Advances in Bias Weld Fatigue Modeling

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Introduction

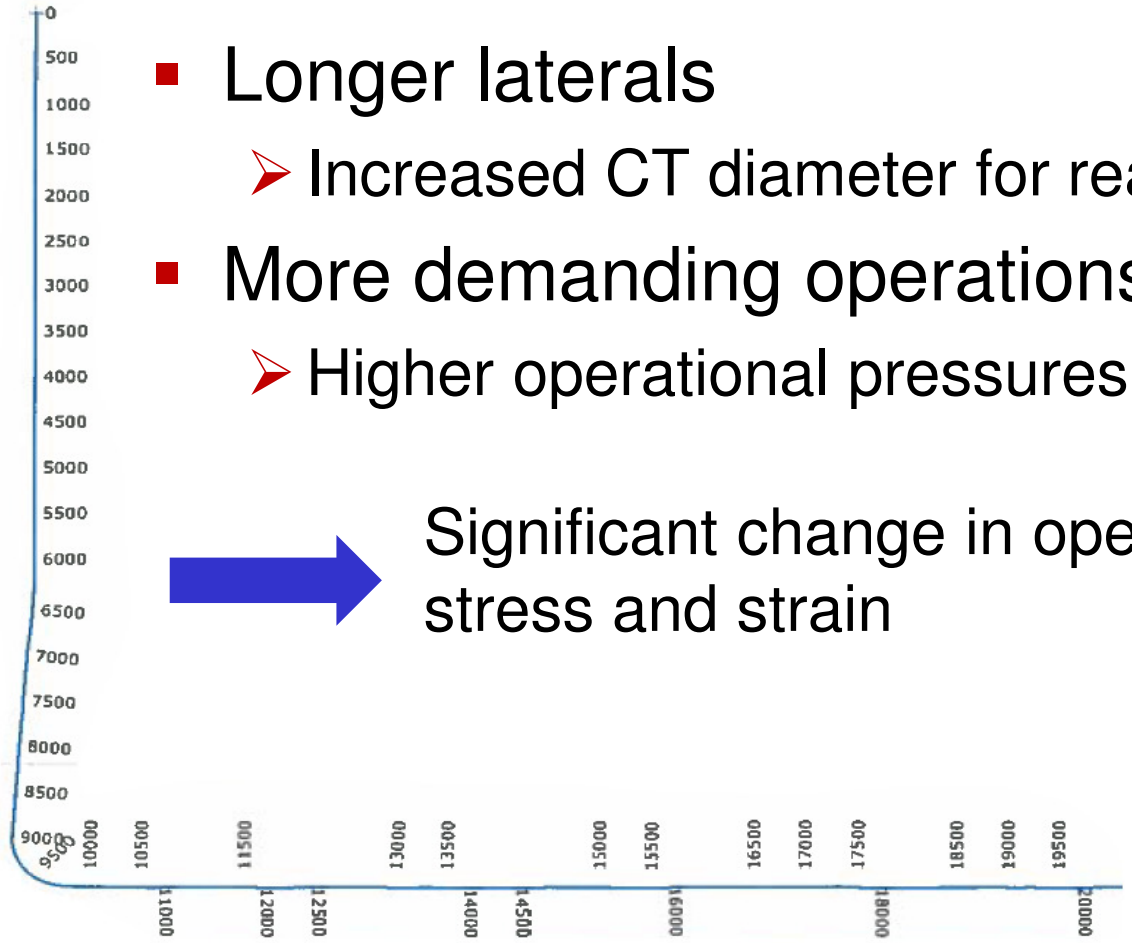
- CT Fatigue Refresher
- Fatigue Modeling
  - Base materials
  - Bias welds
- Case Study

Refresher - CT Fatigue

CT Fatigue Dependencies

- Bending Strain (Geometry)
  - $\varepsilon = r/R$
- Stress due to pressure
  - Von Misses Stress or Hoop Stress
- Tubing Material Properties
- Previous Fatigue Accumulation

Extended Reach Operations and Fatigue



- Longer laterals
  - Increased CT diameter for reach
- More demanding operations
  - Higher operational pressures

