT	MOS_DUR				
	$EVID_i$	EVT_i	$EVID_j$	EVT_j	$EVID_k$	EVT_k		

Revised vFTGSEQ Entry (done internally within CF):

vFTGSEQ	JOBID	EVNTOUT	DURATION UNIT	MOS_DUR				
	$EVID_i$	EVT_i	$EVID_{i*1000+1}$	$EVT_{i*1000+1}$	$EVID_{i*1000+2}$	$EVT_{i*1000+2}$	etc. to i*1000+N	

	$EVID_j$	EVT_j	$EVID_{j+1000+1}$	$EVT_{j+1000+1}$	$EVID_{i*1000+2}$	$EVT_{i*1000+2}$	etc. to j*1000+N	
	$EVID_k$	EVT_k	$EVID_{k+1000+1}$	$EVT_{k+1000+1}$	$EVID_{i*1000+2}$	$EVT_{i*1000+2}$	etc. to k*1000+N	

5. With N_SWEEPS=1, the durations of the derived events will be

First sine wave	= EVTi / (2*SWNUM)
Intermediate sine waves	= EVTi / (SWNUM)
Last sine wave	= EVTi / (2*SWNUM)

6. The following pairs of vFTGEVNT and SINGSINE entries will be created (SINGSINE entries for Ni frequencies from i=1,N).

vFTGEVNT	EVIDi	FLOAD1	FLOAD2	$SWLD_{j*1000+1}$					Sine wave 1
SINGSINE	$SWLD_{j*1000+1}$	LCID	f_1	g_1					
vFTGEVNT	EVIDi	FLOAD1	FLOAD2	$SWLD_{k*1000+i}$					Sine wave i
SINGSINE	$SWLD_{k*1000+i}$	LCID	f_i	g_i					
vFTGEVNT	EVIDi	FLOAD1	FLOAD2	$SWLDm_{*1000+N}$					Sine wave N
SINGSINE	$SWLD_{m*1000+N}$	LCID	f_N	g_N					

Where the sine amplitudes value for sinewave g_i is calculated using the values for g_1, g_2 and N as follows:

$$g_i = g_1 + \frac{(i-1)(g_2 - g_1)}{(N-1)}$$

The frequency value for sine wave “i” is calculated as follows:

For linear frequency axis:

$$f_i = f_1 + \frac{(i-1)(f_2 - f_1)}{(N-1)}$$

For logarithmic frequency axis:

$$f_i = 10^{\left[log(f_1) + \frac{(i-1)(log(f_2) - log(f_1))}{(N-1)}\right]}$$

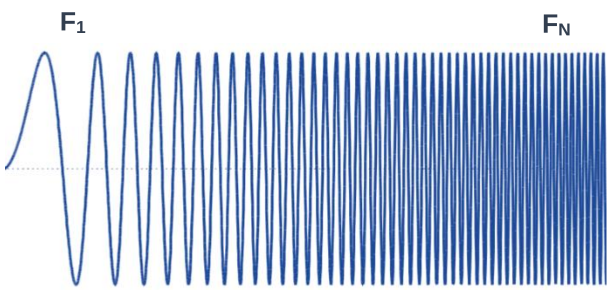
7. Conventional sine sweep specifications define the sweep rate and number of sweeps. These can be entered in the PARAMS line, or these can be manually converted by the User into a total duration "EVT$_i$" that is entered into the vFTGSEQ entry for the appropriate event. Conversion factors are given below.

Sweep Type	SWRATE = Rate (r) PER TIME_UNIT	Number of Sweeps (N_SWEEPS)	Time (T) (time_unit)
Linear	r (Hz / time_unit)	N	$(f_N\text{-}f_1)$*N/r
Decibel (logarithmic)	r (DB / time_unit)	N	$(\log(f_N)\text{-}\log(f_1))$*N/r
Octave (logarithmic)	r (Oct / time_unit)	N	3.3219*$(\log(f_N)\text{-}\log(f_1))$*N/r

Note that "time_unit" can be seconds, minutes, hours or days (as defined by DUR_UNITS in vFTGSEQ entry)

Log(x) is the log of x in base 10

F_1 and F_N are the first and last sine wave frequencies



8. It is assumed that the input sine sweep is in the same basic units as the random PSD (if one is specified). For example, if the input PSD is in G units (e.g. G^2/Hz) then the sine wave must also be specified in the same units, e.g. peak G. Also, sometimes the sine sweep will have changing units for different frequency bands. It may therefore be necessary to pre-convert the sine wave amplitude values before specifying on the sine sweep entry.

FRF Loading Units (FRF_UNIT)	Sine Sweep Loading Units (LD_UNIT)		
	Acceleration Amplitude (A)	Velocity Amplitude (V)	Displacement Amplitude (D)
Acceleration Amplitude (A)	**-**	**$2\pi f$. V**	**$(2\pi f)^2$. V**
Velocity Amplitude (V)	**$1/(2\pi f)$. A**	**-**	**$2\pi f$.D**
Displacement Amplitude (D)	**$1/(2\pi f)^2$. A**	**$1/(2\pi f)$. V**	

PART OF THE CONTROL FILE CREATED BY USER (COMMENTS ADDED FOR CLARITY BUT ARE NOT REQUIRED)

```
$ Applying event 101 for 100 seconds, event 201 for 200 seconds
$ and event 301 for 400 seconds.
vftgseq 777     0       seconds 1.0
        101     100     201     200     301     400
$ Defining each event by applying SINESW ID's 601, 701 and 801. As
$ well as ZEROPSD loads 401, 402 and 403 and STATIC load 420.
vftgevnt101     420     401     601
vftgevnt201     420     402     701
vftgevnt301     420     403     801
$ Defining ZEROPSD loads.
vftgload401     ZEROPSD 501     1.0
 1      "OP2_files/sinesweep2_center.op2"
vftgload402     ZEROPSD 502     1.0
 2      "OP2_files/sinesweep2_center.op2"
vftgload403     ZEROPSD 503     1.0
 3      "OP2_files/sinesweep2_center.op2"
$ Defining STATIC load.
vftgload420     STATIC          1.0
 1      "OP2_files/steady_101_center.op2"
$ Defining SINESW loads.
SINESW  601             10.00   2.00    20.00   4.00    LOG     10
SINESW  701             10.00   2.00    20.00   4.00    LOG     10
SINESW  801             10.00   2.00    20.00   4.00    LOG     10
```

Note that this example would be very similar even if a random PSD input was applied (a case of sine on random).

DERIVED INPUT – INTERNAL CONVERSION BY Cf FROM SINESW TO SINGSINE

```
vftgseq 777     0       seconds 1.0
        101001  5       101002  10      101003  10      101004  10
        101005  10      101006  10      101007  10      101008  10
        101009  10      101010  10      101011  5       201001  10
        201002  20      201003  20      201004  20      201005  20
        201006  20      201007  20      201008  20      201009  20
        201010  20      201011  10      301001  20      301002  40
        301003  40      301004  40      301005  40      301006  40
        301007  40      301008  40      301009  40      301010  40
        301011  20
vftgevnt101001  420     401     600001
vftgevnt101002  420     401     600002
vftgevnt101003  420     401     600003
vftgevnt101004  420     401     600004
vftgevnt101005  420     401     600005
vftgevnt101006  420     401     600006
vftgevnt101007  420     401     600007
vftgevnt101008  420     401     600008
vftgevnt101009  420     401     600009
vftgevnt101010  420     401     600010
vftgevnt101011  420     401     600011
vftgevnt201001  420     402     700001
vftgevnt201002  420     402     700002
vftgevnt201003  420     402     700003
vftgevnt201004  420     402     700004
vftgevnt201005  420     402     700005
vftgevnt201006  420     402     700006
vftgevnt201007  420     402     700007
```

```
vftgevnt201008  420     402     700008
vftgevnt201009  420     402     700009
vftgevnt201010  420     402     700010
vftgevnt201011  420     402     700011
vftgevnt301001  420     403     800001
vftgevnt301002  420     403     800002
vftgevnt301003  420     403     800003
vftgevnt301004  420     403     800004
vftgevnt301005  420     403     800005
vftgevnt301006  420     403     800006
vftgevnt301007  420     403     800007
vftgevnt301008  420     403     800008
vftgevnt301009  420     403     800009
vftgevnt301010  420     403     800010
vftgevnt301011  420     403     800011
vftgload401     ZEROPSD 501     1.0
 1       "OP2_files/sinesweep2_center.op2"
vftgload402     ZEROPSD 502     1.0
 2       "OP2_files/sinesweep2_center.op2"
vftgload403     ZEROPSD 503     1.0
 3       "OP2_files/sinesweep2_center.op2"
vftgload420     STATIC          1.0
 1       "OP2_files/steady_101_center.op2"
SINGSINE600001          10.00   2.0
SINGSINE600002          10.72   2.2
SINGSINE600003          11.49   2.4
SINGSINE600004          12.31   2.6
SINGSINE600005          13.20   2.8
SINGSINE600006          14.14   3.0
SINGSINE600007          15.16   3.2
SINGSINE600008          16.25   3.4
SINGSINE600009          17.41   3.6
SINGSINE600010          18.66   3.8
SINGSINE600011          20.00   4.0
SINGSINE700001          10.00   2.0
SINGSINE700002          10.72   2.2
SINGSINE700003          11.49   2.4
SINGSINE700004          12.31   2.6
SINGSINE700005          13.20   2.8
SINGSINE700006          14.14   3.0
SINGSINE700007          15.16   3.2
SINGSINE700008          16.25   3.4
SINGSINE700009          17.41   3.6
SINGSINE700010          18.66   3.8
SINGSINE700011          20.00   4.0
SINGSINE800001          10.00   2.0
SINGSINE800002          10.72   2.2
SINGSINE800003          11.49   2.4
SINGSINE800004          12.31   2.6
SINGSINE800005          13.20   2.8
SINGSINE800006          14.14   3.0
SINGSINE800007          15.16   3.2
SINGSINE800008          16.25   3.4
SINGSINE800009          17.41   3.6
SINGSINE800010          18.66   3.8
SINGSINE800011          20.00   4.0
```

6 | ENTRIES REQUIRED FOR – SUPPORTING FUNCTIONALITY

The following control file entries are optional and can be used to improve the efficiency of the analysis.

KTDATA – Local KT Material Property Data

Defines additional **Surface Treatment (KT)** parameters for stress scaling and offsets to be applied to element sets specified via ELSETS / FSET3 entries.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
KTDATA	SID	ELSET1	Scale1	Offset1	ELSET2	Scale2	Offset2	
	ELSET3	Scale3	Offset3	Continue ..				

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
KTDATA	777	10001	999	888				

Describer	Contents
JOBID	JOB ID used for entries vFTGSEQ vFTGPARM, vFTGDEF, FE_UNITS, KTDATA and INCLDIR entries. – Required, Integer>0, no default.
ELSIDi	ID of an FSET3 entry containing elements to be included in the random and/or fatigue analysis. – Required, Integer>0, no default. Note: Each ELSET / FSET3 specified must have a unique element list i.e., no overlap of element numbers between sets.
SCALEi	Factor used to scale the equivalent stresses for an element set. This additional scale factor is applied after all other scaling has occurred i.e., just before the fatigue calculation is started. – Required, Real, Default=1.0.
OFFSETi	Offset used to offset the equivalent stresses for an element set. This additional offset is applied after all other scaling has occurred i.e., just before the fatigue calculation is started. – Required, Real, Default=0.0.

Remarks:

none

FSET3 / SET – Element (and node) Set Definition

Defines a list of elements that can be used in conjunction with the ELSET field in the vFTGDEF entry to reduce the number of elements in the analysis. This is very useful when LOGLVL is set to 1 or 2. Also, defines a list of element and nodal information needed for a HEXA 3D seam weld analysis.

Note: SET can only be used for an element list whereas FSET3 can be used for both an element list and node list. Also, both can be entered in free format as shown below.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FSET3	ELSID	DES	ID1	ID2	ID3	ID4	ID5	ID6
	ID7	ID8	Etc.					

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FSET3	600	ELEM	11	12	THRU	16	20	25
FSET3	610	NODE	80000	THRU	90000			
SET	620	26	Thru	100				

Example in FREE FORMAT:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FSET3	600	ELEM	,11 ,12, thru ,26 ,2000 ,2100 ,2200 ,2300 ,2400 ,2500					
	,80000, thru, 90000, 100000000, thru, 999999999							
SET 620 = 26, 28, 30, thru, 100								

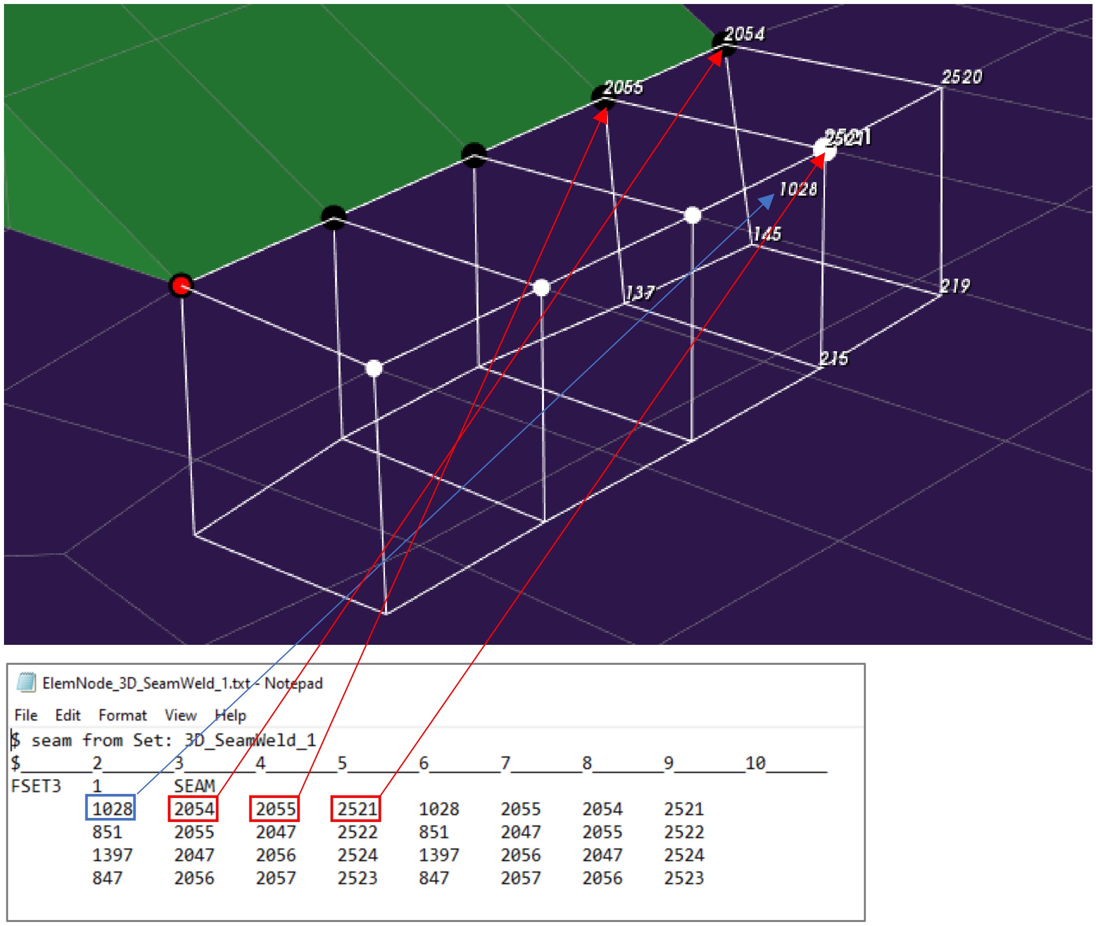
Format for HEXA 3D Seam Weld:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FSET3	SEAMID	DES	ELEMID1	NODEID1	NODEID2	NODEID3		
			ELEMID1	NODEID2	NODEID1	NODEID3		
			ELEMID2	NODEID1	NODEID2	NODEID3		
			ELEMID2	NODEID2	NODEID1	NODEID3		
			ELEMIDi	NODEIDi	NODEID2j	NODEIDk		

Example (see image below for further information):

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FSET3	500	SEAM	163	3055	3115	3114		
			163	3115	3055	3114		
			318	3115	2139	135		
			318	2139	3115	135		

Describer	Contents
ELSID	Unique identification number. Referenced by ELSET field. – Required, Integer>0, no default.
DES	Type of data in FSET3 listing. Options are “ELEM”, “NODE” or “SEAM” (for 3D seam weld). – Required, Character, no default.
IDi	Element or Grid ID (Node ID) number. The word “THRU” can be used to span a large number of elements or nodes. Example: Elements 12, 13, 14, 15 and 16 can be referenced as 12 THRU 16 as shown above. Free form entry is also supported, see Note 5 below. – Required, Character=THRU or Integer>0, no default.
SEAMID	Unique identification number of the FSET3. Referenced by vFTGDEF>SEAMW3dh field. – Required, Integer>0, no default.
ELEMIDi	Element ID along the toe of the 2D/3D or BS7608 seam weld. – Required, Integer>0, no default.
NODEIDx	2 Grid IDs (Node IDs) along the weld toe line and 1 Grid ID on the face of the parent material i.e., the first node ID represents first node on the weld toe line. The second node ID provides the direction of the weld toe line. The third node ID provides a face node on the parent material surface (i.e., not the weld toe line). – Required, Integer>0, no default.




```
$ seam from Set: 3D_SeamWeld_1
$_______2_______3_______4_______5_______6_______7_______8_______9_______10______
FSET3   1       SEAM
        1028    2054    2055    2521    1028    2055    2054    2521
        851     2055    2047    2522    851     2047    2055    2522
        1397    2047    2056    2524    1397    2056    2047    2524
        847     2056    2057    2523    847     2057    2056    2523
```

Above is an example of a **User Defined** FSET3 file format generated by the Fringe Plotter seam weld picking tool for a seam weld. The next elements along the seam weld toe line are 851, 1397 and 847, respectively.

Remarks:

1. On the first line, 6 ID's (in columns 4-9) are allowed and 6 IDs on further lines (in columns 2-8) are allowed until the required ID list is specified. The occurrence of a blank field in column 2 or a field in column 1 (i.e., a new entry is starting) signifies the end of the ID list.

1. The use of THRU (in any columns) is supported and signifies a list of IDs spanning (and including) the element / node numbers on either side of the THRU entry, i.e., 100 THRU 102 means 100, 101 and 102.

2. THRU may not appear in field 4 or 9 on the first row or columns 2 or 8 for continuation rows.

3. IMPORTANT: A node set <u>must</u> be created to use the vFTGDEF flags "ABSRESP" and "RELRESP" if these flags request D, V or A output, which can only be generated at the nodes. An element set can be created for S or F output, although setting LOGLVL=1 will automatically select all elements in the model. However, this may be more than what is needed and the use of ELSET / FSET3 may be wise to narrow the scope of the S or F output to a chosen set of elements.

4. In some instances, IDs are longer than 8 digits. In these cases, the FSET3 must be written using free format entries (i.e., comma separated values) like the example below. Every element / node ID in the list must be preceded by a comma (,) including the word THRU. Spaces can be added for readability and will be ignored by the program.

INCLDIR – Directory Location for "Includes"

Defines the location of "include" files.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
INCLDIR	JOBID	"address of directory for include files"						

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
INCLUDE	Materials/60_material.txt							

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
INCLDIR	JOBID	c:\test library\include directory						

Describer	Contents
JOBID	JOB ID used for entries vFTGSEQ vFTGPARM, vFTGDEF, FE_UNITS, KTDATA and INCLDIR entries. – Required, Integer>0, no default.
"address of directory for include files"	Address for location of "include" files. Example above overwrites local directory with "C:\test library\include directory". – Required, Character, Default=local directory.

