



## AFGROW Workshop 2011 - Layton, UT

# Using the New Multi-Channel Spectrum Format

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# **Current AFGROW Spectrum**

To date, AFGROW has used a single channel load spectrum. Because of this limitation, K-solutions for combined loading (axial, bending, and bearing) are limited by the assumption that fractional components of each load case are constant.

## Why Change?

• Several AFGROW Users have expressed an interest in the ability to input independent loading spectra for axial, bending, and bearing loads

• As we move toward a 3-D capability, it will be important to be able to manage applied loading in more than one direction

### **Current K Calculation**

Alpha tension = Alpha axial \* AxialTensionModifier+ Alphabending \* BendingTensionModifier+Alphabearing \* BearingTensionModifier
Alpha compression = Alpha axial \* AxialCompressionModifier+ Alphabending \* BendingCompressionModifier+Alphabearing \* BearingCompressionModifier

**Beta** tension = (Alpha tension \* Beta<sub>Correction</sub>) / sqrt (Pi\*Crack Length) **Beta** compression = (Alpha compression \* Beta<sub>Correction</sub>) / sqrt (Pi\*Crack Length)

K max = Stress<sub>Max</sub> \* sqrt (Pi\*Crack Length) \* ((Stress<sub>Max</sub> >= 0)? Beta tension: Beta compression) K min = Stress<sub>Min</sub> \* sqrt (Pi\*Crack Length) \* ((Stress<sub>Min</sub> >= 0)? Beta<sub>tension</sub>: Beta<sub>compression</sub>)

 $\mathbf{K}_{\max} = \mathbf{K}_{\max} + \mathbf{K}_{res}$  $\mathbf{K}_{\min} = \mathbf{K}_{\min} + \mathbf{K}_{res}$ 

## **Proposed K Calculation - Alpha**

Alpha <sub>axial-tension</sub> = Alpha <sub>axial</sub> \*AxialTensionModifier Alpha <sub>bending-tension</sub> = Alpha<sub>bending</sub> \*BendingTensionModifier Alpha <sub>bearing-tension</sub> = Alpha<sub>bearing</sub> \*BearingTensionModifier Alpha <sub>axial-compression</sub> = Alpha <sub>axial</sub> \*AxialCompressionModifier Alpha <sub>bending-compression</sub> = Alpha<sub>bending</sub> \*BendingCompressionModifier Alpha <sub>axial-compression</sub> = Alpha<sub>bending</sub> \*BearingCompressionModifier

Beta axial-tension = (Alpha axial-tension * Beta <sub>Correction</sub> ) / sqrt (Pi*Crack Length)
Beta bending-tension = (Alpha bending-tension * Beta <sub>Correction</sub> ) / sqrt (Pi*Crack Length)
Beta bearing-tension = (Alpha bearing-tension * Beta <sub>Correction</sub> ) / sqrt (Pi*Crack Length)
Beta axial-compression = (Alpha axial-compression * Beta <sub>Correction</sub> ) / sqrt (Pi*Crack Length)
<b>Beta</b> bending-compression = (Alpha bending-compression * Beta <sub>Correction</sub> ) / sqrt (Pi*Crack Length)
Beta bearing-compression = (Alpha bearing-compression * Beta Correction) / sqrt (Pi*Crack Length)

## **Proposed K Calculation - Beta**

 $\mathbf{K}_{max} = \mathbf{K}_{max-axial} + \mathbf{K}_{max-bending} + \mathbf{K}_{max-bearing}$  $\mathbf{K}_{min} = \mathbf{K}_{max-bearing} + \mathbf{K}_{min-bending} + \mathbf{K}_{min-bearing}$ 

 $\mathbf{K}_{max} = \mathbf{K}_{max} + \mathbf{K}_{res}$  $\mathbf{K}_{min} = \mathbf{K}_{min} + \mathbf{K}_{res}$ 

### New Spectrum Format Goals

- Forward Compatible Can be added without breaking older versions
- Simple Can be easily understood
- Can be created manually in notepad and similar text editors with relatively minor effort
- Can be easily created using programming tools
- Easy to post process by readily available data processing applications (i.e. Excel)
- Easy to edit Modular

## XML Based New Spectrum Format

- XML was designed to transport and store data with a focus on the data
- Is the basis for a majority document formats today: MS Office for example
- Available software libraries easy and fast development
- Familiar to software developers
- Easy to read
- Not as easy to create manually
- Tools exists that assist with XML file creation
- Powerful transformation pre and post processor library

## **Current Spectrum Format**

- •Minimum of 2 files Information and SubSpectrum
- •Text base
- •Very easy to create manually or programmatically

#### Information

```
AFGROW Tutorial Sample Spectrum
Block
BLOCKED
1
```

#### SubSpectrum

1 2 16.000000 0.000000 1 12.000000 8.000000 1000

## Preliminary View of the New Spectrum Format

#### Header



Sub-Spectrum

## Spectrum Header

Title
Description
SubSpectrum Label
Time Dependent or Not
Hours Per Pass
Multi Channel or Not ???

## Sub Spectrum

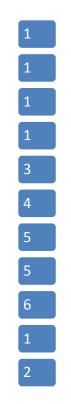


## Level

MinAxial
MaxAxial
MinBearing
MaxBearing
MinBending
MaxBending
Cycles
Time
Cycle Shape

## New Spectrum Format Sequence

List of sub spectra by name in the order to be applied in the spectrum



# New Spectrum Format Application Support

- Afgrow: Open, View, Zoom, Exceedance curve
- New Spectrum Conversion Utility Afgrow tool
- New Spectrum Design/Editing Application, Separate, but still part of AFGROW in terms of licensing
- Old AFGROW spectrum creation Wizard will be removed

## New Spectrum Design/Edit Application Capabilities

- Visual representation of spectrum, sub-spectra
- Editing spectrum in the spreadsheet like control
- Editing Sequence using Drag and Drop
- Clipping
- Truncation
- Spectrum generation from Exceedance Data
- Randomization

# Future Development

- Out of phase spectrum?
- Cycle counting Jim's Cycle counting app?,
- Any other suggestions?

# Summary

- Afgrow will have Multi-channel spectrum support in the next release
- New spectrum format development has been completed
- A new spectrum tool will be created
- Afgrow will support old spectrum format initially, but we hope to transition everyone to the new format