Significant change in operational stress and strain

Bias Weld Derating System

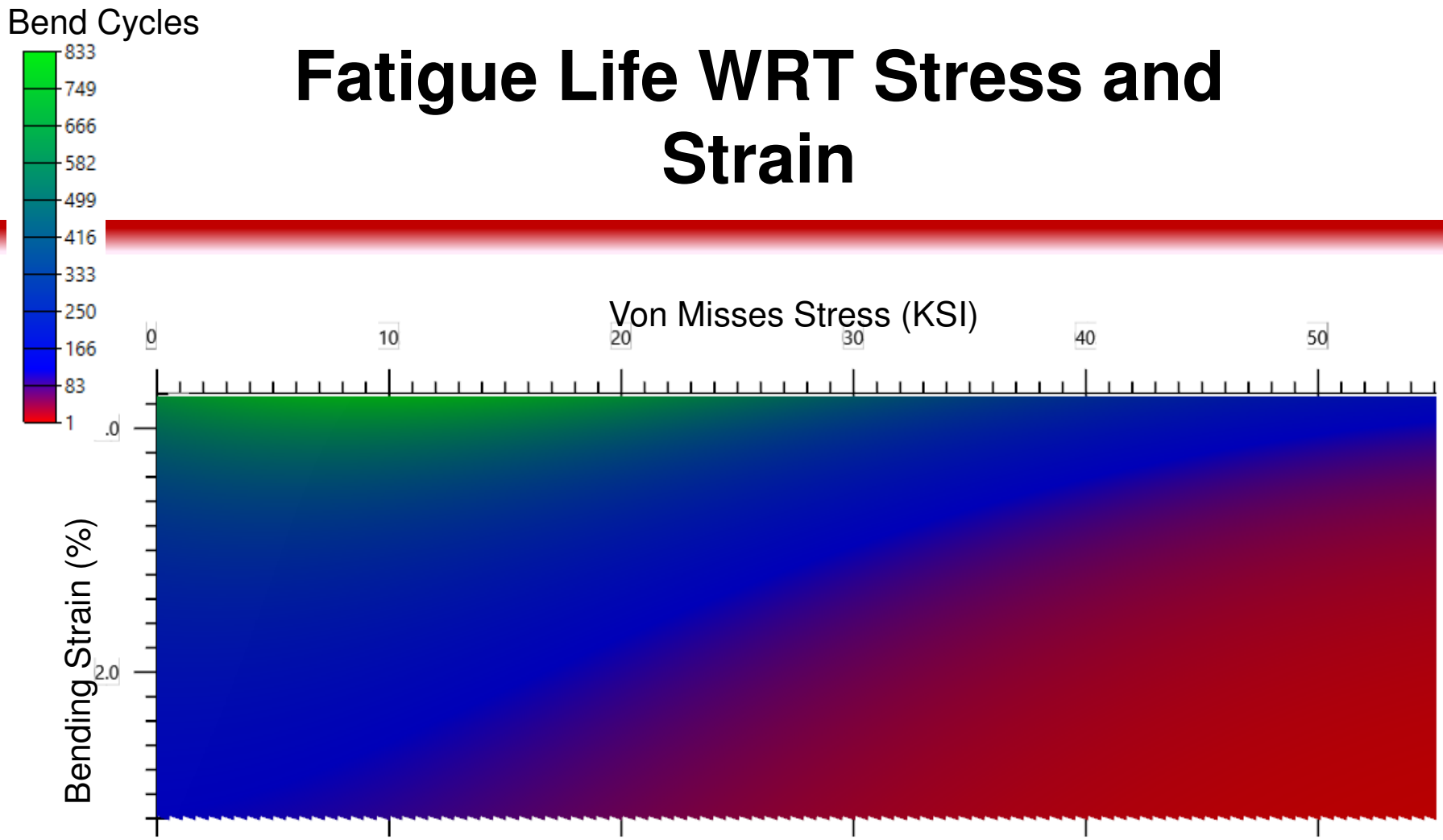
- **Welds Historically Modeled Using Constant "Derating Factors"**
  - **Developed in 1995**
  - **CT70 to CT100 grades only**
  - **110 total bias weld tests**
  - **CT sizes from 1.25" to 3.5"**
    - **Primary focus on 1.75"**
  - **3 Test Pressures Used: 1,500 // 3,000 // 5,000 PSI**