Remarks:

1. Note that more than one INCLDIR entry can be specified, however, the last occurring entry will define the location for any specified include file.

INCLUDE – External Text File to be used for "Includes"

Points to a text file that has a number of control file entries already created. This is useful as a means to create, for example, a library of material property definitions or PSD loading definitions (via the vTABRND entry) that can easily be reused for future analyses.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
INCLUDE	"name of text file to be used in control file"							

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
INCLUDE	Materials/60_material.txt							

Describer	Contents
"name of text file to be used in control file"	This is the name of a separate file that can be used as an included file in the control file. This could be useful for, as an example, materials or loading data. This can be changed with the INCLDIR entry. – Required, Character, Default=local directory.

Remarks:

none

RESTART – Option to Request Restart from *.CFDATA* Binary Files

The RESTART entry allows the User to restart a job without having to reread the original stress values from the solver (i.e. eliminate First Pass in the Cf process). When using RESTART, the parameters applied in the original run for vIBFAT, FE_UNIT, vFTGPARM, and mapping entries are carried through into the restart files, CFDATA*, and can affect the original solver stresses depending on the parameters specified. These parameters cannot be changed for any subsequent runs using the RESTART entry. All other parameters are not carried through into the restart files and are available to change as desired in any subsequent run using the RESTART entry.

Example: if TSCALE is used in the vFTGSEQ entry for the original Cf analysis, then the effect of TSCALE is not carried into the restart files, CFDATA*, because parameters in vFTGSEQ can be modified by the User when doing any subsequent RESTART run. However, if FE_L_MAG is used in the FE_UNITS entry for the original Cf analysis, then the effect of FE_L_MAG on the original stresses is carried through into the restart files, CFDATA*, because parameters in FE_UNITS are required in the restart files.

The RESTART entry requests that a new analysis be started from the data captured in the filename.CFdata* binary files. This allows the user to change several parameters, like the input loading, and quickly complete a random response or damage calculation. However, as mentioned above, certain parameters cannot be change such as the equivalent stress (COMB) field in the vFTGPARM entry or the FE_L_MAG field in the FE_UNITS entry. See notes below for more detailed information on what can and cannot be changed.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
RESTART	Restart Filename							

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
RESTART	Job300							

Describer	**Contents**
Restart filename	Name of restart files. The extensions.CFVdata* will be added internally by CF, e.g., Job300 will become Job300.CFdata*. – Required, Character, no default.

Remarks:

1. The RESTART entry should be placed below the vIBFAT entry in the Cf Control File.
2. RESTART entry <u>will allow</u> the parameters in the following entries to be changed:
   - vFTGDEF, except field HOTSPOT
   - vMATFTG
   - vMATSTAT
   - All entries related to input loading setup including vFTGSEQ, vFTGEVNT, vFTGLOAD, vRANDPS, vTABRND, NBLOAD, DETLOAD, SINGSINE and SINSW.
   - All supporting entries including FSET3, INCLDIR, INCLUDE, PERTURB and FNOTCH.

3. RESTART will not allow the parameters in the following entries to be changed:
    - vIBFAT (except JOBNAME and OUTDIR)
    - OD2MAP, OP2MAPS, ODBMAP, ODBMAPS
    - FE_UNIT
    - vFTGPARM

Below is an example control file. The commands/fields highlighted cannot be alter prior to the use of RESTART. All other parameters can be changed.

```
$ TPL - Nastran PSD + static Loading
$ Loaded in X, Y and Z directions
$
vibfat  777     csv     nastran center  0       JOBNAME
       OPTIONS                                OUTDIR
$
RESTART JOBNAME
$
OP2MAP  OP2_files/beam_center.op2
        1       1
        2       2
        3       3
OP2MAPS OP2_files/steady_101_center.op2
        1       1
$
vftgdef 777     Dirlik  100     60
$
vmatftg 60      MPa     Range
        static  135     400     7.17E4
        table   60
vtabrnd 60      log     log
        1.0E15  121.10  2.0E11  121.10  7.19E9  150.00  1.86E7  220.00
        1.0E6   265.50  1.71E3  400.00  5.31E1  500.00  1.0E0   645.50
        endt
$
fe_units777     PSI     2.0
$
vftgparm777
        stress  sgvon   modgood
$
vftgseq 777     1       hours
        101     5       102     5       103     5
vftgevnt101     401     701
vftgload401     PSD     501     1.0
 1
vrandps 501     1       1       1.0     0.0     601
vtabrnd 601     LINEAR  LINEAR
        2.0     0.0001  10.0    0.0010  590.0   0.0010  600.1   0.0001
        endt
vftgevnt102     402     701
vftgload402     PSD     502     1.0
 2
```

```
vrandps 502     2       2       1.0     0.0     602
vtabrnd 602     LINEAR  LINEAR
        2.0     0.0001  10.0    0.0010  590.0   0.0010  600.1   0.0001
        endt
vftgevnt103     403     701
vftgload403     PSD     503     1.0
 3
vrandps 503     3       3       1.0     0.0     603
vtabrnd 603     LINEAR  LINEAR
        2.0     0.0001  10.0    0.0010  590.0   0.0010  600.1   0.0001
        endt
vftgload701     STATIC          1.0
 1
```

VECTOR – Option to Calculate Vector Direction Output from Single or Multiple Inputs

The VECTOR entry allows the User to specify a unique direction in which to calculate an output. This can be the X, Y or Z direction only or a vector combination of the 3. The VXCOMP, VYCOMP and VZCOMP values specify the amount of each direction is to be used in the vector formulation. The sum of the 3 components must equal 1.0. The User can also choose to allow Cf to calculate multiple vector outputs based on an angular increment. In this case, the values of VXCOMP, VYCOIMP and VZCOMP will be calculated by Cf and presented as a Vector plot. **The use of VECTOR is compatible with a Surrogate Loading calculation**.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
VECTOR	JOBID	VXCOMP	VYCOMP	VZCOMP	VINCR			

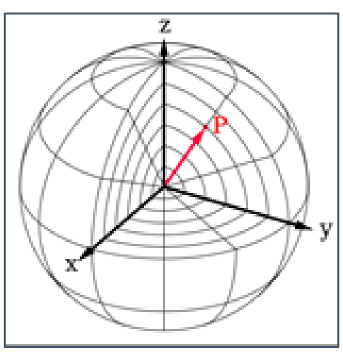
Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
VECTOR	777	1.0	0.0	0.0				

This example specifies a vector in the X direction ONLY.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
VECTOR	777	0.0	0.0	0.0	90			

Describer	Contents
JOBID	Unique ID with respect to all other vFTGSEQ, vFTGPARM, vFTGDEF and FE_UNITS entries. – Required, Integer>0, no default.
VXCOMP, VYCOMP, VZCOMP	Specific X, Y and Z components of the vector that will be used when computing the output for the specified direction. The total of all 3 must equal a value of 1.0, representing the X, Y and Z components that make up the magnitude P. – Required, 0.0 ≤ Real ≥ 1.0, no default.

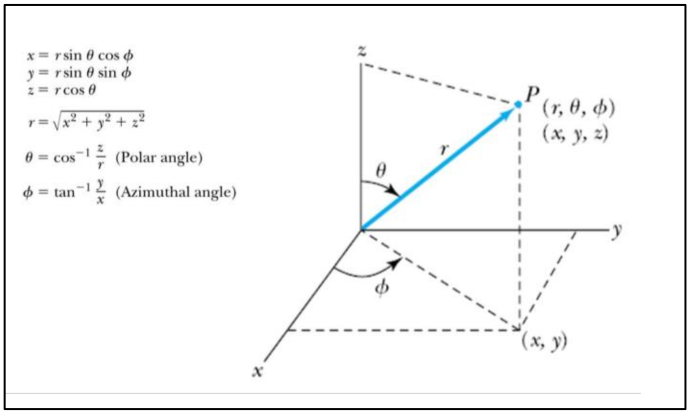


Example:

- 0.333 (33.3%) of X, 0.333 (33.3%) of Y and 0.333 (33.3%) of Z mean all 3 directions are used equally to define the vector direction.
- 0.10 (10.0%) of X, 0.10 (10.0%) of Y and 0.80 (80.0%) of Z means that the vector is mostly pointed in the Z direction.

VINCR	Number of angular increments to rotate through for calculating a number of vector outputs. If using this option, the vector calculation will be done repeatedly by rotating around the 2 angles used in specifying spherical coordinates: Θ and Φ. The vector calculation will be done in the Φ direction through a full 360 degrees, whereas it will be done in the Θ direction through 180 degrees. The number of degrees for each increment is 180° divided by VINCR. Example: if VINCR is set to 90, the incremental angle change between each vector calculation is 2° (180° / 90). – Required, Integer >0, no default NOTE: When using VINCR, the values of VXCOMP, VYCOMP and VZCOMP are ignored.

This example will evaluate several vector directions and provide the output in a Vector plot.



The output of using Vector is a plot of cylinders for every vector analysis. The color coding of the cylinders is based on the ***Quality of Fit (QoF),*** see formula below. A good result is between 0.5 and 2.0, which means the damage comparisons are out by a factor of 2.

$$Quality\ of\ Fit\ (QoF) = 1 - Average\ [\ |Ad\text{-}Td|\ /\ \max\ (Ad\text{-}Td)]$$

Where,
A_d is the achieved damage,
T_d is the target damage,

Remarks:

1. To use VECTOR, there must be 3 subcases supplied from the Solver representing X, Y and Z directions.
2. To use VECTOR, the User must also specify VECTOR for the LCID in the **vFTGLOAD** entry.
3. To use VECTOR, each **vRANDPS** must have the values for J and K set to 1 and 1, respectively.
4. To use VECTOR with VINCR field, the User must also specify the **PERTURB** entry with PTYPE set to VECTOR.

PERTURB – Option to Create Damage Increments for Incoming Load Changes

The PERTURB entry changes the output created by Cf after the analysis. The presence of this entry will suppress the creation of ***filename.csv*** and creates a new CSV output file called ***filenamePERTURB.csv*** that has a column containing Damage values a function of Element, Grid ID and Layer ID for the original random PSD values plus, other columns containing incremental changes to Damage as the original random PSD values are increased (perturbed) by the small amount defined in PTYPE. The incremental damage is calculated as follows.

$$\text{Damage increment} = \frac{d(dam_i)}{d(PSD_j)}$$

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
PERTURB	PTYPE	Value						

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
PERTURB	0	0.001						

Describer	Contents
PTYPE	Whether the perturbation should be relative (the amount of change is a scale applied to the local PSD value) or absolute (the amount of change is an absolute value). Options: 0 = Relative or 1 = Absolute. NOTE: This option must be set to VECTOR when using the VECTOR entry. – Required, Integer 0 or 1 or VECTOR, no default.
Value	Value of relative (or local) perturbation. 0.001 means that the PSD value is changed by 0.1%, So a PSD value of 0.001 becomes 0.001001. Value of absolute perturbation. 0.00001 means that a PSD value of 0.001 is changed to 0.00101. – Required, Real>0.0, no default.

Remarks:

none

FNOTCH – Option to Filter Out Section of the Transfer Function

This entry will allow the User to “scale” sections of the Transfer Function in order to evaluate the impact on the Response PSD and resulting output. Depending on the scale factor chosen, FNOTCH can be used to completely remove a section of the Transfer Function, if desired. NOTE: FNOTCH is applied like a loading and is therefore, referenced in the vFTGEVNT entry.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FNOTCH	FNID							
	LCIDi	fia	fib	SCALEi				

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FNOTCH	444							
	1	120.0	130.0	0.0				

The example above will filter out all transfer function points between (and including) 120 Hz and 130 Hz, i.e. all transfer function points between 120 Hz and 130 Hz are multiplied by 0.0.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FNOTCH	444							
	1	120.0	130.0	2.0				

The example above will multiply all transfer function points between (and including) 120 Hz and 130 Hz by 2.0: effectively scaling up this portion of the transfer function.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
FNOTCH	444							
	1	120.0		0.0				

The example above has omitted the upper frequency and scale=0.0. In this case, FNOTCH will filter out ALL frequencies above (and including) 120Hz. Essentially this acts as a low pass filter, allowing all frequencies below 120 Hz to pass through to the Response PSD calculation.

Describer	Contents
FNID	ID number to reference in vFTGEVNT entry. – Required, Integer>0, no default.
LCIDi	CF load case ID. Note: FNOTCH only works on a single LCID so an LCID must be specified even when dealing with a Multiple input analysis. – Required, Integer>0, no default.
fia	Starting frequency for the FNOTCH section filter. If a point in the Transfer Function exists at this frequency than this frequency will be included in the section. If not, the next point to

the right (a higher frequency) will be the starting frequency point included in the FNOTCH. – Required, Real≥0.0, no default.

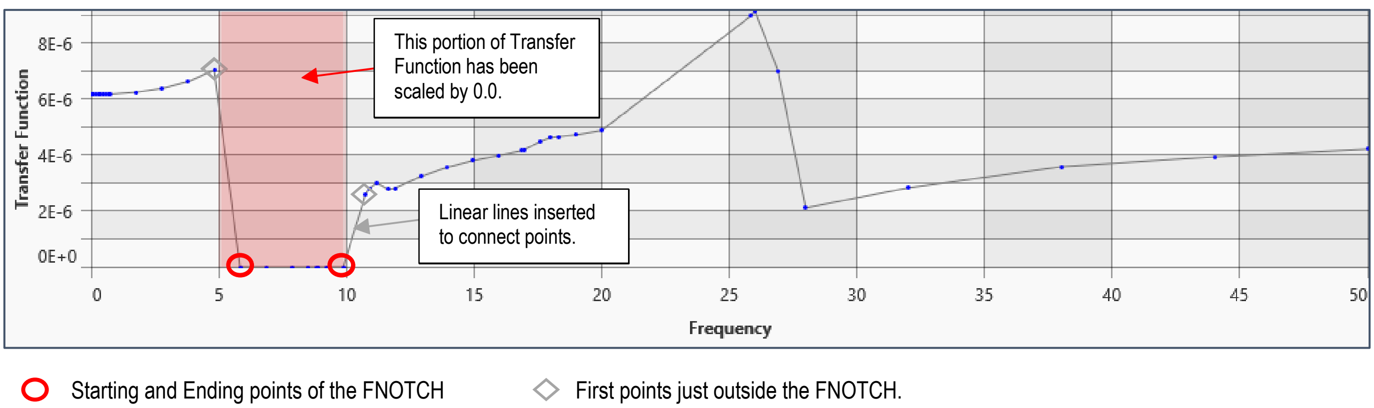
fib Ending frequency for the FNOTCH section filter. If a point in the Transfer Function exists at this frequency than this frequency will be included in the section. If not, the next point to the left (a lower frequency) will be the ending frequency point included in the FNOTCH. If left blank, it will select the highest FRF frequency point. – Required, Real>0.0, Default=highest FRF frequency.

SCALEi Multiplication scale factor to apply to the transfer function point in notch (i). ; i.e. multiply all transfer function points in the notch by 0.0. Effectively remove all of the signal. If SCALEi=2, this would multiple all transfer function points by 2. – Required, Real>0.0, Default=1.0.

Remarks:

1. NOTE: FNOTCH is only applied to frequency points that are in the transfer function, i.e. points that came from the FRF file.

Example of FNOTCH between 5.0 Hz and 10 Hz with scale set to 0.0.



CHSCALE – Required to Perform a Pseudo-Damage Analysis

This entry is required to perform a Pseudo-Damage analysis in the time domain.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CHSCALE	JOBID	SFID					STATUS	

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CHSCALE	777	60					CALIB	

Describer	Contents
SID	Unique ID which is referenced by the vFTGEVNT entry, FLOAD field. – Required, Integer>0, no default.
SFID	ID of a vTABRND entry that stores the damage scale factors to use in the analysis. – Required, Integer>0, no default.
STATUS	Defines what the scale factor values are used for. CALIB means the scale factors were generated after the Calibration analysis was completed, otherwise the field is left blank. – Required, Character, no default.

Remarks:

none

MEMORY – Setting the Max Memory that can be used in a TIME DOMAIN Analysis

This entry will set the maximum amount of memory that a Time Domain analysis can use. For very large Time Domain fatigue jobs, the User should consider setting the max memory to approximately 90% of the available memory. Hence for a device with 32 Gb of memory, the typical setting would be 29 Gb.

NOTE: MEMORY MUST BE ABOVE VIBFAT ENTRY IN THE CONTROL FILE.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
MEMORY	Mem_Cap							

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
MEMORY	29							

Describer	Contents
Mem_Cap	The maximum amount of memory in Gigabytes (Gb) that can be used in a Time Domain analysis. – Required, Real, no default.

Remarks:

none

PARALLEL – Setting the Max Number of Threads that can be used in the Analysis

This entry will set the maximum number of threads (logical processors) that fatigue analysis can use. For very large fatigue jobs, the User should consider setting the maximum threads to 1 less than available on the computer so that the computer is still responsive for other activities while the job is underway.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
PARALLEL	Th_Cap							

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
PARALLEL	7							

Describer	Contents
Th_Cap	The maximum number of threads (also called Logical Processors) that can be used in an analysis. – Required, Real, default (see note 1).

Remarks:

1. By default, PARALLEL will use the number of threads specified by the Windows Environment Variable OMP_NUM_THREADS. Otherwise, it will use the number of threads specified by TH_CAP.
2. This entry can only be used if the number of points, where damage is calculated, is greater than 1000.
3. The number of threads used by the Intel MKL is, by default, the same as the number of threads used by the software but the threads are not use simultaneously by MKL and the software. The "parallel n" command reduces/increases the number of threads used be Intel MKL to "n". However, if software stops using PARALLEL because the model has less than 1000 points than the Intel MKL will switch back to using the maximum number of threads permitted by the OMP_NUM_THREADS variable.

CUDA – Switch Off the use of a Graphics Card that Supports CUDA

This entry will allow a User to switch off the use of a graphics card that supports CUDA during an analysis. This might be useful in cases where the access to the CUDA graphics card is blocked as is the case for when one is working through a virtual machine.

NOTE: CUDA is automatically turned on unless this entry is used.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CUDA	Status							

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
CUDA	NO							

Describer	Contents
Status	The switch to turn off the use of CUDA. Only option is NO. – Required, Character, no default

Remarks:

1. CUDA is only used during a time domain fatigue analysis. It is only used for LQSTATIC and LMTRANS and is not used for LTRANS. It is also not used for the critical plane method (whether LQSTATIC, LMTRANS or LTRANS). If there is any problem during memory allocation CUDA is turned off automatically. Also, it is only used for the max/min portion of the computations and not for the damage computations.

PARAM – To Set Various Parameters

This entry will allow a User to switch on certain parameters.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
PARAM	NAME	SETTING						

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
PARAM	timeout	CSV						
PARAM	timestrn	no						

Describer	Contents
Name	Name of the parameter to set. – Required, Character, no default
Setting	Parameter value. - Required, Character, no default

Remarks:

1. The list of available parameters is below

Name	Setting	Description
TIMEOUT	CSV	This parameter overrides the default HDF5 output of the vFTGDEF> TIMEOUT entry and replaces it with a CSV output.
TIMESTRN	NO	This parameter overrides the default output setting for TIMEOUT and will give a “Stress Amplitude versus Time” plot for both EN and SN materials. Note: Current default is “Stress Amplitude versus Time” plot for SN material and “Strain Amplitude versus Time” plot for EN material.

OUTPUT – OUTPUT CONTROL PARAMETERS

This entry will allow a User to set certain output format.