Type	Derating Factor
Bias Weld	80%
Bias Tapered Weld	50%
Orbital Weld	45%
Manual Weld	35%
Manual Tapered Weld	15%

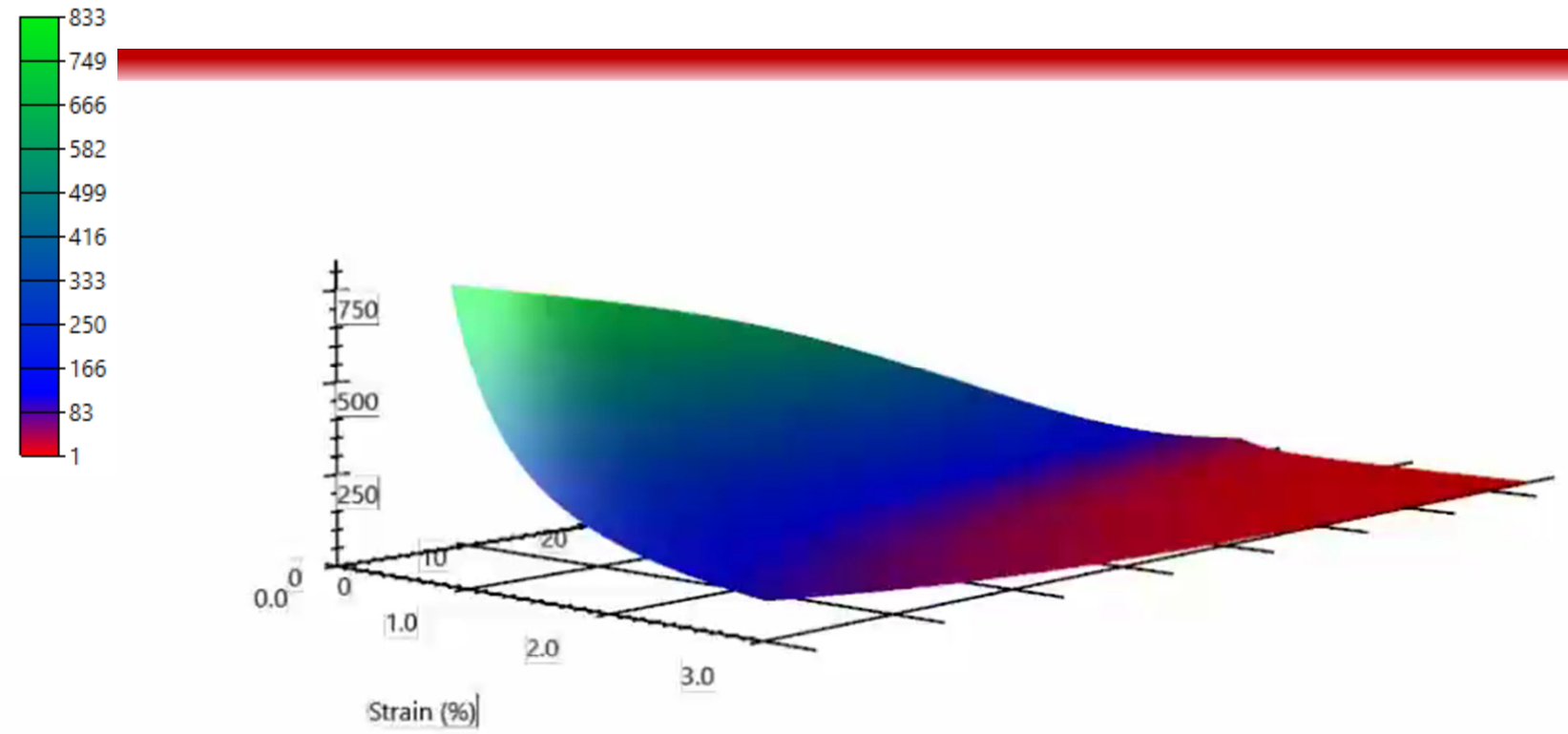
Base Material + Bias Weld Model Approach

- Perform fatigue tests on both base material and bias welds
- Generate independent base tubing and bias weld models
- Use bias weld model in place of the historical derating method

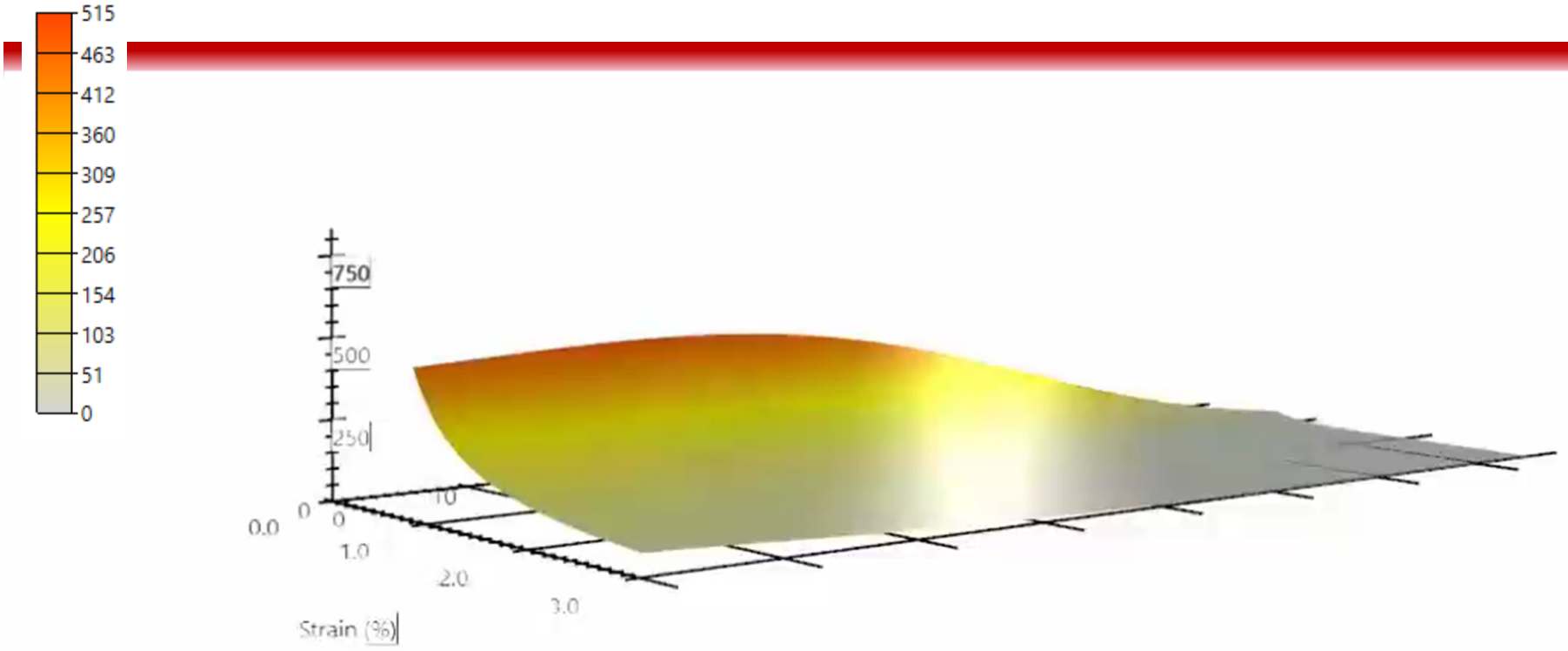
Fatigue Life WRT Stress and Strain



100 ksi Fatigue Life WRT Stress and Strain

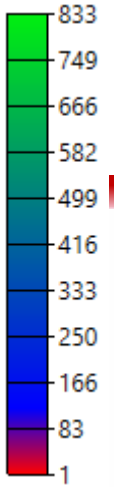


100 ksi Bias Weld Fatigue WRT Stress and Strain

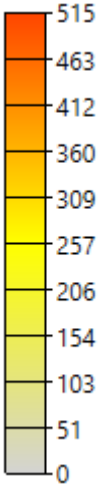


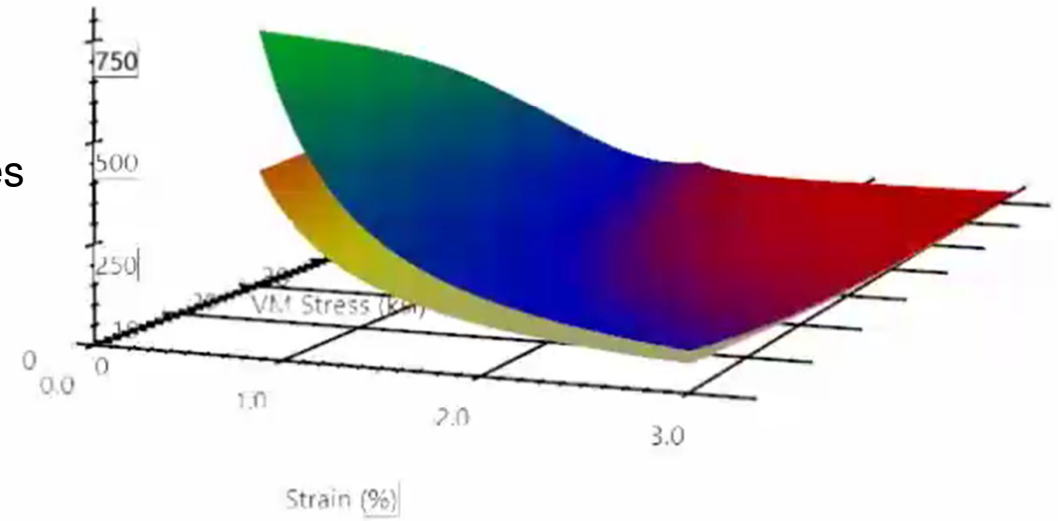
Comparison of Base and Bias Weld Fatigue