Format:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
OUTPUT	“RESULT”	FORMAT						

Example:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
OUTPUT	RESULT	COMPACT						

Describer	Contents
“RESULT”	Flag indicating the control of csv results output.
FORMAT	Format of the csv output. Only option is COMPACT. – Required, Character, no default

Remarks:

1. When COMPACT output result is set, a much smaller csv file will be created. It only has the column of element, grid, layer, event, event name, damage of duty cycle, life in repeats. If critical plane/critical plane 3d then critical angle(s) is output. If FOS is done, then FOS is output. If multiaxial or spotweld or seamweld is done, then output columns specific to them are retained.

7 | INTRODUCTION TO TIME2PSD (CONVERTING A TIME HISTORY INTO A PSD)

TIME2PSD - Used to Create an Event PSD Matrices from Input Event Time History Data

TIME2PSD is a pre-processing step that is used prior to running CF. It requires a separate control deck, which is detailed below. TIME2PSD will allow the conversion of multiple time histories (i.e. channels) from a single event or multiple events (example: such as RPC road load data from a proving ground for automotive testing). An entire Duty Cycle made up of hundreds of time histories can be converted with TIME2PSD.The control file format below defines the parameters used for converting time history data to frequency domain data.

Any item in GREY is not yet supported.

Format:

DATA COLUMN 1	DATA COLUMN 2	DATA COLUMN 3	DATA COLUMN 4	DATA COLUMN 5	DATA COLUMN 6	DATA COLUMN 7	DATA COLUMN 8	DATA COLUMN 9
vIBFAT	JOBID				LOGLVL (0)	JOBNAME		
TIME2PSD	SRATE (1 for RPC or RSP format)	EVIDST	TABIDST	EVENT_N (1)	WINDOW (Hanning)	FORMAT (CSV)	MINF	MAX (the Nyquist Frequency)
	"FILEDIR"	TS_file_directory						
	"dcyfile"	DCY_filename						
	"MAPPING"	skip	CHAN_N	*T_UNITS (seconds)*	chan1	chan2	chan3	chan4
	chan5	chan6	chan7	chan8	chan9	chan10	chan11	cont
	"autoT"	T_Init (0.5)	K_PTS (100)	K_PCENT (2)	Level (50)	Method (5)		
	"autoD"	T_DEL (0.5)	RMS_FL (50.0)	HPFILT (1.0)				
	"Post"	Operation (Diagonal)	Type (if Scale)	Event	Channel			Scale (1.0)
	"Post"	Operation (Diagonal)	Type (if Envelope or Average)	Action (Scale)	Envelope Channel	*StartF*	*EndF*	Scale (1.0)
	"Post"	Operation (Target)	Type (if stress)	Event	Channel	Element	Node	Layer
	"Post"	Operation (Target)	Type (if acce)	Event	Channel	Node	Direction	
	"EV_OPTS"	EV_NUM	*NSI (1)*	*RMSI (1)*	*TSMOOT (1)*	*SF (1.0)*	T	δ (0.0)
	Load_Name							
	"SUBEV"	S1	S2	S3	S4	S5	S6	
		S7	S8	S0	S10	continue		

	T1	T2	T3	T4	T5	T6	T7	T8
	T9	T10	T11	T12	continue			

NOTE:

See vIBFAT entry for details regarding the first row. Note the following difference:

a. LOGLVL=0: Produces PSDM files with the following format "***load_name" _ "jobname or filename" _ "event number" _PSDM.txt***. This is the default value.

b. LOGLVL=1 or 2: Produces PSDM files mentioned above PLUS the files below. These files are needed if you wish to use the FFT PLOTTER to view results.

   i. ***_autoPSD_debug.txt*** files that provide XY data to plot Channel PSD data versus Frequency.

   ii. ***_time_data.txt*** files that provide XY data to plot Channel Time History data versus Time (for the original time histories).

   iii. ***_time_data_del.txt*** files that provide XY data to plot Channel Time History data versus Time (after DELETES has modified time histories).

   iv. ***_subev_time_data.txt*** files that provide XY data to plot Channel Time History data verse Time (after SUBEV has modified the time histories).

TIME2PSD can only be used as a pre-processing step. It must be run before the main fatigue (CF) job is executed if you wish to use the output from TIME2PSD in the Cf analysis.

Describer	Contents
SRATE	If using an RPC (RSP) file, SRATE will automatically be obtained from the file and this field will be ignored. If using an CSV file, the User must input the sampling rate (SRATE) of the time history. -- Required, Real>0.0, Default=1.0.
EVIDST	Start ID for SID field in vRANDPS entry for events. -- Required, Integer>0, no default.
TABIDST	Start ID for TID field in vTABRND entry for events. -- Required, Integer>0, no default.
EVENT_N	Number of time history event files. -- Required, Integer>0, Default=1.
WINDOW	Window function to use. Options are Hanning Window or no window. This is applied to the "block" of data extracted from the total time signal. -- Optional, Character, Default=Hanning.
FORMAT	Format of time signal files. Options are RPC or RSP for binary format road load data. CSV for text format. NOTE: the CSV file must only contain columns of Y data; although Header rows of text are allowed. -- Required, Character, Default=CSV.
MEANS	Legacy Field: Used to decide if means to be calculated (YES or NO). Ignored if no mean stress correction specified (optional – default = NO). MEANS will

automatically be writing. This cell will not be used by MINF field. Any value of YES or NO in this cell will be ignored.

MINF — Frequency below which the PSD data will be set to zero. Must be less than MAXF. – Optional, Real ≥ 0.0, Default=0.0.

MAXF — Max frequency in output (used to override the Nyquist frequency when outputting PSD data). This is useful when PSDM files are much larger than necessary due to frequency content in the time history that is well above the last FRF frequency of interest. This field has the effect of supressing the writing of all PSD and cross PSD frequencies above MAXF. Must be greater than MINF. – Optional, Real>0.0, Default = the Nyquist Frequency.

“**FILEDIR**” — Optional FLAG. Used to specify the directory where all input time history files are located and where output data files will be written when vIBFAT > LOGLVL=1.

TS_filedirectory — This should correspond to the name of the directory. – Required, Character, no default.

“**dcyfile**” — Optional FLAG. Name of the DCY file used to specify repeats of each event, the event names and order of events.

DCY_filename — This should correspond to the DCY filename. If no file exists, then the vFTGSEQ entry in the Cf analysis must be used to specify the time durations. – Optional, Character, no default.

“**MAPPING**” — Optional FLAG. Used to specify format and order of channel data. Required when not all channels are used from the RPC/RSP/CSV file.

skip — Number of header lines to skip in an CSV file. – Optional, Integer>0, no default.

CHAN_N — Number of channels in event file to use. Required if not all channels from RPC/RSP/CSV file are used in conversion. Otherwise, format is -- Optional, Integer>0, no default.

T_UNITS — Time units. Options are seconds, minutes, hours or days. – Optional, Character, Default=seconds.

chani — Location in asci input file for channel “i” of data. – Optional, Integer>0, no default.

“EV_OPTS” — Required FLAG. Event parameters are to follow (one set for each Event).

EV_NUM — Number of Event. First EV_NUM must equal EVIDST number and each consecutive EV_NUM must increase by 1. Example: EVIDST=55 so therefore, EV_NUM_1=55, EV_NUM_2=56, EV_NUM_3=57, etc. The number of EV_OPTS entries must match the number specified in EVENT_N. – Required, Integer>0, no default.

NSI — Number of non-stationary intervals for this Event. – Optional, Integer>0, Default=1.

RMSI — Number of rms scaling intervals for this Event. – Optional, Integer>0, Default=1.

TSMOOTH — Number of adjacent time points to be used for temporal smoothing of response PSD for this Event. – Optional, Integer>0, Default=1.

SF *Scale factor to apply to time signals in this Event before FFT. – Optional, Real>0.0, Default=1.0.*

T Length of FFT buffer window function in time for this Event. NOTE: if using AutoT, this field must be left blank otherwise this field will override AutoT. Otherwise, format is – Required, Real>0.0, no default.

δ Overlap or gap in time between windows for this Event. Positive value mean overlap. Negative value means gap. Value must be less than T. NOTE: if using AutoT, this field must be left blank otherwise this field will override AutoT. Otherwise, format is – Required, Real ≥ 0.0, Default=0.0.

Load_name Name of the input time history loading file used for this event (e.g. “load.rsp”). – Required, Character, no default.

“SUBEV” Optional FLAG indicating that a subevent will be created using the specified times S1, S2, etc. This entry must be placed below the Load_Name field of the Event of interest along with the T values (if used).

Si, Si+1 Used to separate time segments within an Event that become additional events in the analysis (defined by pairs of time values S1-S2, S3-S4, S5-S6, etc.). If needed, a continuation row start in column 3. – Required, Real>0.0, no defaults.

MANUAL DELETES

Ti, Ti+1 These entries are used to manually delete sections in an Event (or subevent) and are defined by pairs of time values t1-t2, t3-t4, t5-t6, t7-t8, etc. These portions of the Event are removed before the FFT process is applied.

The T1 value can be set to START if the User wishes to use the first point in the Event. The last value can be set to END if the User wishes the deleted section to span to the end of the Event.

These T values must be listed directly below the Load_Name to which it applies. IF SUBEV is being used, then SUBEV would be below the Load_Name entry first, followed by the Delete T values.

If needed, a continuation row start in column 2.

NOTE: if using AutoD, this field must be left blank otherwise this field will override AutoD. – Optional, Real>0.0 and Character=Start or END, no default.

Additional Automated Functions - AutoT, AutoD.

“**autoT**” Optional FLAG indicating that an automatic FFT buffer window length “T” will be calculated.

T_Init Initial value of the FFT window length in seconds. – Required, Real>0.0, Default=0.5.

K_PTS K_PTS are peak and valley points in the final converted PSD curve. A target value can be specified as a single value (example 200.0) or range (example 2,3) to use for calculation of K_PTS based on Methods 1 to 6 described below. If a single value is specified, then the range is determined using K_PCENT above and below the single value. Example: A target single value of 100.0 becomes a range of 98.0 to 102.0 if K_PCENT=2%. – Required, Integer>0, Default= 100.0 for all methods.

Note: when time signals have low sampling rates you may find that a lower K_PTS value/range may work better.

K_PCENT — Percentage used to define a range of K_PTS when only a single value is specified for K_PTS. – Required, Real>0.0, Default=2.0 (2%).

Level — Percentage of maximum PSD height (if Method=1 / 2) or the average PSD height (if Method=3 / 4) when evaluating K_PTS. Ignored for Method=5 and 6. – Required, Real>0.0, Default=50.0 (50%).

Method — The method to use when evaluating K_PTS. – Required, Integer=1 to 6, Default=5.

1 – Number of K_PTS above a line defined as a percentage (level) of the maximum height.

2 – As Method 1 but normalised by total number of points in PSD plot.

3 – As Method 1 but where the Level used is the PSD average defined as the sum of the PSD values divided by the total number of points in the PSD plot.

4 – As Method 3 but where the result calculated for K_PTS is normalised by the total number of points in the PSD plot.

5 – K_PTS is calculated as the number of peaks and valleys in the PSD plot.

6 – As Method 5 but where the result calculated for K_PTS is normalised by the total number of points in the PSD plot.

"autoD" — Optional FLAG indicating that automatic deletes based on signal intensity will be calculated. Note: TIME2PSD will look for Ti values FIRST to use for the manual deletion of time history segments from within an event. If Ti values are not present, the software will use AutoD to make automatic deletes within each event using the parameters defined for AutoD.

T_DEL — Value of window length in seconds used for deletes assessment. – Required, Real>0.0, Default=0.5.

RMS_FL — RMS level of window (of length T_DEL) as a percentage of raw signal event below which the window will be deleted, i.e. the small window of time signal being analyzed will be removed if its RMS is RMS_FL percent below the RMS of the raw signal. This assessment will be repeated in multiple runs through the signal until no part of the signal is less than RMS_FL percent of the overall raw signal RMS. – Required, Real>1.0, Default=50.0 (50%).

HPFILT — High pass filter value used to pre-filter the time data before deletes are assessed. Any data removed by the filter is restored before the FFT processing. – Required, Real>0.0, Default=1.0.

Entries for Bounding Diagonals or Target File Output

"**Post**" — Optional FLAG indicating that a Bounding Diagonals or Target File request has been made.

Operation	Type of operation to be carried out. Current options are Diagonal and Target. – Required, Character, no default.
Type	The type of action to be carried out. Options for Operation=Diagonal are Scale and Envelope, whereas options for Operation=Target are Stress and Acce. – Required, Character, no default.
Event	Event ID. – Required, Integer, no default.
Action	Action to be carried out. Only option is SCALE when using Operation=Diagonal and Type=Envelope or Average. Not applicable when Operation=Target. – Required, Character, no default.
Channel or Envelope Channel	Channel or Envelope Channel ID required when Operation=Diagonal and Type=Envelope or Average. Not applicable when Operation=Target. – Required, Integer, no default.
Element	Element ID that will be added as a reference in the output TXT file. Used only for Target>Stress selection. – Required, Integer, no default.
Node	Node ID that will be added as a reference in the output TXT file. Used only for Target>Acce selection. – Required, Integer, no default.
Layer	Layer ID that will be added as a reference in the output TXT file. Options are None, Lower and Upper. Used only for Target>Stress selection – Required, Character, no default.
Direction	Acceleration direction required when Operation=Target and Type=acce. Options are X, Y, Z, Mx, My and Mz. – Required, Character, no default.
Scale	Scale factor to apply. Used only for Operation=Diagonal – Required, Real>0.0, Default=1.0.

Remarks:

1. All events must be in the same format, use the same window function, have the same sample rate and number and order of channels.
2. Each event file can be a different length.
3. The number of event files “TS_filenameX” should correspond to the number of vFTGLOAD PSD entries.
4. If LOGLVL=1 or 2 is specified, the input time histories, conditioned time histories, subevent time histories (if used) and PSD data will be written to TXT files in the TS_file_directory.
5. When deleting portions of an Event time history, the TIME2PSD program will look for Ti values first and if not present, will look for the AutoD flag with associated parameters. If neither are present, TIME2PSD does not make any deletes to the Event time history.
6. When deleting portions of a SubEvent time history, the TIME2PSD program will look for Ti values first and if not present, will look for the AutoD flag with associated parameters. If neither are present, TIME2PSD does not make any deletes to the SubEvent time history.

Example of an automotive testing Duty Cycle with 6 events containing 4 channels (time signals) per event:

Duty Cycle:

Event	Name	Description	Time Duration of Event
1	ea10	Empty Abbreviated Belgian Block at 10 mph	152.0 seconds
2	egvl	Empty Gravel Road	42.0 seconds
3	er20	Empty Railroad Crossing at 20 mph	18.0 seconds
4	la10	Loaded Abbreviated Belgian Block at 10 mph	480.0 seconds
5	lgvl	Loaded Gravel Road	130.0 seconds
6	lr20	Loaded Railroad Crossing at 20 mph	20.0 seconds

Each EVENT contains 4 channels (time histories) that were recorded during each event.

Example for Event 1:

Channel	Location	Duration	View of Time History
1	Left Front Z	152.0 seconds	
2	Right Front Z	152.0 seconds	
3	Left Rear Z	152.0 seconds	
4	Right Rear Z	152.0 seconds	

Each EVENT is read into TIME2PSD and converted into a PSD matrix of real and imaginary (direct and cross PSD) information

Example for Event 1:

Direct PSD 1-1	Cross PSD 1-2	Cross PSD 1-3	Cross PSD 1-4
Cross PSD 1-2	Direct PSD 2-2	Cross PSD 2-3	Cross PSD 2-4
Cross PSD 1-3	Cross PSD 2-3	Direct PSD 3-3	Cross PSD 3-4
Cross PSD 1-4	Cross PSD 2-4	Cross PSD 3-4	Direct PSD 4-4

TIME2PSD output file will be called:

loading_jobname_event_PSDM.txt
Example: ea10_job1_EV1_PSDM.txt

Direct PSD with only real portion.

Cross PSD – real portion of complex PSD

Cross PSD – imaginary portion of complex PSD

OUTPUT FILE FORMAT

For each event the following information is contained in the PSD Matrix output file. As mentioned previously, the 4 time histories in each event (i.e., 4 subcases in the solver) will result in a 4x4 matrix.

Refer to the vRANDPS and vTABRND entries in this guide for information about the various parameters noted below.

Table 90001
PSD_{11} (real)

vRANDPS	SID	1	1	1.0	0.0	TID			
vTABRND	TID	XAXIS	YAXIS						
f1	g1	f2	g2	f3	g3	f4	g4		
f5	g5	f6	g6	endt					

Table 90002
$CPSD_{12}$ (real)

vRANDPS	SID	1	2	1.0	0.0	TID			
vTABRND	TID	XAXIS	YAXIS						
f1	g1	f2	g2	f3	g3	f4	g4		
f5	g5	f6	g6	endt					

Table 90003
$CPSD_{12}$ (imag)

vRANDPS	SID	1	2	0.0	1.0	TID			
vTABRND	TID	XAXIS	YAXIS						
f1	g1	f2	g2	f3	g3	f4	g4		
f5	g5	f6	g6	endt					

Table 90004
$CPSD_{13}$ (real)

vRANDPS	SID	1	3	1.0	0.0	TID			
vTABRND	TID	XAXIS	YAXIS						
f1	g1	f2	g2	f3	g3	f4	g4		
f5	g5	f6	g6	endt					

Table 90005
$CPSD_{13}$ (imag)

vRANDPS	SID	1	3	0.0	1.0	TID			
vTABRND	TID	XAXIS	YAXIS						
f1	g1	f2	g2	f3	g3	f4	g4		
f5	g5	f6	g6	endt					

Repeated for 1,4 (real & imag) then 2,1(real & imag) then 2,2 (real) … up to 4,4 (real) with TID = 90016

Table 90016
PSD_{44} (real)

vRANDPS	SID	4	4	1.0	0.0	TID			
vTABRND	TID	XAXIS	YAXIS						
f1	g1	f2	g2	f3	g3	f4	g4		
f5	g5	f6	g6	endt					

The MEANs are also written at the end of each Event block, where LCID is the ID of the event and g1 is the mean value.

MEANLDS	SID	$LCID_1$	g_1	$LCID_2$	g_2	$LCID_3$	g_3	
	$LCID_4$	g_4						

The MEAN offset values are important to know because TIME2PSD removes the mean offset from each event before processing the PSD Matrix. If the mean values are significant, the User should rerun the solver analysis and add a static stress field for each event using the MEANLDS values provided in the PSDM files. This STATIC load should then be added to the Cf run as an additional load using vFTGLOAD with Type=STATIC.