Base Cycles

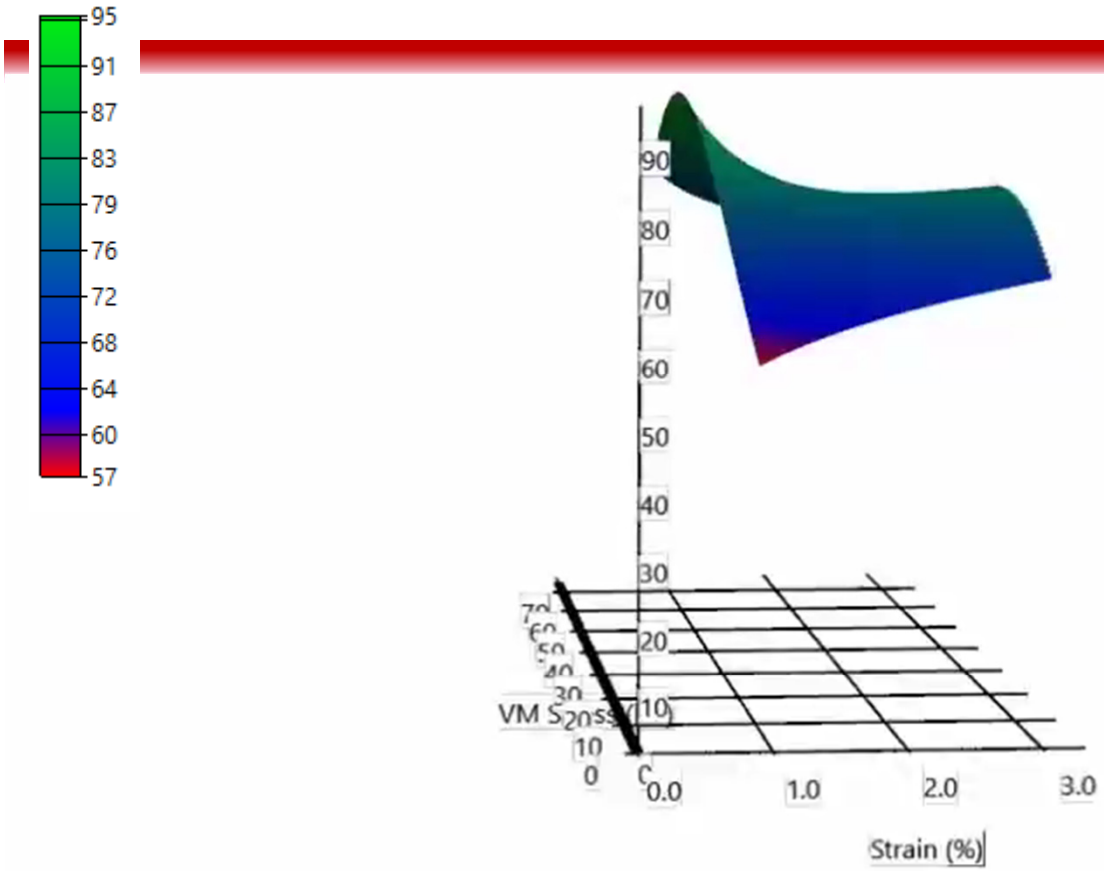


Bias Weld Cycles