Below is an example of a PSDM file (Event1_EV1_PSDM.txt used in TPL85 - see User Guide).

```
RANDPS         1        1        1   1.0    0.0      90001
TABRND1    90001  LINEAR  LINEAR
, 0.0000E+00, 0.00000000E+00, 4.0960E+00, 0.00000000E+00, 8.1920E+00, 5.19477256E-04, 1.2288E+01, 1.80753005E-03
, 1.6384E+01, 1.88816080E-03, 2.0480E+01, 1.26649212E-03, 2.4576E+01, 8.45384013E-04, 2.8672E+01, 4.74157329E-04
, 3.2768E+01, 2.95051024E-04, 3.6864E+01, 2.84398916E-04, 4.0960E+01, 4.21242774E-04, 4.5056E+01, 5.00282997E-04
, 4.9152E+01, 2.57082378E-04, 5.3248E+01, 1.72063273E-04, 5.7344E+01, 1.47104813E-04, 6.1440E+01, 8.10068563E-05
, 6.5536E+01, 5.61132733E-05, 6.9632E+01, 4.47835291E-05, 7.3728E+01, 2.43660378E-05, 7.7824E+01, 1.48725782E-05
, 8.1920E+01, 5.03707684E-06, 8.6016E+01, 3.00188149E-07, 9.0112E+01, 0.00000000E+00,ENDT
RANDPS         1        2        2   1.0    0.0      90002
TABRND1    90002  LINEAR  LINEAR
, 0.0000E+00, 0.00000000E+00, 4.0960E+00, 0.00000000E+00, 8.1920E+00, 1.76679603E-04, 1.2288E+01, 7.25226862E-04
, 1.6384E+01, 9.54473298E-04, 2.0480E+01, 7.07657790E-04, 2.4576E+01, 3.24881115E-04, 2.8672E+01, 1.35855127E-04
, 3.2768E+01, 1.57480244E-04, 3.6864E+01, 1.53685204E-04, 4.0960E+01, 9.15122935E-05, 4.5056E+01, 6.64721897E-05
, 4.9152E+01, 7.68537707E-05, 5.3248E+01, 1.54987918E-04, 5.7344E+01, 2.10522963E-04, 6.1440E+01, 2.45639473E-04
, 6.5536E+01, 2.28412738E-04, 6.9632E+01, 1.71041015E-04, 7.3728E+01, 1.22774565E-04, 7.7824E+01, 5.77716769E-05
, 8.1920E+01, 1.29941491E-05, 8.6016E+01, 6.00212530E-07, 9.0112E+01, 0.00000000E+00,ENDT
RANDPS         1        3        3   1.0    0.0      90003
TABRND1    90003  LINEAR  LINEAR
, 0.0000E+00, 0.00000000E+00, 4.0960E+00, 0.00000000E+00, 8.1920E+00, 1.57374454E-03, 1.2288E+01, 2.37469150E-03
, 1.6384E+01, 2.45451606E-03, 2.0480E+01, 1.55653609E-03, 2.4576E+01, 6.96304831E-04, 2.8672E+01, 4.87261584E-04
, 3.2768E+01, 3.72684195E-04, 3.6864E+01, 4.42056156E-04, 4.0960E+01, 3.82056743E-04, 4.5056E+01, 2.92174567E-04
, 4.9152E+01, 2.80007472E-04, 5.3248E+01, 2.89328385E-04, 5.7344E+01, 8.22476928E-04, 6.1440E+01, 1.03550576E-03
, 6.5536E+01, 8.82737892E-04, 6.9632E+01, 6.74390867E-04, 7.3728E+01, 3.36868889E-04, 7.7824E+01, 1.58128757E-04
, 8.1920E+01, 5.26738500E-05, 8.6016E+01, 3.37857967E-06, 9.0112E+01, 0.00000000E+00,ENDT
RANDPS         1        1        2   1.0    0.0      90004
TABRND1    90004  LINEAR  LINEAR
, 0.0000E+00, 0.00000000E+00, 4.0960E+00, 0.00000000E+00, 8.1920E+00,-6.63764793E-05, 1.2288E+01,-2.21557390E-04
, 1.6384E+01,-1.13978075E-04, 2.0480E+01,-2.78923328E-05, 2.4576E+01,-1.89517189E-05, 2.8672E+01,-8.21278932E-06
, 3.2768E+01,-5.12276987E-05, 3.6864E+01,-4.71544110E-05, 4.0960E+01,-2.47018408E-05, 4.5056E+01,-2.61851235E-05
, 4.9152E+01,-2.11968436E-05, 5.3248E+01,-4.30313705E-05, 5.7344E+01,-4.90499826E-05, 6.1440E+01,-5.19507998E-05
, 6.5536E+01,-5.89852639E-05, 6.9632E+01,-4.19092599E-05, 7.3728E+01,-2.30046115E-05, 7.7824E+01,-7.59186943E-06
, 8.1920E+01,-1.44310050E-06, 8.6016E+01,-5.12954074E-08, 9.0112E+01, 0.00000000E+00, ENDT
RANDPS         1        1        2   0.0    1.0      90005
TABRND1    90005  LINEAR  LINEAR
, 0.0000E+00, 0.00000000E+00, 4.0960E+00, 0.00000000E+00, 8.1920E+00,-3.44335714E-05, 1.2288E+01,-1.58017636E-04
, 1.6384E+01,-1.02503005E-04, 2.0480E+01,-9.87119341E-05, 2.4576E+01,-1.57712403E-05, 2.8672E+01, 5.53782166E-05
, 3.2768E+01, 5.40370955E-05, 3.6864E+01, 2.51319312E-05, 4.0960E+01, 2.00896263E-05, 4.5056E+01, 4.73679054E-05
, 4.9152E+01, 4.13345353E-05, 5.3248E+01, 3.85334446E-05, 5.7344E+01, 4.16369703E-06, 6.1440E+01,-1.24975294E-05
, 6.5536E+01,-2.01197205E-05, 6.9632E+01,-2.49822015E-05, 7.3728E+01,-1.93625194E-05, 7.7824E+01,-8.07448980E-06
, 8.1920E+01,-8.46264660E-07, 8.6016E+01,-3.01127297E-08, 9.0112E+01, 0.00000000E+00, ENDT
RANDPS         1        1        3   1.0    0.0      90006
TABRND1    90006  LINEAR  LINEAR
, 0.0000E+00, 0.00000000E+00, 4.0960E+00, 0.00000000E+00, 8.1920E+00, 2.78555689E-04, 1.2288E+01, 4.14131373E-04
, 1.6384E+01, 9.27174742E-05, 2.0480E+01,-3.38593660E-04, 2.4576E+01,-2.54989482E-04, 2.8672E+01,-1.80130098E-04
, 3.2768E+01,-6.97964194E-05, 3.6864E+01,-1.15118801E-05, 4.0960E+01, 1.72130877E-05, 4.5056E+01, 9.32398380E-05
, 4.9152E+01, 5.13702175E-05, 5.3248E+01, 5.83138750E-05, 5.7344E+01, 9.38465940E-05, 6.1440E+01, 6.32184065E-05
, 6.5536E+01, 3.31679801E-05, 6.9632E+01, 2.30537147E-05, 7.3728E+01, 1.61324518E-05, 7.7824E+01,-6.20741639E-07
, 8.1920E+01,-3.04028293E-06, 8.6016E+01,-3.27234663E-07, 9.0112E+01, 0.00000000E+00, ENDT
RANDPS         1        1        3   0.0    1.0      90007
TABRND1    90007  LINEAR  LINEAR
, 0.0000E+00, 0.00000000E+00, 4.0960E+00, 0.00000000E+00, 8.1920E+00,-3.83645601E-04, 1.2288E+01,-4.17860541E-04
, 1.6384E+01, 2.68320954E-04, 2.0480E+01, 4.00909086E-04, 2.4576E+01, 3.65937127E-04, 2.8672E+01, 2.87004067E-04
, 3.2768E+01, 1.75229374E-04, 3.6864E+01,-4.26881688E-05, 4.0960E+01,-1.16548883E-04, 4.5056E+01,-1.54358407E-05
, 4.9152E+01, 1.44178726E-05, 5.3248E+01, 3.92043166E-05, 5.7344E+01, 3.70360549E-05, 6.1440E+01, 1.48751304E-05
, 6.5536E+01,-3.45699293E-05, 6.9632E+01,-3.80279272E-05, 7.3728E+01,-1.22199594E-06, 7.7824E+01, 6.21209507E-06
, 8.1920E+01, 1.06414635E-06, 8.6016E+01,-1.11251903E-07, 9.0112E+01, 0.00000000E+00, ENDT
RANDPS         1        2        3   1.0    0.0      90008
TABRND1    90008  LINEAR  LINEAR
, 0.0000E+00, 0.00000000E+00, 4.0960E+00, 0.00000000E+00, 8.1920E+00, 1.27664459E-04, 1.2288E+01, 4.27888243E-04
, 1.6384E+01, 3.89613372E-04, 2.0480E+01, 2.50868112E-04, 2.4576E+01, 8.52211953E-05, 2.8672E+01, 2.36739243E-05
, 3.2768E+01, 1.09637446E-05, 3.6864E+01,-3.11944156E-06, 4.0960E+01, 4.92058721E-05, 4.5056E+01, 1.21487317E-05
, 4.9152E+01,-2.03234308E-05, 5.3248E+01,-6.07454891E-05, 5.7344E+01,-1.52622999E-04, 6.1440E+01,-1.67327554E-04
, 6.5536E+01,-6.76462877E-05, 6.9632E+01,-6.09512545E-05, 7.3728E+01,-6.76122743E-05, 7.7824E+01,-1.12931552E-05
, 8.1920E+01, 1.22611949E-06, 8.6016E+01, 1.19388425E-07, 9.0112E+01, 0.00000000E+00, ENDT
RANDPS         1        2        3   0.0    1.0      90009
TABRND1    90009  LINEAR  LINEAR
, 0.0000E+00, 0.00000000E+00, 4.0960E+00, 0.00000000E+00, 8.1920E+00, 6.34450485E-05, 1.2288E+01,-2.05755982E-04
, 1.6384E+01,-4.78361964E-04, 2.0480E+01,-3.60702620E-04, 2.4576E+01, 6.91371920E-06, 2.8672E+01, 8.05874579E-05
, 3.2768E+01, 1.79522758E-05, 3.6864E+01, 4.56657113E-05, 4.0960E+01, 4.21476722E-05, 4.5056E+01, 3.16854504E-05
, 4.9152E+01, 2.83924827E-05, 5.3248E+01, 2.01210044E-05, 5.7344E+01, 2.14461540E-04, 6.1440E+01, 3.43397769E-04
, 6.5536E+01, 3.39146566E-04, 6.9632E+01, 2.38572514E-04, 7.3728E+01, 1.09906030E-04, 7.7824E+01, 2.18374104E-05
, 8.1920E+01,-3.32642282E-06, 8.6016E+01,-2.36489771E-07, 9.0112E+01, 0.00000000E+00, ENDT
$MEANLDS         1    1   5.01683483E-03    2  -3.00918291E-02    3   6.96196435E-03

VRANDT         1  11.104
```

The PSDM file contains the definition of all direct and cross PSDs generated from the time signal to PSD conversion process.

The PSDM file uses the fields RANDPS and TABRND1. This is a legacy naming convention which is acceptable to use. The new convention is vRANDPS and vTABRND.

MEANLDS is an output that provides the MEAN offsets for each channel in the loading file. In this case, there are 3 channels, and each have a very small mean offset. However, if the offsets were significant, the User should use these offsets in a separate linear static superposition analysis and add the additional mean stresses to the fatigue analysis in CAEfatigue.

NOTE: This can also be done using a **UNITY** load in Nastran and the feature **MEANLDS** in CAEfatigue.

VRANDT is the duration of the conditioned time history, which is passed through to the fatigue analysis and used as a duration of a "repeat" in the sequency (vFTGSEQ) entry.

Using a different example, below is the MEANLDS output for Event 1 PSDM file that contains 66 output channels, and most channels have a significant mean offset. These mean loads can be brought into the Cf analysis as scale factors on static loads using the entry **MEANLDS** (must also do a unit load SOL101 analysis) or these mean offsets are brought directly into a separate SOL101 analysis to calculate the additional mean stress that is added to the fatigue calculation.

See **TPL57_ACTUAL** and **TPL57_UNITY** for examples of how this done within Nastran and CAEfatigue.

.

USE OF MEANS FOR MEAN STRESS CORRECTION (ONLY APPLICABLE TO FORCE INPUTS – NOT APPLICABLE TO ACCELERATION INPUTS)

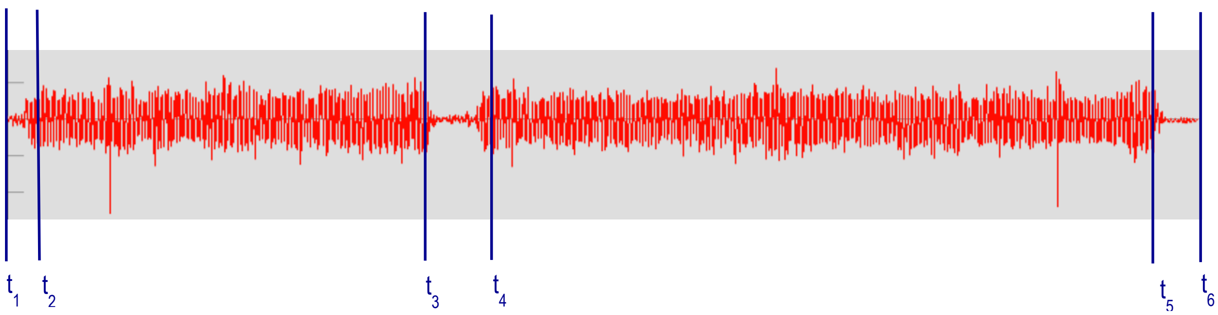
The stress at any GID (used for mean stress correction) is then:

$$\left[\sum_{i=1}^{no\ subcases} FRF(at\ 0Hz)_i * g_i\right] + static\ stress\ (if\ specified)$$

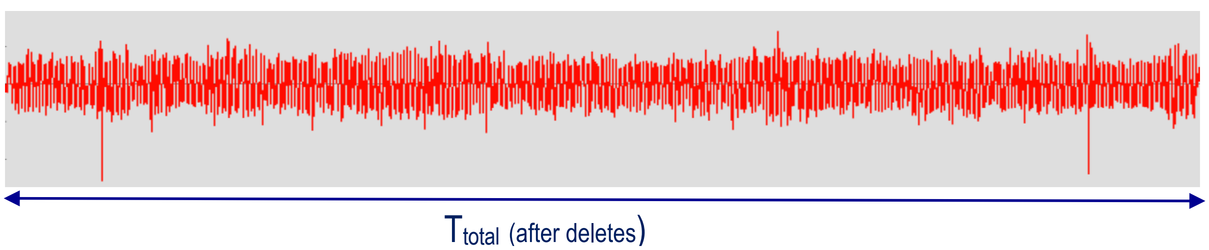
And this should be converted to the appropriate equivalent stress, e.g., von-Mises, before being used in the mean stress calculation.

WHAT ARE DELETES?

It is very common to have parts of a time history that do not contribute to the damage. The example below shows “dead” spots in the time history where no input activity was captured while the data acquisition was underway. These dead spots artificially increase the duration of the time history and should be removed from the signal to accurately convert the time history to a PSD and still get the same damage from both methods. This step is <u>crucial</u> to getting similar damage results from time to frequency domain.

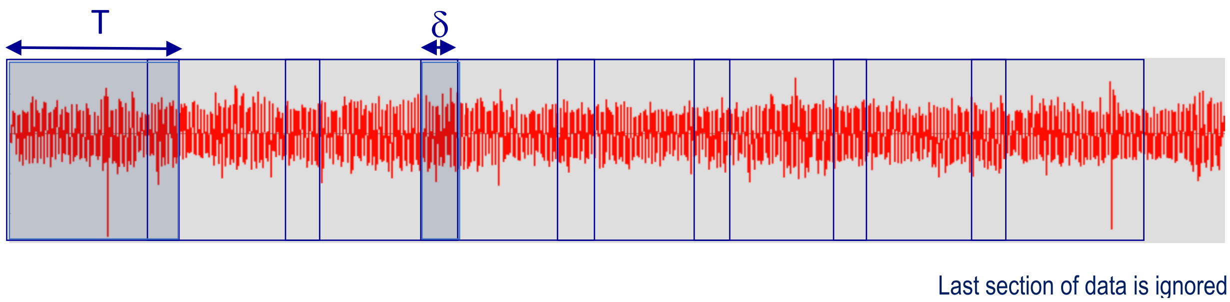


Removing the dead spots results in the following adjusted time signal with a new time signal duration**.**

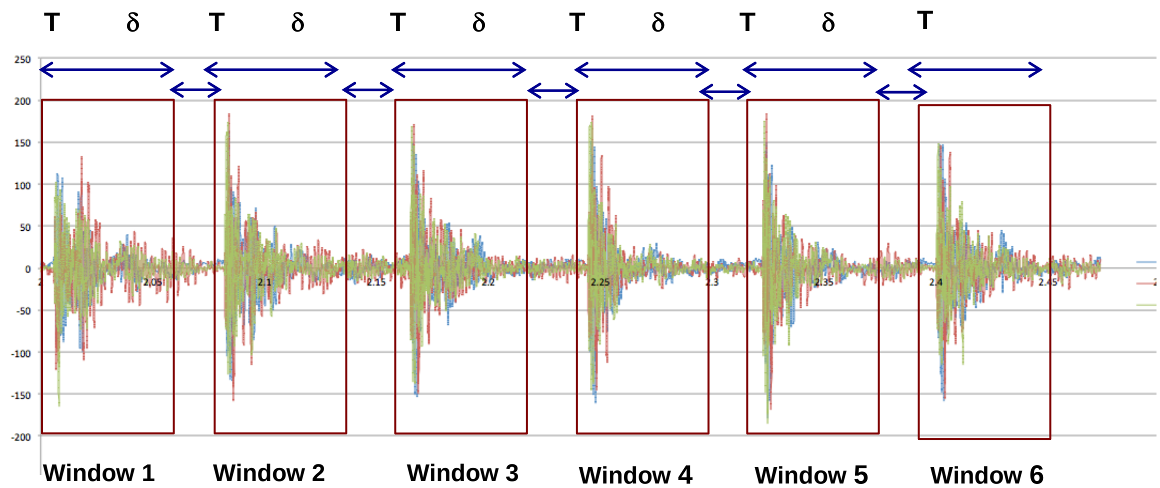


WHAT IS WINDOW LENGTH AND OVERLAP (GAP)?

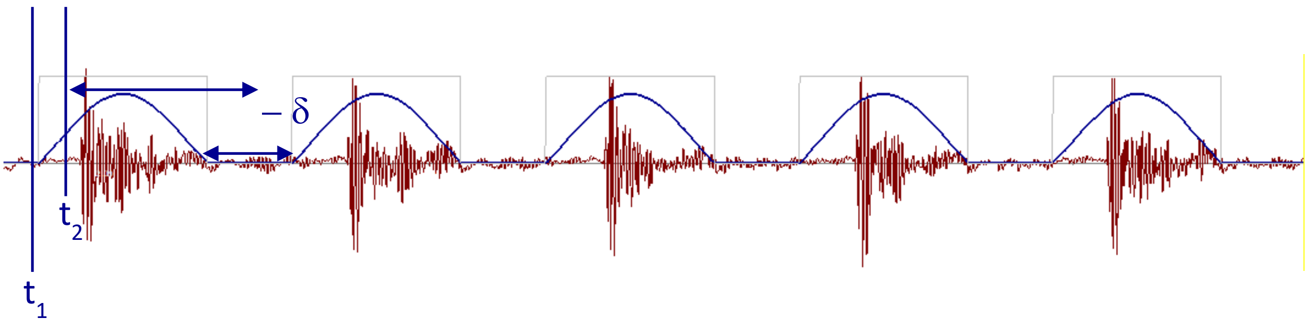
Converting a time signal to a PSD requires a Fast Fourier Transform calculation. This calculation separates the time signal into “windows” with a particular shape (Window field in control file), length (T), and overlap (δ) as part of the calculation. Below is an example showing use of T (window length) with positive δ (overlap).



Alternative example with negative δ (gap) with no window shape (window=none) and size T. This is a typical SAE575 example.



Alternative example with negative δ (gap) with a Hanning window shape (window=Hanning) and size T. This is a typical SAE575 example.



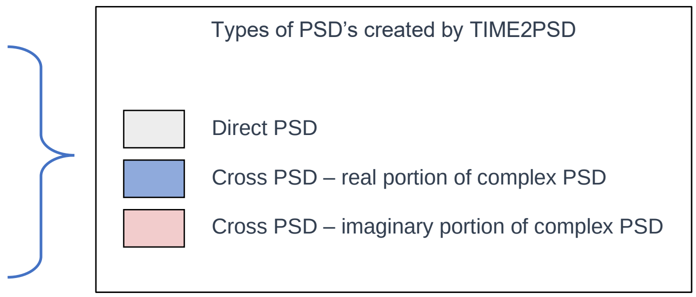
TIME2PSD – Viewing Output using PSDM Plotter and the FFT Plotter

The output generated by using TIME2PSD can be viewed with two features within CFG. The PSDM Plotter and the FFT Plotter. Below are images taken from TPL85 in the Cf User Guide.

PSDM PLOTTER

The PSDM Plotter provides the User with a view of the Direct PSDs as well as the real portion and imaginary portion of the Cross PSDs. The Direct PSD plot is identical to the plot that will be seen using the PSD Plotter and selecting an individual Direct PSD along the diagonal box shown below.

Direct PSD 1-1	Cross PSD 1-2	Cross PSD 1-3
Cross PSD 1-2	Direct PSD 2-2	Cross PSD 2-3
Cross PSD 1-3	Cross PSD 2-3	Direct PSD 3-3



PSDM Plotter Example Image (TPL85 – Event 1)

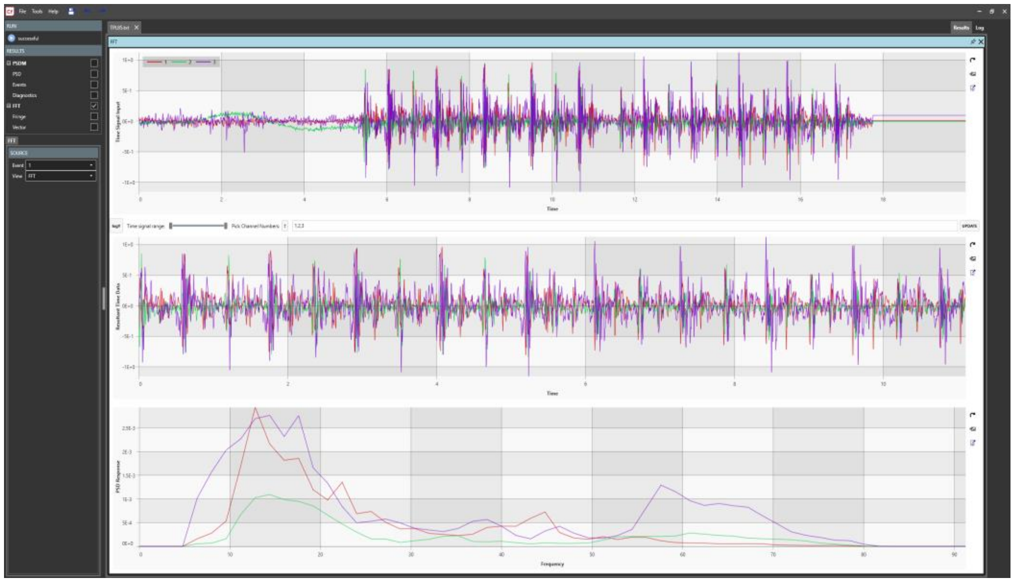
FFT Plotter

The FFT Plotter provides the User with a detailed view of the Time History files (both original file and modified file) as well as the Direct PSDs that were created during the Time History to PSD conversion. The image below provides a view of the original Time History, the modified Time History after portions of the original Time History are removed and the final Direct PSDs. Note: the portions of the original Time History that are removed do not have any significant impact on the damage calculation.

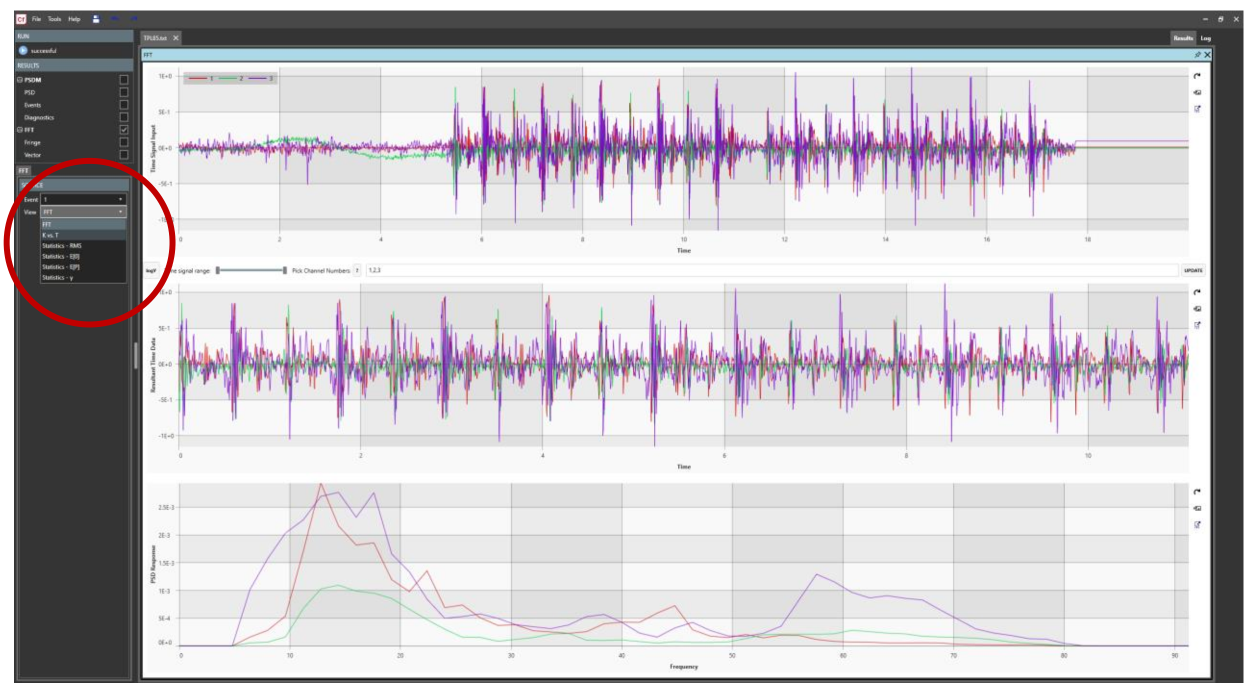
Original Time History
Including dead spots at
beginning and end of signal

MODIFIED Time History
dead spots at beginning and
end of signal are removed

Direct PSDs
Created from modified
Time Histories



The FFT Plotter also provides the User with an option to view additional output including a K vs. T plot as well as Statistical plots for RMS, E[0], E[P], and Irregularity Factory (γ).

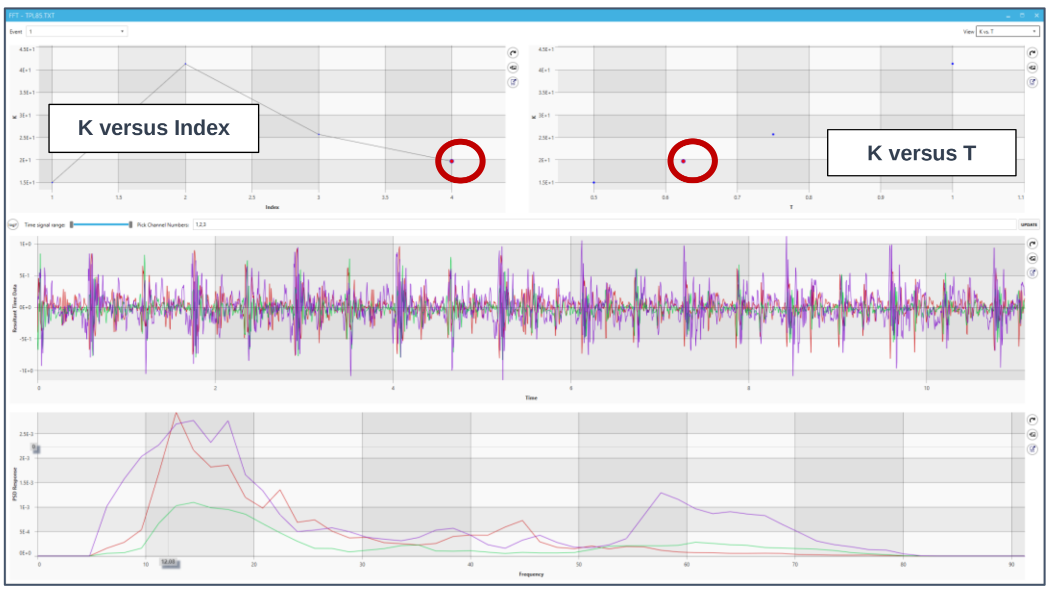


K Value and **T Value**

The “AutoT” function***** is an automated function that calculates a suitable FFT window length needed to convert the time history to a PSD. K (actually, K_PTS) and T are specific parameters specified within the AutoT function that are used by TIME2PSD to repeatedly evaluate the FFT window length until the K and T parameters are satisfied.

The “K” versus “Index” plot (left side) shows the evaluation of the K parameter over multiple iterations (called indexes). In the image below, the first calculated K value (Index=1), results in a value of 15, which did not satisfy the K value thresholds specified in the TIME2PSD control file (for this example the K value required is 20 (+/- 2%) using Method=5). The second K value (Index=2), was calculated at 42 which was also unsuccessful. The final K value (Index=4), was calculated at 20 and was successful at satisfying the threshold values specified in the control file. This index point is identified with a RED DOT to indicate that this is the final K value used for the FFT window length (T) calculation.

The “K” versus “T” plot (right side) shows the evaluation T as the K value is calculated. As discussed, “K” versus “Index” plot, there were 4 calculations of K value in the TIME2PSD analysis. The successful K value of 20 resulted in an FFT window length (T) of 0.63.



* AutoT will automatically calculate the best FFT window length (buffer length) through an automated, reiterative process based on a series of User specified parameters.

Statistics Views (RMS, E[O], E[P], γ)

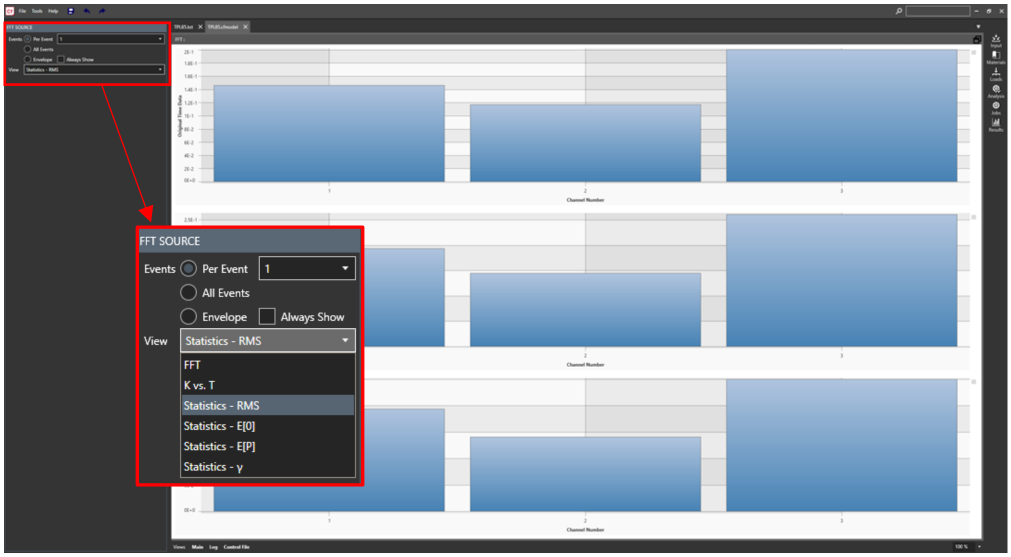
The statistical plots provided by the FFT viewer are excellent diagnostics tools for comparing raw time signal statistics to those for the conditioned time signals and converted PSDs. It is often useful to compare statistics between these 3 to see how the conditioning and conversion process has affected the original raw time signals.

In the Statistics – RMS plot below, we can see that the RMS values of the 3 raw time signal channels are all higher than the conditioned time signals or converted PSDs. This makes sense because the conditioned time signals and converted PSDs are missing the RMS values that were present in the original raw time signals due to the dead spots and other anomalies that the conditioning process eventually removed. Hence, in the process of conditioning the raw signals (i.e. making the signals stationary), some RMS was removed from the raw signals. This is acceptable because the removed RMS was not significantly contributing to the fatigue life calculation.

Original Time History
RMS of signals that include dead spots

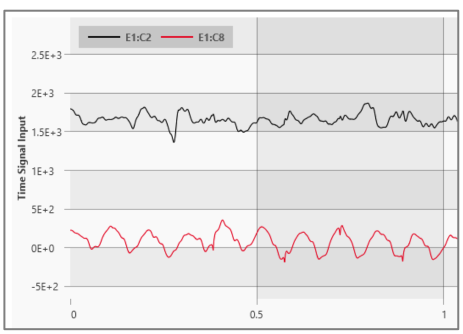
MODIFIED Time History
RMS of signals with all dead spots removed

Direct PSDs
RMS of converted PSDs



Dealing with Signal Offsets: RMS versus Standard Deviation

The fluctuations of a time signals typically vary about the signal's mean value. Most times that mean value is zero but sometimes that value is not zero (see 2 examples below). When the signal mean value is zero, the **RMS** of the time signal is equal to the **Standard Deviation** of the time signal. This is because the Standard Deviation of a time signal ignores any mean offset in the signal, but the RMS calculation will incorporate the mean offset in the result. When we calculate the RMS from a PSD, there is never a mean offset, so the RMS equals the Standard Deviation when dealing with PSDs.



Non-zero offset means RMS ≠ Standard Deviation

Zero offset means RMS = Standard Deviation

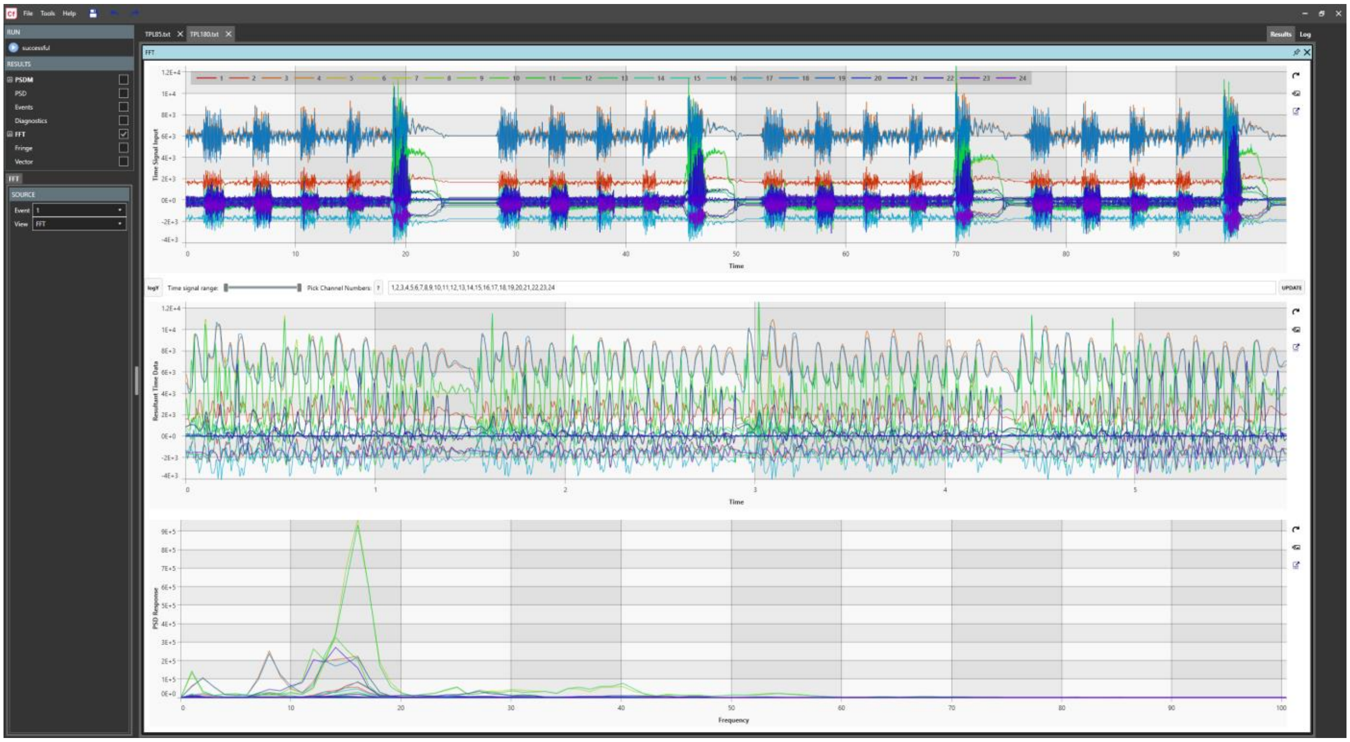
Therefore … technically speaking … when we want to compare the RMS values from time signals and PSDs, we really are looking at Standard Deviation values for the time signals (so that all mean values are removed) and the Standard Deviation for the PSDs (which is same as RMS for PSDs).

This is exactly what the FFT Plotter provides in a separate statistical view that can be seen by selecting the option from the menu as shown above. The label says RMS but it should be understood that any non-zero mean values are removed from the time signals before this RMS value is calculated; so in essence, the RMS plot is a Standard Deviation plot for the time signals and an RMS/STD plot for the PSD signals.

Controlling the Channel Numbers to View

Below is an example from TPL180 that contains 24 channels. What if these channels contained a repeating pattern of X, Y, Z, MX, MY, MZ and the User was only interested in viewing the X, Y, Z channels and not the moment (M) channels?

FFT image showing all 24 channels in Event 1.



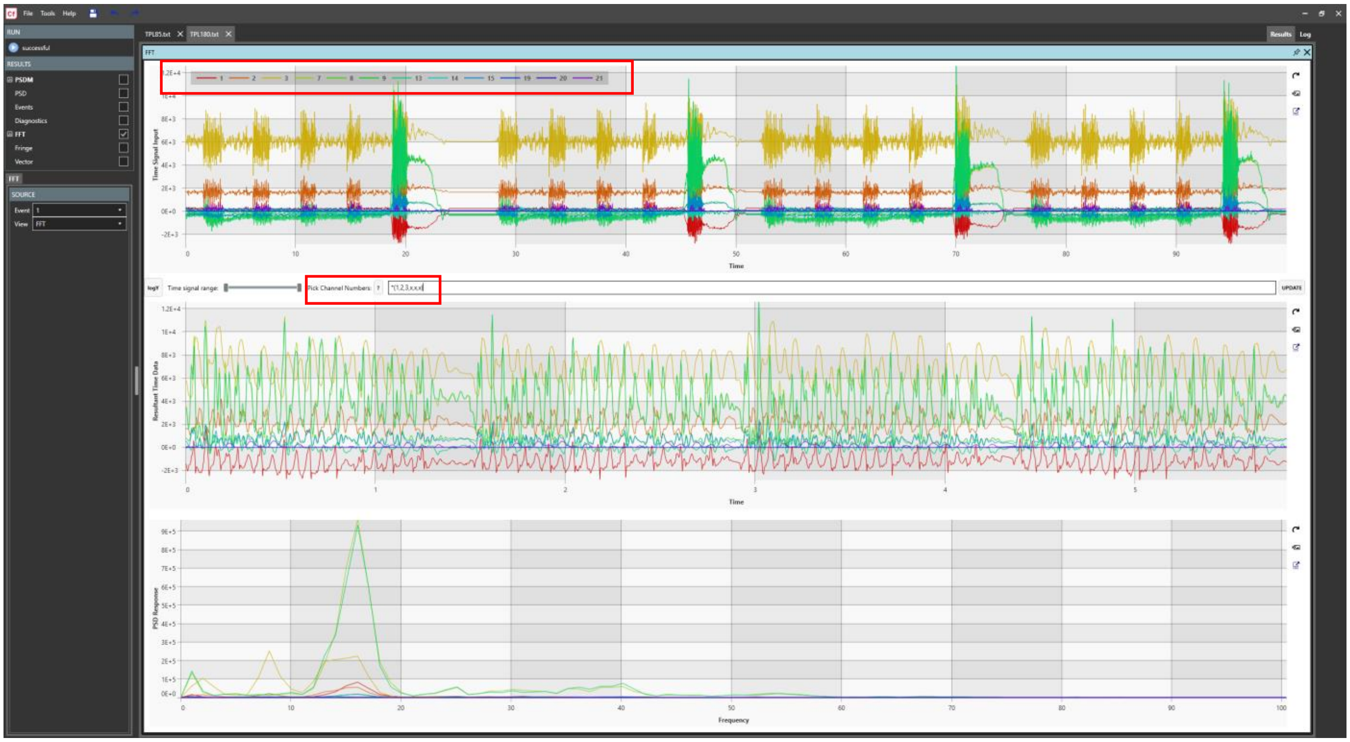
To allow easy filtering of the viewable channels the User can specify a filter to the “Pick Channels Numbers:” box. In the case below, the filter used is

* (1,2,3,x,x,x)

Which means,

- *( ) indicates a filtering algorithm is requested where the content within the brackets is repeated.
- Within the brackets, we are requesting to initially start at channel 1.
- We are then requesting to show the first 3 channels (i.e. 1,2,3) but remove the next 3 channels (i.e. remove 4, 5, 6).