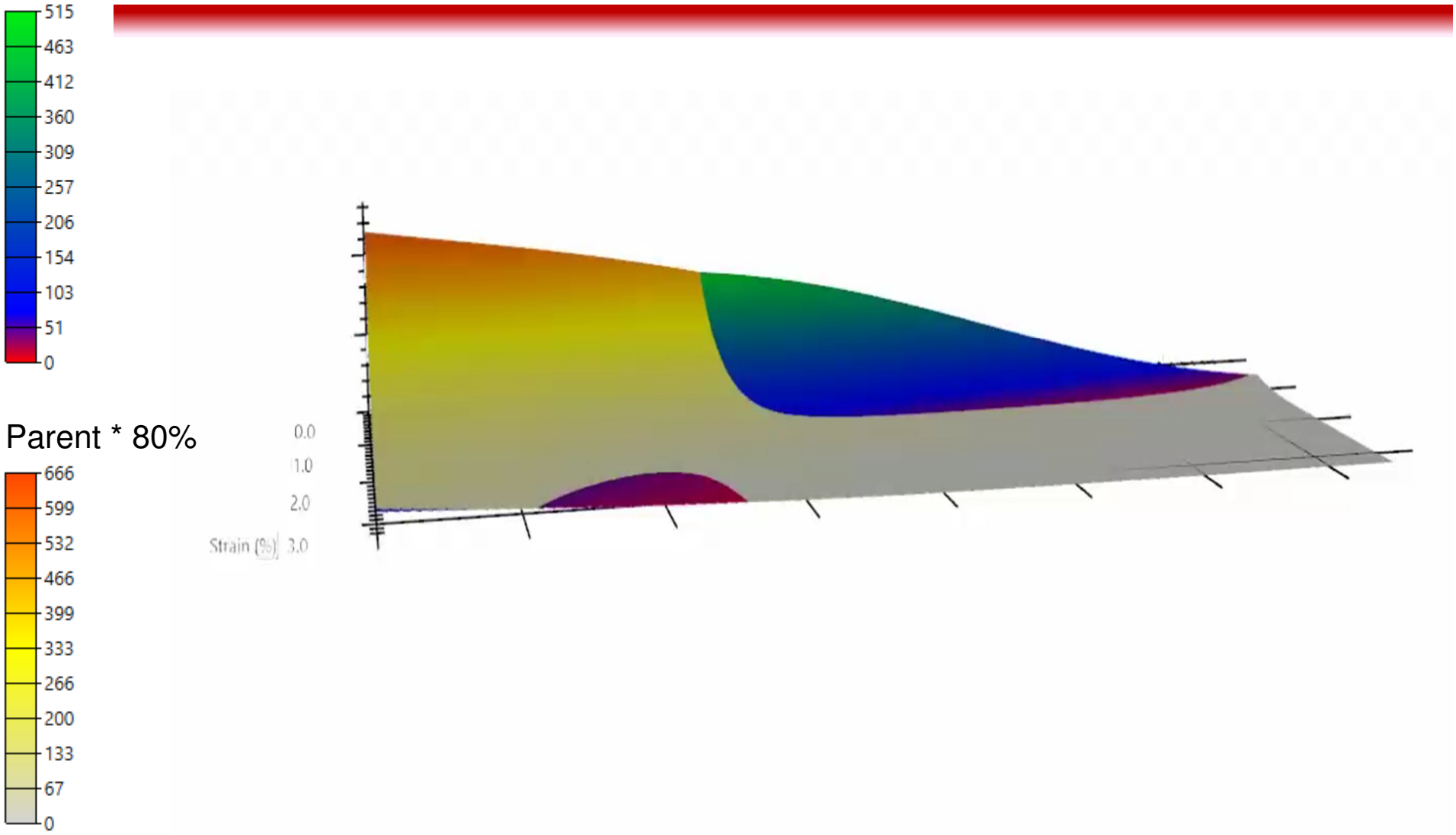




Bias Weld ‘Derating’ WRT Stress and Strain