This request results in the plotting of channels 1, 2, 3, 7, 8, 9, 13, 14, 15, 19, 20 and 21.



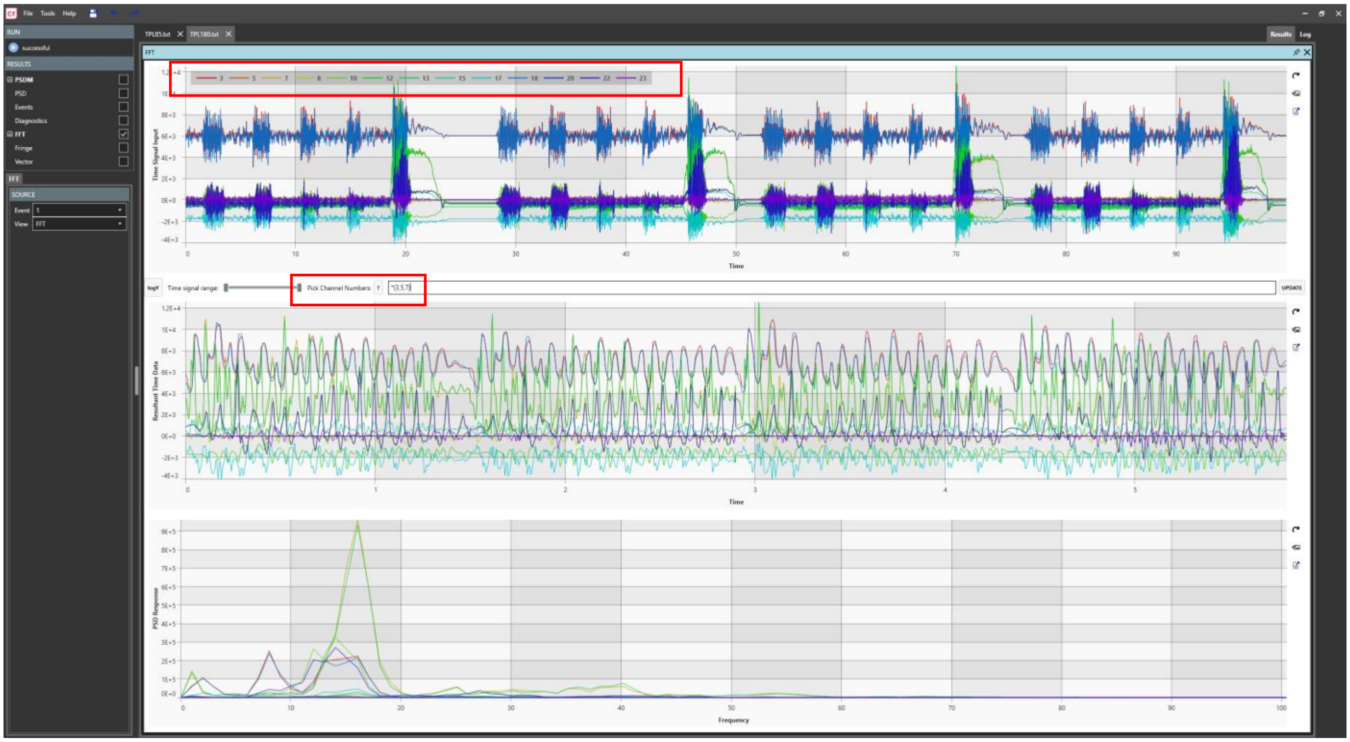
Another filtering example could be:

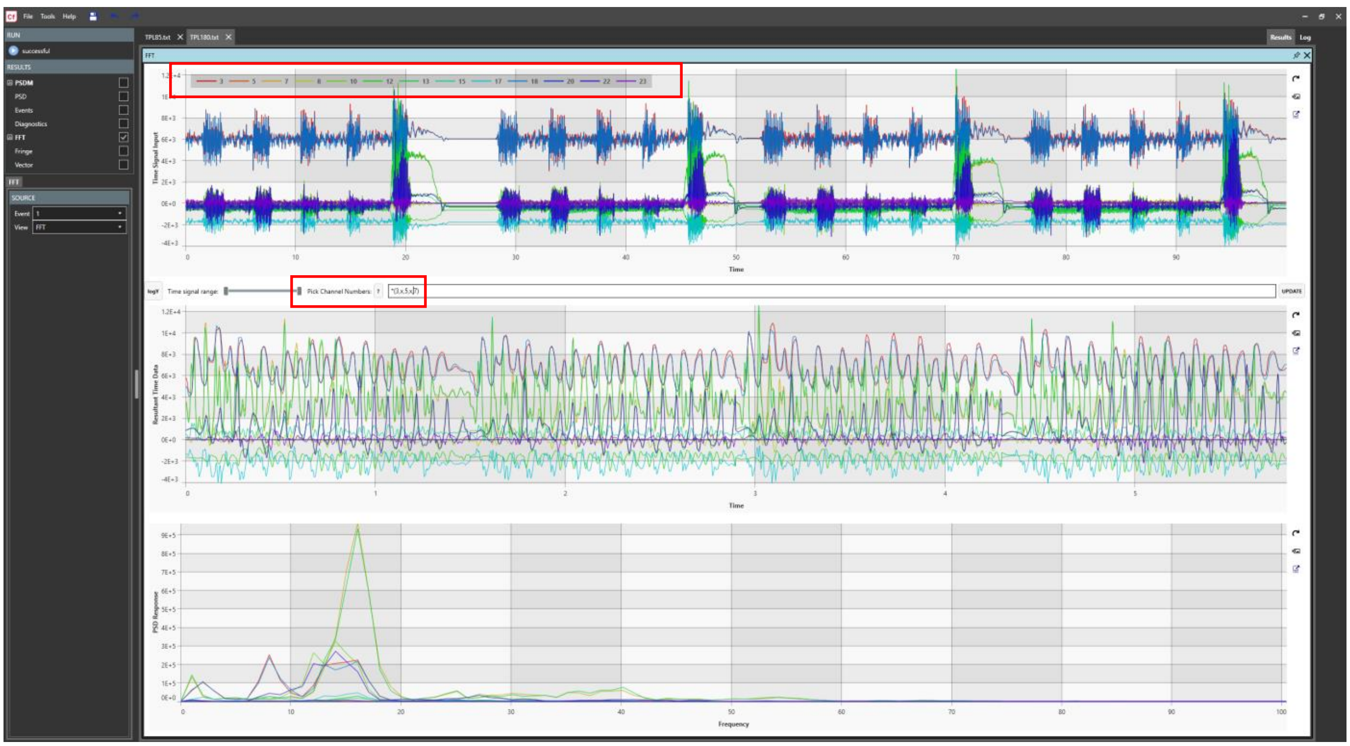
*(3, 5, 7)

Which means,

- *( ) indicates a filtering algorithm is requested where the content within the brackets is repeated.
- Within the brackets, we are requesting to initially start at channel 3 (i.e. bypass channels 1, 2)
- We are then requesting to show the first channel then skip a channel, show a channel, skip a channel and show a channel. This also could have been written as *(3,x,5,x,7).

This request results in the plotting of channels 3,5,7,8,10,12,13,15,17,18,20,22, etc. See images below that show the same result using both *(3, 5, 7) or *(3,x,5,x,7).



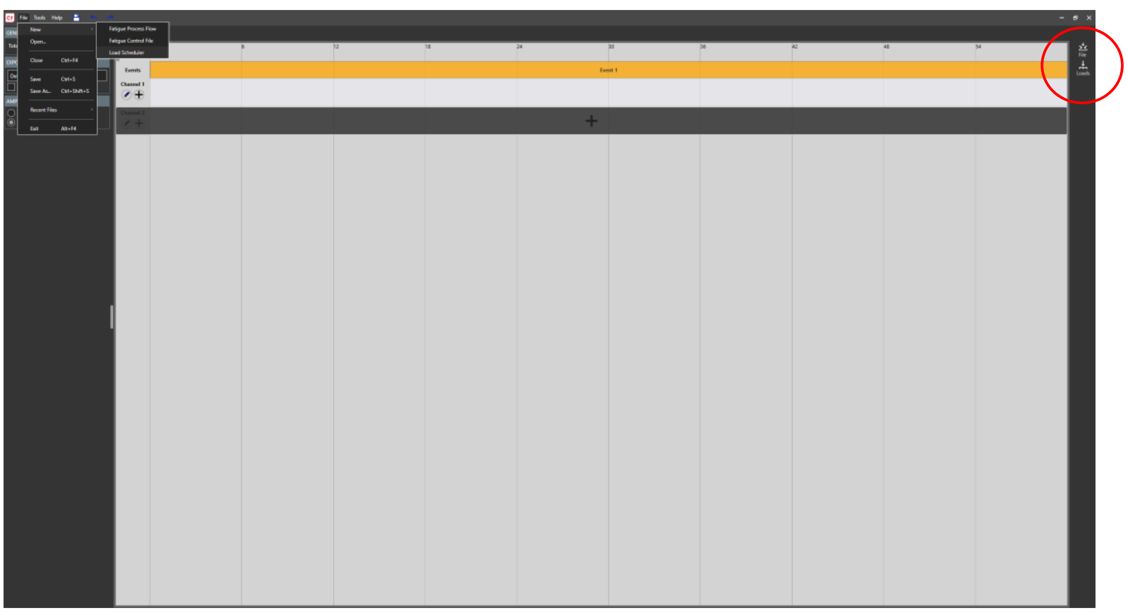


8 | INTRODUCTION TO THE LOAD SCHEDULER (CREATING A TIME HISTORY OF LOADING)

Introduction to the LOAD SCHEDULER for Creating Time Domain Loading Profiles

CAEfatigue provides a standalone toolset called LOAD SCHEDULER that allow for the creation of time domain loading that can be used in a random response or fatigue analysis.

The LOAD SCHEDULER is selected from the FILE>NEW menu (see below). Once selected the user is provided with choice on the right side of the GUI to import/export a FILE or to begin selecting / creating LOADS.



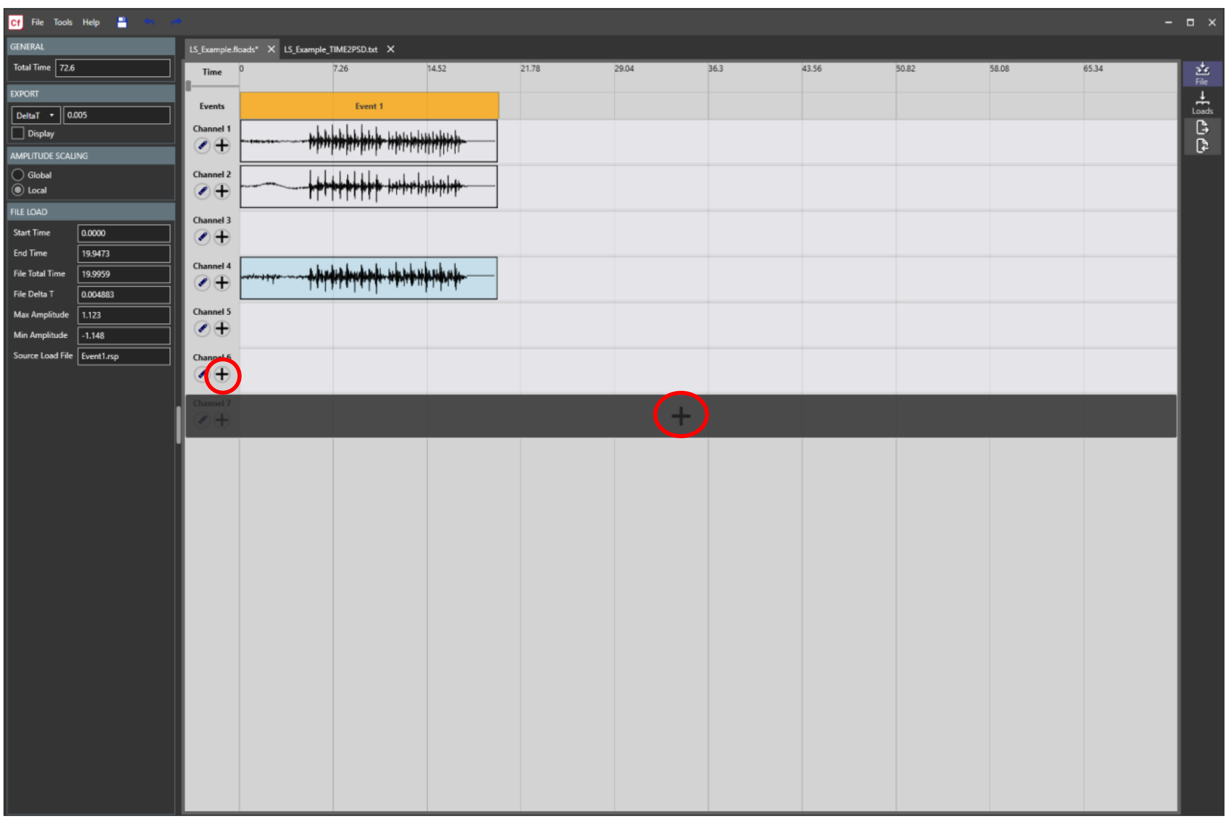
FILE IMPORT

The FILE IIMPORT option allows the user to import existing time domain signal data from an RSP, RPC, CSV, TXT or DAC format. This data may represent a single time history or many time signals.

To import, simple select the EVENT you wish to import the file into and then select the IMPORT FILE icon to select the data you wish to import. If you wish to import a file into a second event, you must create the second event first by selecting the "Drag to create an Event" icon and repeat the import process.

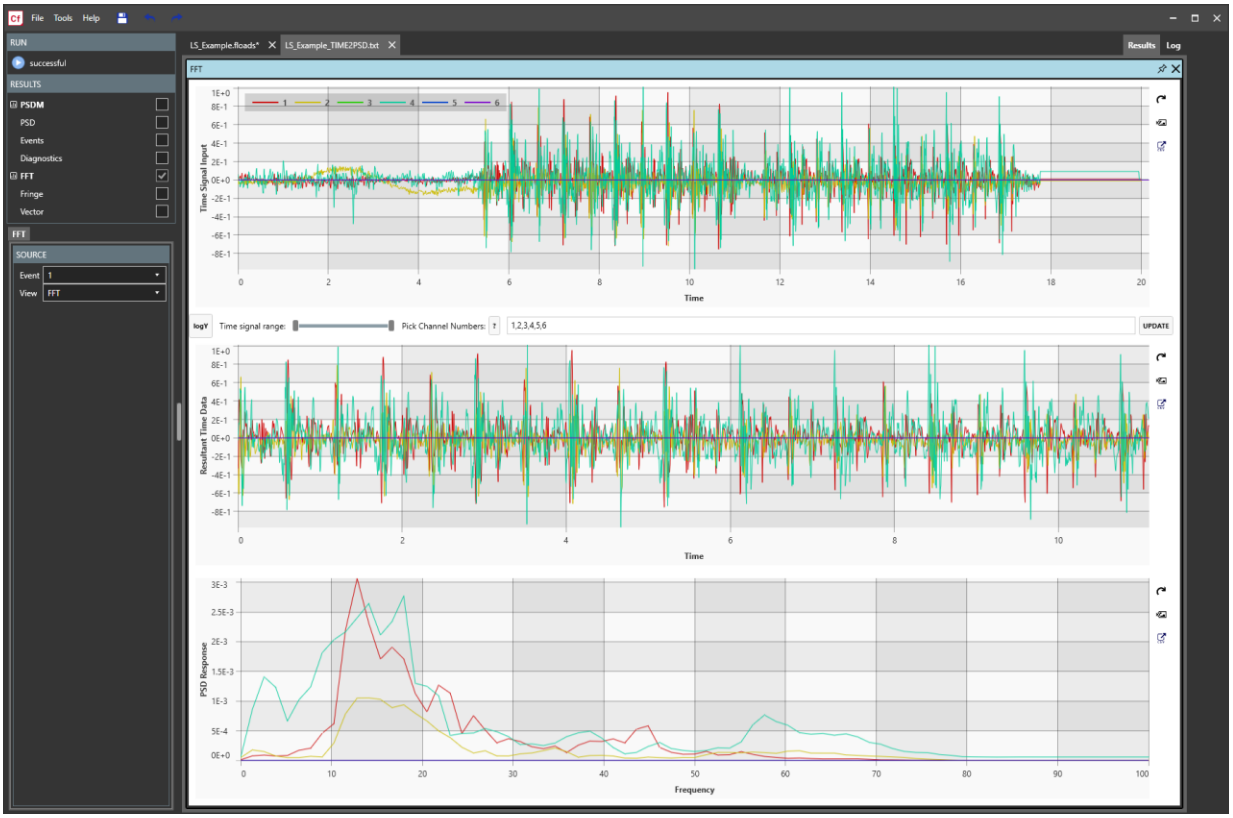
To modify the time signals that has been imported, the User can select the individual time signals and delete, move, or copy / paste the time signal to other channels or other events. Below is an example of several time signals that have been imported from an RSP file. Event 1, Channel 4 was created by dragging the former Channel 3 down to Channel 4. This creates a ZERO amplitude signal Channel 3 plus ZERO amplitude signals for the added Channels 5 and 6.

NOTE: The same number of channels will be used for all events in the LOAD SCHEDULER. Hence, if a second Event is created in the example below, it would automatically have 6 channels. If another channel is added (by selecting the + sign), then it will be applied to both events. Also, any channel can have a subchannel by selecting the + sign on the Channel itself. This may be desired if the User wants to apply multiple sinewaves (for example) to the same channel. In this case, all subchannels would be added together to create a new signal for the channel.



Once complete, the User can export the scheduler content to an RPC / RSP or CSV / TXT format. We can then use the exported file as a loading input for a Time Domain fatigue analysis or use it in the TIME2PSD tool to convert the signals into PSDs for a Frequency Domain fatigue analysis.

On the following page is the TIME2PSD FFT Plotter output generated from the conversion of the loading schedule layout shown above, into a PSD format. Note that the RAW DATA in the upper image matches the time signals above including the zero amplitude Channels 3, 5 and 6.



LOADS CREATION

The LOAD SCHEDULER also has the capability to add additional time signals to events using simple formats like sine waves, sine sweeps, square waves, block loading, etc. or to create a new EVENT using other type of loads. In the example on the next page, the original LOAD SCHEDULE from the previous page as been modified to add:

Channel 3 – 3 Hz sine wave with an amplitude of 1.0

Channel 5 – 1 Hz square tooth wave with an amplitude of 2.0

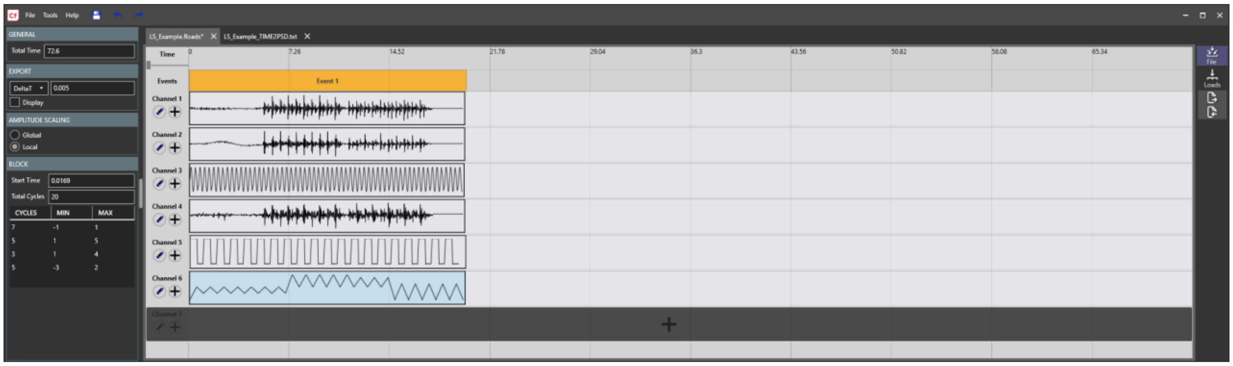
Channel 6 – 1 Hz block loading comprising various amplitude (up to 5) and block sections

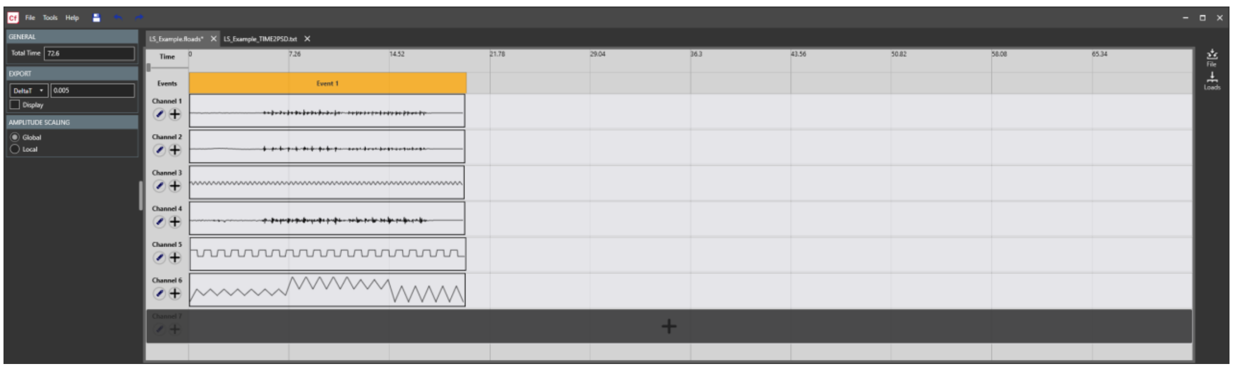
This additional content varies significantly in amplitude compared to the original time signals brought in from the RSP file. This can be an issue for the User if this was not the intention. In the figures to follow, the LOAD SCHEDULER signals are show in LOCAL scaling, meaning each signal is plotted to fill the box, and shown in GLOBAL scaling, meaning each signal is plotted using the same scaling across all boxes.

GLOBAL scaling can give the User and immediate check to ensure the amplitudes entered for the loading is appropriate to what was intended.

Load Scheduler with added content. TOP: Showing all signals at a LOCAL scale. BOTTOM: Showing all signals using same GLOBAL scale.

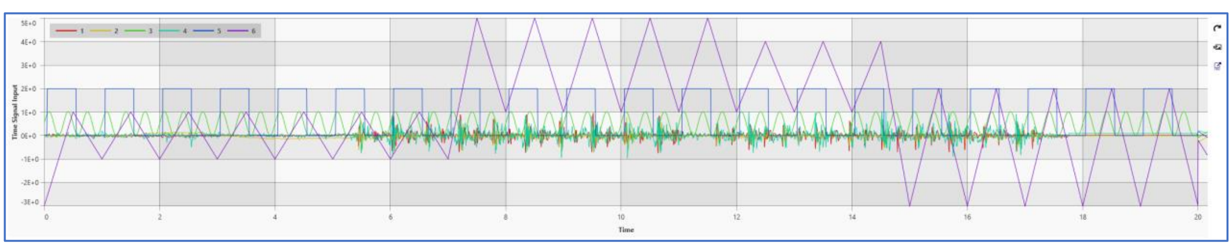
Note BLOCK LOADING is much larger than the other loads and will dominate the event.





Below is a raw data image from the FFT Plotter what shows the time signals from the Loads Scheduler combined into one event. You can see from this plot that the BLOCK LOADING clearly dominates the event as depicted in the global view of the Loads Scheduler above.

Figure 8-1 Figure 8-2 FFT Plotter – Raw Data image representation of the Load Scheduler file above.



Please note: It would not be appropriate to convert this data into the Frequency Domain because several of the signals are not RANDOM. All signals in an event must be Stationary, Random and Gaussian in order to be properly converted into the Frequency Domain. The above event however can be used in a Time Domain analysis without issue.

9 | APPENDIX 1: CSV FILE FORMATS

Please refer to the User Guide document for output format specifications

10 | APPENDIX 2: Fatigue Material Properties

Detailed information about the XML Material Database

Location:

CAEfatigue provides the User with a Material Database in the form of an XML text file. A copy of the Material Database file is stored in the **TPL\Materials** directory. This is a text file that can be edited to included Customer data and saved as a User material database. The Master of the original database is stored in the default installation directory **C:\Program Files\MSC.Software\CAEfatigue\2020\Windows\Resources\Materials**.

Format:

The XML file is text base and can be edited by any text based editor. The format for an SN material entry is show below. The database also includes EN material entries and simple Static data material entries. The highlighted **ID** and **ParentID** are the references needed to use the XML file via the **vMATFTG** and **vUDNAME** entries in the control file.

To enter additional materials into the database, the User must take care to use the same NAME entries as referenced below. Note: **Value="">** means there is no entry for this property.

```
<Object ID="2014_HV_O" ParentID="" Type="GenericMatDat" Category=”Aluminum”>
<property Name="Comment" Value="2nd Edition, 1988, John Wiley &amp; Sons."/>
<property Name="E" Units="MPA" Value="7.17E4"/>
<property Name="K" Units="MPA" Value=""/>
<property Name="K1C" Units="MPASQRTM" Value=""/>
<property Name="MaterialType" Value="101"/>
<property Name="Nc1" Value="1E6"/>
<property Name="RR" Value="-1"/>
<property Name="Reference" Value="Vibration Analysis for Electronic Equipment, D S
Steinberg:"/>
<property Name="SE" Value="0"/>
<property Name="SRI1" Units="MPA" Value="645.5"/>
<property Name="UTS" Units="MPA" Value="200"/>
<property Name="YS" Units="MPA" Value="135"/>
<property Name="b1" Value="-0.064300000667572"/>
<property Name="b2" Value="-0.064300000667572"/>
<property Name="me" Value=""/>
<property Name="mp" Value=""/>
<property Name="n" Value=""/>
</Object>
```

```
Below is an example to reference the XML file within the CAEfatigue control file:
$-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
$       MID
vmatftg 60
$       FLAG    UDID    TYPE    XML_FILE_REFERENCE
        FILE    22      SN      ID="2014_HV_O" ParentID=""
vudname 22
        materials/material_db.xml
$-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
```

Material Listing from XML Material Database

Below is a listing of materials contained in the XML database provided by CAEfatigue. SN or EN means the full fatigue properties are available. STATIC means that only the modulus (E) and UTS are available, but this can be used with the “autogenerate” feature in CAEfatigue (AUTOSN / AUTOEN) to create an SN or EN curves. Some materials are also provided with comments taken from simple web searches.

ID	Parent ID If Blank use “” in Control File	TYPE	E	UTS	Data Format	COMMENTS
1100		aluminium	6.90E+04	110	EN	1000 series aluminium pure alloy. Commonly used in rivets.
2014-T6_125_HF		aluminium	7.27E+04	483	EN	2000 series aluminium alloy with primarily copper. High strength, but low corrosion resistance. Needs cladding. Often used in Aerospace.
2014_HV_0		aluminium	7.17E+04	200	SN	
2014_HV_T4		aluminium	7.17E+04	410	SN	
2014_HV_T6		aluminium	7.17E+04	470	SN	
Strain-life (E-N)	2014-T6_125_HF	aluminium	7.27E+04	483	EN	Also referred to as 2014-T6 (483)
2014-T6 (510)		aluminium	6.90E+04	510	EN	
2017_HV_T31		aluminium	7.17E+04	300	SN + Static	
2024-T3		aluminium	7.17E+04	460	EN + Static	
2024-T4		aluminium	7.04E+04	476	EN	
2024_HV_O		aluminium	7.17E+04	200	SN + Static	
2024_HV_T3		aluminium	7.17E+04	450	SN + Static	
2024_HV_T4		aluminium	7.17E+04	450	SN + Static	
2024_HV_T851		aluminium	7.17E+04	450	SN + Static	
2024_HV_T86		aluminium	7.17E+04	450	SN + Static	
2219-T851		aluminium	7.00E+04	448	SN + Static	
2219_HV_T62		aluminium	7.17E+04	320	SN + Static	
2219_HV_T81		aluminium	7.17E+04	410	SN + Static	
2219_HV_T87		aluminium	7.17E+04	470	SN + Static	
3003_HV_H14		aluminium	7.17E+04	200	SN + Static	3000 series aluminium alloy with primarily manganese. Moderate strength, have good corrosion resistance, good formability and are suited for use at elevated temperatures. Often used for heat exchangers in vehicles and power plants.
3003_HV_H16		aluminium	7.17E+04	200	SN + Static	
3003_HV_H18		aluminium	7.17E+04	220	SN + Static	
3004_HV_H34		aluminium	7.17E+04	215	SN + Static	
3004_HV_H38		aluminium	7.17E+04	295	SN + Static	
3004_HV_0		aluminium	7.17E+04	295	SN + Static	
5052-H32		aluminium	6.96E+04	231	EN + Static	5000 series aluminium alloy with primarily magnesium. High strength, readily weldable, and for these reasons they are used for a wide variety of applications such as shipbuilding, transportation, pressure vessels, bridges and buildings.
5052_HV_H34		aluminium	7.17E+04	215	SN + Static	
5052_HV_H38		aluminium	7.17E+04	295	SN + Static	
5052_HV_O		aluminium	7.17E+04	200	SN + Static	
5056_HV_CON		aluminium	7.17E+04	260	SN + Static	
5083_114_CF		aluminium	6.96E+04	414	Static	
5083_87_CF		aluminium	6.96E+04	385	EN + Static	
5083_H12		aluminium	6.90E+04	385	EN	
5454		aluminium	6.90E+04	334	EN	

ID	Parent ID If Blank use "" in Control File	TYPE	E	UTS	Data Format	COMMENTS
5454-H311		aluminium	6.90E+04	400	EN	
5454_NONE_CF		aluminium	6.90E+04	334	EN + Static	
6061-T6_80_HF		aluminium	7.27E+04	340	EN + Static	6000 series aluminium alloy with primarily magnesium. High strength, can be heat treated, readily weldable, and for these reasons they are used for a wide variety of applications such as shipbuilding, transportation, pressure vessels, bridges and buildings.
6061-T6_NONE_CF		aluminium	6.90E+04	389	EN + Static	
6061-T6_NONE_SHEET		aluminium	6.96E+04	314	EN + Static	
6061-T6 (314)		aluminium	6.90E+04	314	EN	
6061-T6 (340)		aluminium	7.27E+04	340	EN	
6061-T6 (389)		aluminium	6.90E+04	389	EN	
6061_HV_O		aluminium	7.17E+04	150	SN + Static	
6061_HV_T4		aluminium	7.17E+04	215	SN + Static	
6061_HV_T6		aluminium	7.17E+04	305	SN + Static	
7075_HV_O		aluminium	7.17E+04	220	SN + Static	7000 series aluminium alloy with primarily zinc. High strength. These alloys are often used in high performance applications such as aircraft, aerospace, and competitive sporting equipment.
7075_HV_T6		aluminium	7.17E+04	570	SN + Static	
7075_T6		aluminium	7.09E+04	558	SN + Static	
7075_T6 (572)		aluminium	7.22E+04	572	EN	
7075_T651		aluminium	7.00E+04	580	EN	
7075_T73		aluminium	7.13E+04	524	EN	
7175-T73_NONE_HF		aluminium	7.17E+04	570	Static	
A356_T6 (252)		aluminium	7.10E+04	252	EN	
A356_T6 (266)		aluminium	7.00E+04	266	EN	
A356_T6 (283)		aluminium	7.00E+04	283	EN	
Beryllium		beryllium	2.89E+05	323	EN + Static	
2789_370		cast iron	1.63E+05	436	EN + Static	BS2789 is cast iron with spheroidal or nodular graphite. Suitable for applications where optimal impact, fatigue, electrical conductivity and magnetic permeability features are required. This includes valves, dies, pistons and moulds.
2789_420		cast iron	1.72E+05	468	EN + Static	
2789_600		cast iron	1.74E+05	591	EN + Static	
2789_700		cast iron	1.62E+05	885	EN + Static	
2789_800		cast iron	1.62E+05	890	EN + Static	
ASTMA536		cast iron	1.45E+05	480	EN + Static	Ductile cast iron commonly used for gears and industrial applications.
BS1452-260		cast iron	1.25E+05	277	EN + Static	Cast iron typically used for pistons, moulds, dies, bearings, cams, brushes and gears.
EIBSG1400		cast iron	1.75E+05	1407	EN + Static	
Hybrid_Cast_Iron		cast iron	1.51E+05	296	EN + Static	
EZ33A_HV_T5		cast magnesium	4.40E+04	140	Static	Magnesium cast alloy primarily for commercial and military casting relatively free of microporosity with good strength properties.
Copper		copper	1.14E+05	206	EN + Static	
Spot Weld (S-N)	ALMg5Nm	spot weld	7.00E+04	300	SN	
Spot Weld (S-N)	FePo4	spot weld	2.00E+05	313	SN	
Spot Weld (S-N)	Spot_Nugget_Generic	spot weld	2.10E+05	500	SN	

ID	Parent ID If Blank use "" in Control File	TYPE	E	UTS	Data Format	COMMENTS
Spot Weld (S-N)	Spot_Sheet_Generic	spot weld	2.10E+05	500	SN	
Spot Weld (S-N)	ZSTE380	spot weld	2.00E+05	484	SN	
Spot Weld (S-N)	1.4003	spot weld	2.00E+05	496	SN	
Spot Weld (S-N)	1.4301_IIIA	spot weld	2.00E+05	670	SN	
Spot Weld (S-N)	1.4301_IIIC	spot weld	2.00E+05	670	SN	
Spot Weld (S-N)	1.4589	spot weld	2.00E+05	523	SN	
1005		steel	2.07E+05	359	EN	A low carbon steel.
1008		steel	2.00E+05	363	EN	A low carbon steel. Typical uses include extrusions and cold pressed parts and forms.
1015		steel	2.07E+05	414	EN	A low carbon steel. Typical uses include cold formed or forged parts which are low strength with hard, wear resistant surfaces.
1020 (393)		steel	2.07E+05	393	EN	A low carbon steel. Typical uses include shafts, lightly stressed gears, hard wearing surfaces, pins, chains and case hardened parts where core strength is not critical.
1020 (441)		steel	2.07E+05	441	EN	
1040		steel	2.07E+05	621	EN	A medium carbon steel. Typical uses include bolts, reinforcing rods, forgings, non-critical springs, cylinder head studs and machined parts..
1045 (621)		steel	2.07E+05	621	EN	A medium carbon steel. Typical uses include gears, shafts, axles, bolts, studs and machine parts.
1045 (752)		steel	2.02E+05	752	EN	
1045 (942)		steel	2.06E+05	942	EN	
1045 (1322)		steel	2.08E+05	1322	EN	
1045 (1345)		steel	2.07E+05	1345	EN	
1045 (1516)		steel	2.07E+05	1516	EN	
1045 (1862)		steel	2.07E+05	1862	EN	
1045 (1956)		steel	2.07E+05	1956	EN	
1045 (2297)		steel	2.05E+05	2297	EN	
150M19		steel	2.07E+05	682	EN + Static	Also known as EN14A and 14B. Carbon manganese steel suitable for welding.
2.25Cr1Mo		steel	2.30E+05	603	Static	
Strain-life (E-N)	2TA11	steel	1.17E+05	1233	EN	
3.5NCMV		Steel	2.00E+05	1320	Static	
Strain-life (E-N)	349S52	steel	1.90E+05	991	EN	Retains hardness at high temperatures, excellent rupture strength, good scaling resistance and good corrosion resistance against chlorine. Primarily used for engine valves.
Strain-life (E-N)	352S52	steel	1.74E+05	1027	EN	
4130 (778)		steel	2.00E+05	778	EN	4130 / 4140 is a low carbon steel (chromium-molybdenum added). Used in forgings typically for aerospace, automotive, defense and agricultural industries.
4130 (1358)		steel	2.21E+05	1358	EN	
4140 (848)		steel	2.07E+05	848	EN	
4140 (2033)		steel	2.00E+05	2033	EN	
4142 (827)		steel	1.93E+05	827	EN	4142 is a medium carbon steel with chromium and molybdenum. Used in forgings for gears, flanges, spindles, axles and various machine tool components.
4142 (1413)		steel	2.07E+05	1413	EN	

ID	Parent ID If Blank use "" in Control File	TYPE	E	UTS	Data Format	COMMENTS
4142 (1551)		steel	2.00E+05	1551	EN	
4142 (1758)		steel	2.07E+05	1758	EN	
4142 (1929)		steel	2.00E+04	1929	EN	
4142 (2248)		steel	2.00E+05	2248	EN	
4340 (1048)		steel	1.90E+05	1048	EN	4130 low alloy steel (nickel-chromium-molybdenum steel). Tough and high strength in heat treated condition with good fatigue properties. Used in forgings like automotive crankshafts.
4340 (1468)		steel	2.00E+05	1468	EN	
4340 (1584)		steel	1.93E+05	1584	EN	
Strain-life (E-N)	526M60	steel	2.02E+05	939	EN	Also known as EN11.
Strain-life (E-N)	605M30	steel	2.00E+05	705	EN	Also known as EN16D. Excellent ductility and shock resistance.
Strain-life (E-N)	605M36	steel	2.07E+05	835	EN	Also known as EN16. Excellent ductility and shock resistance.
Strain-life (E-N)	709M40	steel	2.10E+05	781	EN	Also known as EN19. EN 19 is used in Machine tool and automotive industries gear, gears, shafts, spindles, gears, bolts, studs
Strain-life (E-N)	722M24	steel	2.05E+05	976	EN	Also known as EN40B. EN40B has become a popular engineering material for use in industries such as textiles, automotive and aerospace. It is also used extensively by billet crankshaft manufacturers
Strain-life (E-N)	817M40	steel	2.00E+05	1277	EN	
Strain-life (E-N)	826M31	steel	2.00E+05	1209	EN	Also known as EN25. EN25 is used extensively in most industry sectors for applications requiring higher tensile and yield strength than 4140 can provide Typical uses are: Adapters, Axles, Connecting Rods, Die Holders, Drill Shanks, Ejector Rods, Hydraulic Clamps, Jack Shafts, Line Shafts, Motor Shafts, Nuts, Pins, Piston Rods, Pump Shafts, Rams, Spindles, Torsion Bars Winch Gears etc.
Strain-life (E-N)	835M30_V	steel	1.94E+05	1034	EN	Also known as EN30B. EN30B alloy steel can be used for many purposes where toughness and high tensile strength are requirements. For example: components of small presses including anvils, collars, strikers or hammers, rams or punch holders. Other applications include rivet snaps, air hardening cold chisels, crimping tools, clutch keys, racks, pinions and angle pins for pressure die casting tooling. EN30B will machine readily in the annealed condition in which it is supplied
AISI1012		steel	2.00E+05	333	EN + Static	Carbon steel with good machinability and formability.
AISI1020		steel	2.00E+05	416	EN + Static	AISI 1020 steel is used in case hardened condition and used for simple structural applications such as cold headed bolts. AISI 1020 steel is also used to manufacture axles, general engineering and machinery parts and components, shafts and camshafts, pins, ratchets, light duty gears and spindles
B40PK		steel	2.00E+05	394	EN + Static	
B40PO		steel	2.00E+05	438	EN + Static	
B50XF		steel	2.00E+05	486	EN + Static	
B50XK-CR		steel	2.00E+05	461	EN + Static	
B50XK-HR		steel	2.00E+05	450	EN + Static	