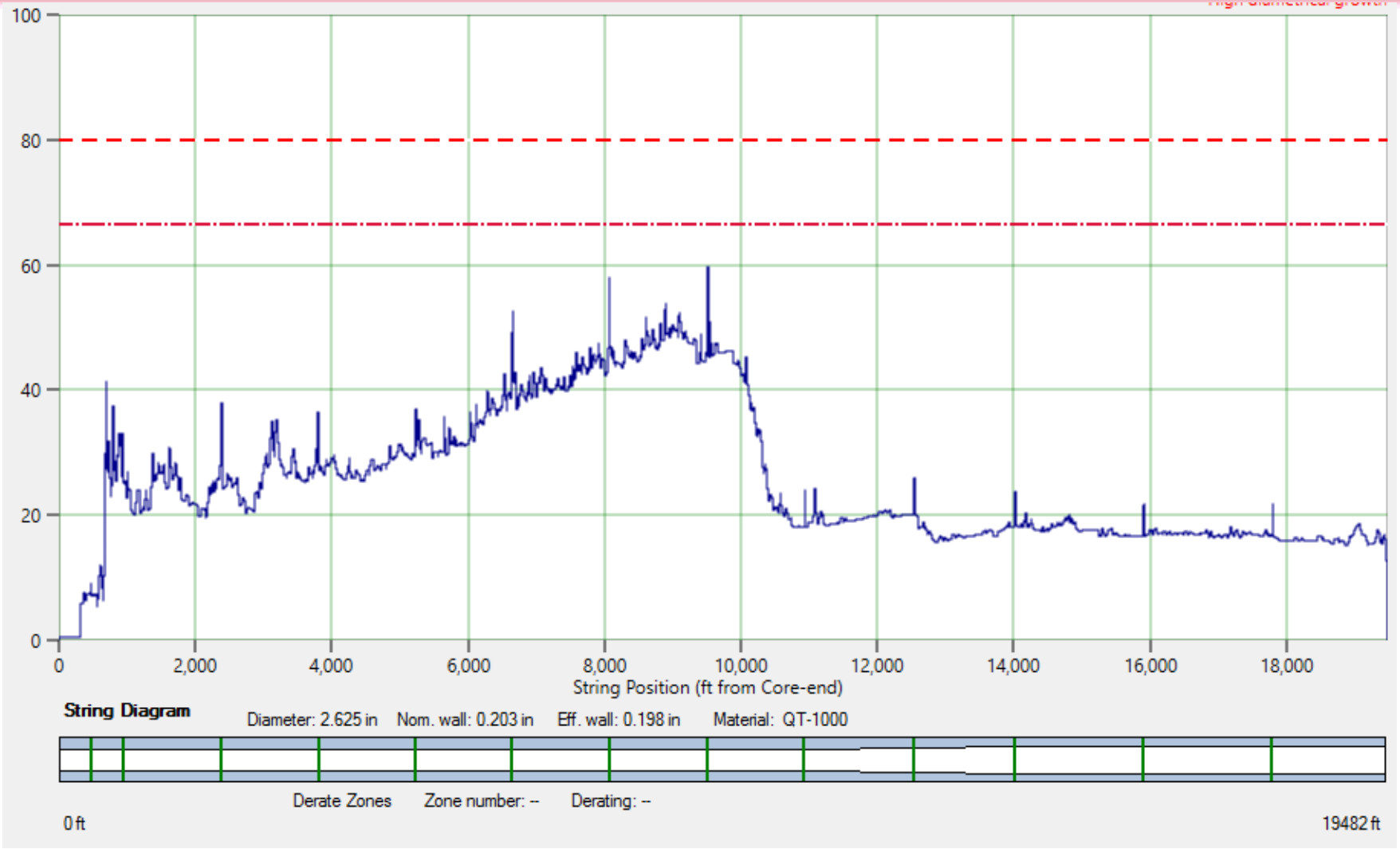
Bias Weld Model Compared to 80% Derating