ID	Parent ID If Blank use "" in Control File	TYPE	E	UTS	Data Format	COMMENTS
B55XF		steel	2.00E+05	488	EN + Static	
B60RO		steel	2.00E+05	503	EN + Static	
B80RK		steel	2.00E+05	610	EN + Static	
B80XF		steel	2.00E+05	645	EN + Static	
BS376_Nickel		steel	2.07E+05	366	EN + Static	
BS4360-43A		steel	2.07E+05	486	EN + Static	BS4360 is weldable carbon steel plate mainly used for the production of various types of steel rivets, steel bolts, steel weld and other structural components.
BS4360-43C		steel	2.07E+05	478	EN + Static	
BS4360-43D		steel	2.07E+05	490	EN + Static	
BS4360-50D		steel	1.91E+05	480	EN + Static	
ClassB		steel	2.07E+05	500	SN + Static	
ClassC		steel	2.07E+05	500	SN + Static	
ClassD		steel	2.07E+05	500	SN + Static	
ClassE		steel	2.07E+05	500	SN + Static	
ClassF		steel	2.07E+05	500	SN + Static	
ClassF2		steel	2.07E+05	500	SN + Static	
ClassG		steel	2.07E+05	500	SN + Static	
ClassW		steel	2.07E+05	500	SN + Static	
Cold_Rolled_Sheet		steel	2.00E+05	303	EN + Static	
DP1		steel	2.00E+05	659	EN + Static	
DP2		steel	2.00E+05	753	EN + Static	
EICG315		steel	1.51E+05	315	EN + Static	
EICG400		steel	1.50E+05	404	EN + Static	
EICG493		steel	1.63E+05	493	EN + Static	
EN24V		steel	1.90E+05	1047	EN + Static	Very high strength steel alloy with good ductility and wear resistance. Typical applications are shafts, punches, dies, drill bushings, retaining rings and gears.
HSLA4		steel	2.00E+05	486	EN + Static	
hypress20		steel	2.00E+05	445	EN + Static	
hypress23		steel	2.00E+05	437	EN + Static	
hypress26		steel	2.00E+05	523	EN + Static	
hypress29-4		steel	2.00E+05	544	EN + Static	
hypress29-8		steel	2.00E+05	539	EN + Static	
INC718		steel	2.04E+05	1304	EN + Static	
Manten		steel	2.03E+05	552	EN + Static	
Manten_MSN		steel	2.03E+05	600	SN + Static	
Manten_SN		steel	2.03E+05	600	SN + Static	
Mild_Steel		steel	2.00E+05	462	EN + Static	
Nitro		steel	2.00E+05	483	EN + Static	
Nitro-SA		steel	2.00E+05	648	EN + Static	
Rephos		steel	2.00E+05	421	EN + Static	
PSCI_DV_Test		steel	1.65E+05	795	Static	
RQC100		steel	2.03E+06	863	EN + Static	
RQC100_MSN		steel	2.03E+06	800	SN + Static	
RQC100_SN		steel	2.03E+06	800	SN + Static	
RQT501		steel	2.00E+05	590	EN + Static	
RQT701		steel	2.00E+05	825	EN + Static	

ID	Parent ID If Blank use "" in Control File	TYPE	E	UTS	Data Format	COMMENTS
SAE1006_85_HR		steel	2.07E+05	318	EN + Static	Carbon steel with low hardness and plasticity. Primarily used for panels for automobiles.
SAE1006_85A_HR		steel	2.07E+05	318	EN + Static	
SAE1006_85B_HR		steel	2.07E+05	318	EN + Static	
SAE1008_91_HR		steel	2.07E+05	363	EN + Static	
SAE1015_80_NORM		steel	2.07E+05	415	EN + Static	
SAE1018_106_HR		steel	2.07E+05	354	EN + Static	
SAE1018_118_QT		steel	2.07E+05	496	EN + Static	
SAE1018_209_QT		steel	2.07E+05	696	EN + Static	
SAE1020_107_HR		steel	2.07E+05	441	EN + Static	
SAE1020_108_ANLD		steel	2.07E+05	392	EN + Static	
SAE1030_128A_HR		steel	2.07E+05	454	EN + Static	
SAE1030_128_HR		steel	2.07E+05	454	EN + Static	
SAE1035_169_CON		steel	2.10E+05	550	SN + EN + Static	
SAE1045_225_ANLD		steel	2.07E+05	751	EN + Static	
SAE1045_390_QT		steel	2.07E+05	1343	EN + Static	
SAE1045_450_QT		steel	2.07E+05	1584	EN + Static	
SAE1045_500_QT		steel	2.07E+05	1956	EN + Static	
SAE1045_595_QT		steel	2.07E+05	2239	EN + Static	
SAE1045_705_QT		steel	2.07E+05	2067	EN + Static	
SAE1045_HV_HR		steel	2.07E+05	671	EN + Static	
SAE1045_Shaft		steel	2.04E+05	621	EN + Static	
SAE1050_189_CON		steel	2.10E+05	637	SN + EN + Static	
SAE1055_251_CON		steel	2.10E+05	860	SN + EN + Static	
SAE1080_371_QT		steel	2.07E+05	1298	EN + Static	
SAE1080_410_QT		steel	2.07E+05	1432	EN + Static	
SAE1080_421_AUST		steel	2.07E+05	1349	EN + Static	
SAE1315_155_CON		steel	2.10E+05	530	SN + EN + Static	
SAE1522_289_HR		steel	2.07E+05	1005	EN + Static	
SAE1522_304_HR		steel	2.07E+05	1088	EN + Static	
SAE1541_362_QT		steel	2.07E+05	1200	EN + Static	
SAE1561_234_HR		steel	2.07E+05	836	EN + Static	
SAE2310_138_CON		steel	2.10E+05	480	SN + EN + Static	
SAE2335_217_CON		steel	2.10E+05	745	SN + EN + Static	
SAE4130_259_QT		steel	2.07E+05	895	EN + Static	
SAE4130_267_CON		steel	2.10E+05	912	SN + EN + Static	
SAE4130_366_QT		steel	2.07E+05	1426	EN + Static	
SAE4142_380_QT		steel	2.07E+05	1412	EN + Static	
SAE4142_400_QT		steel	2.07E+05	1550	EN + Static	
SAE4142_450A_QT		steel	2.07E+05	1929	EN + Static	
SAE4142_450_QT		steel	2.07E+05	1757	EN + Static	
SAE4142_475A_QT		steel	2.07E+05	2032	EN + Static	
SAE4142_475_QT		steel	2.07E+05	1929	EN + Static	
SAE4142_560_QT		steel	2.07E+05	2239	EN + Static	

ID	**Parent ID** If Blank use "" in Control File	**TYPE**	**E**	**UTS**	**Data Format**	**COMMENTS**
SAE4142_670_QT		steel	2.07E+05	2446	EN + Static	
SAE4340_242_HR		steel	2.07E+05	826	EN + Static	
SAE4340_350A_QT		steel	2.07E+05	1171	EN + Static	
SAE4340_350B_QT		steel	2.07E+05	1171	EN + Static	
SAE4340_350C_QT		steel	2.07E+05	1240	EN + Static	
SAE4340_409_QT		steel	2.07E+05	1467	EN + Static	
SAE5160_434_QT		steel	2.07E+05	1584	EN + Static	
SAE52100_517_H		steel	2.07E+05	2011	EN + Static	
SAE8630_254_NORM		steel	2.07E+05	785	EN + Static	
SAE8640_361_QT		steel	2.07E+05	1373	EN + Static	
SAE9262_260_NORM		steel	2.07E+05	923	EN + Static	
SAE9262_271_QT		steel	2.07E+05	999	EN + Static	
sra_60		steel	2.00E+05	531	EN + Static	
sra_70		steel	2.00E+05	570	EN + Static	
st00		steel	2.10E+05	347	EN + Static	
UNSG10200		steel	2.00E+05	393	EN + Static	
30304 (951)		steel (stainless)	1.72E+05	951	EN	304 Stainless steel alloy with superior corrosion resistance. Used in tubing, pressure vessels, shipping drums, etc.
30304 (572)		steel (stainless)	1.90E+05	572	EN	
Strain-life (E-N)	304SS	steel (stainless)	1.86E+05	1000	EN	Known as 30304 (1000)
30310		steel (stainless)	1.93E+05	641	EN	310 stainless steel alloy for high temperature applications.
FeE255TM		steel (stainless)	2.00E+05	475	EN + Static	Stainless steel alloy with superior corrosion resistance.
FeE37D		steel (stainless)	2.00E+05	388	EN + Static	Stainless steel alloy with superior corrosion resistance.
FeE420TM		steel (stainless)	2.00E+05	490	EN + Static	Stainless steel alloy with superior corrosion resistance.
FeE52D		steel (stainless)	2.00E+05	550	EN + Static	Stainless steel alloy with superior corrosion resistance.
HT-30		steel (stainless)	7.10E+04	355	EN + Static	
Ti-6AL-4V		titanium	1.20E+05	986	EN + Static	

Fatigue Property Defaults for Welds and CODE Field

Default properties that are referenced when using the **CODE** field in vMATFTG.

Property	Generic Nugget Spot Weld		Generic Top/Bot Sheet Spot Weld		Generic Flexible Seam Weld (r=1)		Generic Stiff Seam Weld (r=0)	
CODE	steel <100	alum 100-199	steel <100	alum 100-199	steel <100	alum 100-199	steel <100	alum 100-199
UTS (MPa)	4000	4000	4000	4000	1.8E4	4000	1.8E4	4000
YS (MPa)	355	150	355	150	Blank	Blank	Blank	Blank
E (MPa)	2.1E5	7E4	2.1E5	7E4	2.1E5	7E4	2.1E5	7E4
SRI1	2100	2462	2900	2462	3.6E4	3140	1.8E4	1275
b1	-0.1667	-0.2	-0.1667	-0.2	-0.3333	-0.1734	-0.3333	-0.1625
Nc1	1E6	1E7	1E6	1E7	1E7	1E7	1E7	1E7
b2	-0.09091	-0.1111	-0.09091	-0.1111	-0.3333	-0.1734	-0.3333	-0.1625
SE	0.334	0.33	0.33	0.33	0.4	0.4	0.4	0.4
RR	0.0	0.0	0.0	0.0	-1.0	-1.0	-1.0	-1.0
Nfc	1E30	1E30	1E30	1E30	1E30	1E30	1E30	1E30
MSS	0.1	0.2	0.1	0.2	Blank	Blank	Blank	Blank
M1	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
M2	-0.1	-0.2	-0.1	-0.2	-0.25	-0.25	-0.25	-0.25
M3	-0.1	-0.2	-0.1	-0.2	-0.1	Blank	-0.1	Blank
M4	Blank	Blank	Blank	Blank	-0.1	Blank	-0.1	Blank
BTHRESH	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
RTHICK	Blank	Blank	Blank	Blank	1 (mm)	1 (mm)	1 (mm)	1 (mm)
nTHICK	Blank	Blank	Blank	Blank	0.16667	0.16667	0.16667	0.16667

Using the AutoSN / AutoEN Calculation and Material CODE Numbers

CAEfatigue provides the capability to automatically generate SN or EN fatigue material properties based on the material Ultimate Tensile Strength (UTS) and knowledge of the material code number i.e., Ferrous = Code 99, Aluminum = Code 100, Titanium = Code 300, all other Codes.

The fatigue properties generated are generic and may not perfectly match the materials being applied by the User. However, it is a good estimate with which to begin a fatigue evaluation.

SN Fatigue Material Properties generated using Auto\SN. A default UTS value of 400 MPa is set if the User does not enter the UTS value.

Parameter	Ferrous	Aluminum	Titanium	Other
UTS	User Defined	User Defined	User Defined	User Defined
Youngs Modulus E	2.1E5 MPa	7.3E4 MPa	1.1e5 MPa	7.3e4 MPa
Code Number	99	100	300	0
Stress at 1000 cycles: called S1	0.9 x UTS	0.7 x UTS	0.8 x UTS	0.8 x UTS
Transition Life Nc1: called S2	0.357 x UTS	0.258 x UTS	0.307 x UTS	0.274 x UTS
SRI1	2 x S2/(Nc1)b1	2 x S2/(Nc1)b1	2 x S2/(Nc1)b1	2 x S2/(Nc1)b1
b1	(log(S2)–log(S1)) / (log(Nc1)-3)	(log(S2)–log(S1)) / (log(Nc1)-3)	(log(S2)–log(S1)) / (log(Nc1)-3)	(log(S2)–log(S1)) / (log(Nc1)-3)
Nc1	1E6	5E8	1E6	1E6
b2	b1/(2+b1)	b1/(2+b1)	b1/(2+b1)	b1/(2+b1)
SE	User Entry	User Entry	User Entry	User Entry
RR	-1	-1	-1	-1
Nfc	not set	not set	not set	not set
M1	not set	not set	not set	not set
M2	not set	not set	not set	not set
M3	not set	not set	not set	not set
M4	not set	not set	not set	not set

EN Fatigue Material Properties generated using AutoEN. A default UTS value of 400 MPa is set if the User does not enter the UTS value.

Parameter	Ferrous	Aluminum	Titanium	Other
UTS	User Defined	User Defined	User Defined	User Defined
Youngs Modulus E	2.1E5 MPa	7.3E4 MPa	1.1e5 MPa	User Defined
Code Number	99	100	300	0
Sf’	1.5 x UTS	1.67 x UTS	1.67 x UTS	1.9 x UTS
b	-0.087	-0.095	-0.095	-0.12
c	-0.58	-0.69	-0.69	-0.6
Ef’	0.59 x Phi	0.35	0.35	0.76 x $D^{0.6}$
n’	0.15	0.11	0.11	0.2
K’	1.65 x UTS	1.61 x UTS	1.61 x UTS	Sf’ / ($Ef'^{\,n'}$)
Nc	2E8	2E8	2E8	2E8
SEe	Default or User Entry via Control File	Default or User Entry via Control File	Default or User Entry via Control File	Default or User Entry via Control File
SEp	Default or User Entry via Control File	Default or User Entry via Control File	Default or User Entry via Control File	Default or User Entry via Control File
SEc	Default or User Entry via Control File	Default or User Entry via Control File	Default or User Entry via Control File	Default or User Entry via Control File
Ne	not set	not set	not set	not set
FSN	not set	not set	not set	not set
S	not set	not set	not set	not set
Notes:	If UTS/E <= 3E-3, then Phi=1.0 If UTS/E > 3E-3 but <1E-2, then Phi=1.375 - (125 x UTS/E) If UTS/E >= 1E-2, then Phi=0.1			D = log (1 / (1-RA/100), where RA is the reduction in area (%) entered by the User.

Material Code Numbers

1	Flake cast iron (FCI)		99	Steel of unknown heat treatment (STEEL)
2	Ferritic cast iron with compacted graphite (FCICG)		100	Wrought aluminum (WA)
3	Pearlitic cast iron with compacted graphite (PCICG)		101	Wrought aluminum-copper alloy (WACA)
4	Bainitic cast iron with compacted graphite (BCICG)		102	Wrought aluminum-manganese alloy (WAMNA)
5	Ferritic cast iron with spheroidal graphite (FCISG)		103	Wrought aluminum-magnesium alloy (WAMGA)
6	Ferrite/pearlite cast iron with spheroidal graphite (FPCISG)		104	Wrought aluminum-magnesium-silicon alloy (WAMGSA)
7	Pearlitic cast iron with spheroidal graphite (PCISG)		105	Wrought aluminum-zinc alloy (WAZA)
8	Bainitic cast iron with spheroidal graphite (BCISG)		106	Cast aluminum alloy (CAA)
9	Cast steel with less than 0.2% carbon (CSL2C)		107	Wrought complex special purpose aluminum alloys (WCSPAA)
10	Normalized cast steel with 0.2-0.4% carbon (NCS24C)		200	Wrought copper (WCU)
11	Quenched & tempered cast steel with 0.2-0.4% carbon (QTCS24)		201	Wrought brass (WBR)
12	Normalized cast steel with 0.4-0.7% carbon (NCS47)		202	Wrought aluminum bronze (WABR)
13	Plain carbon wrought steel with < 0.2% carbon (PCWS)		203	Cupronickel (CUPNI)
14	Hot rolled/normalized plain carbon wrought steel, 0.2-0.4% carbon (HNPCWS24)		204	Nickel silver (NIAG)
15	Quenched & tempered cast steel with 0.4-0.7% carbon (QTCS47)		205	Wrought phosphor bronze (WPHBR)
16	Quenched & tempered plain carbon wrought steel, 0.2-0.4% carbon (QTPCWS24)		206	Wrought copper beryllium (WCUBE)

17	Hot rolled/normalized plain carbon wrought steel, 0.4-0.7% carbon (HNPCWS47)		207	Cast copper alloys (CCUA)
18	Quenched & tempered plain carbon wrought steel, 0.4-0.7% carbon (QTPCWS47)		300	Titanium alloy (TA)
19	Normalized low alloy wrought steel (NLAWS)		400	Wrought magnesium alloys (WMGA)
20	Quenched & tempered low alloy wrought steel (QTHSLAWS)		401	Cast magnesium alloys (CMGA)
21	Normalized Ni/Cr/Mo wrought steel (NNCMWS)		500	Fusible alloys, solders (FUSSOL)
22	Quenched & tempered Ni/Cr/Mo wrought steel (QTNCMWS)		600	Cast zinc alloys (CZINCA)
23	Austenitic stainless steel (ASS)		700	Wrought nickel alloys (WNIA)
24	Ferritic stainless steel (FSS)		701	Cast nickel alloys (CNIA)
25	Martensitic stainless steel (MSS)		800	Precious metals (PRECMET)
26	Annealed plain carbon wrought steel, 0.2-0.4% carbon (APCWS24)		900	Clad materials (CLADMAT)
27	Annealed plain carbon wrought steel, 0.4-0.7% carbon (APCWS47)		1000	Thermoplastics (THERPLAS)
28	Normalized carbon/manganese steel (MCMS)		1001	Thermosetting plastics (TSETPLAS)
29	Quenched and tempered carbon/manganese steel (QTCMS)			
30	Hardened chromium steel (HCS)			
31	Quenched and tempered chromium steel (QTCS)			

11 | APPENDIX 3: CAEfatigue – Open Source Software

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Zlib – 1.2.11

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zlib.h -- interface of the 'zlib' general purpose compression library
  version 1.2.11, January 15th, 2017
```

Microsoft Automatic Graph Layout,MSAGL – 1.1.11

Threading Building Blocks (TBB) – 2021.5

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Microsoft.Web.WebView2 – 1.0.1823.32

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