String Case Study

- Locate full work history for a string retired due to high fatigue at bias welds
  - 2 5/8” 100 ksi string, 0.156 – 0.203” wall thickness
  - Commissioned: June 2014
  - Retired: September 2014
  - 36 Jobs, ~ 400,000 running feet
- Compare constant derating with bias weld model across the string’s operational stress / strain range

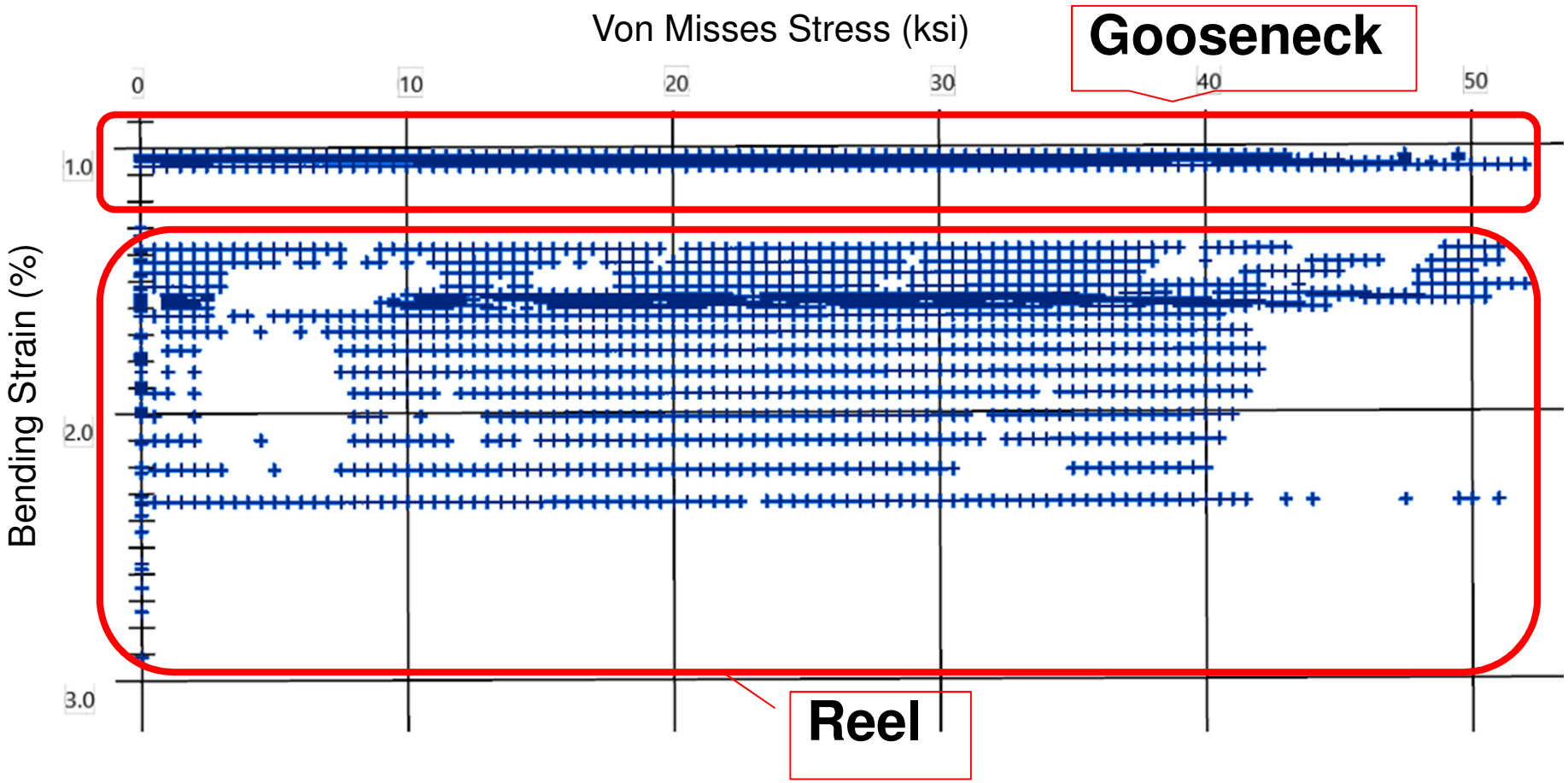
2 5/8” OD String Case Study



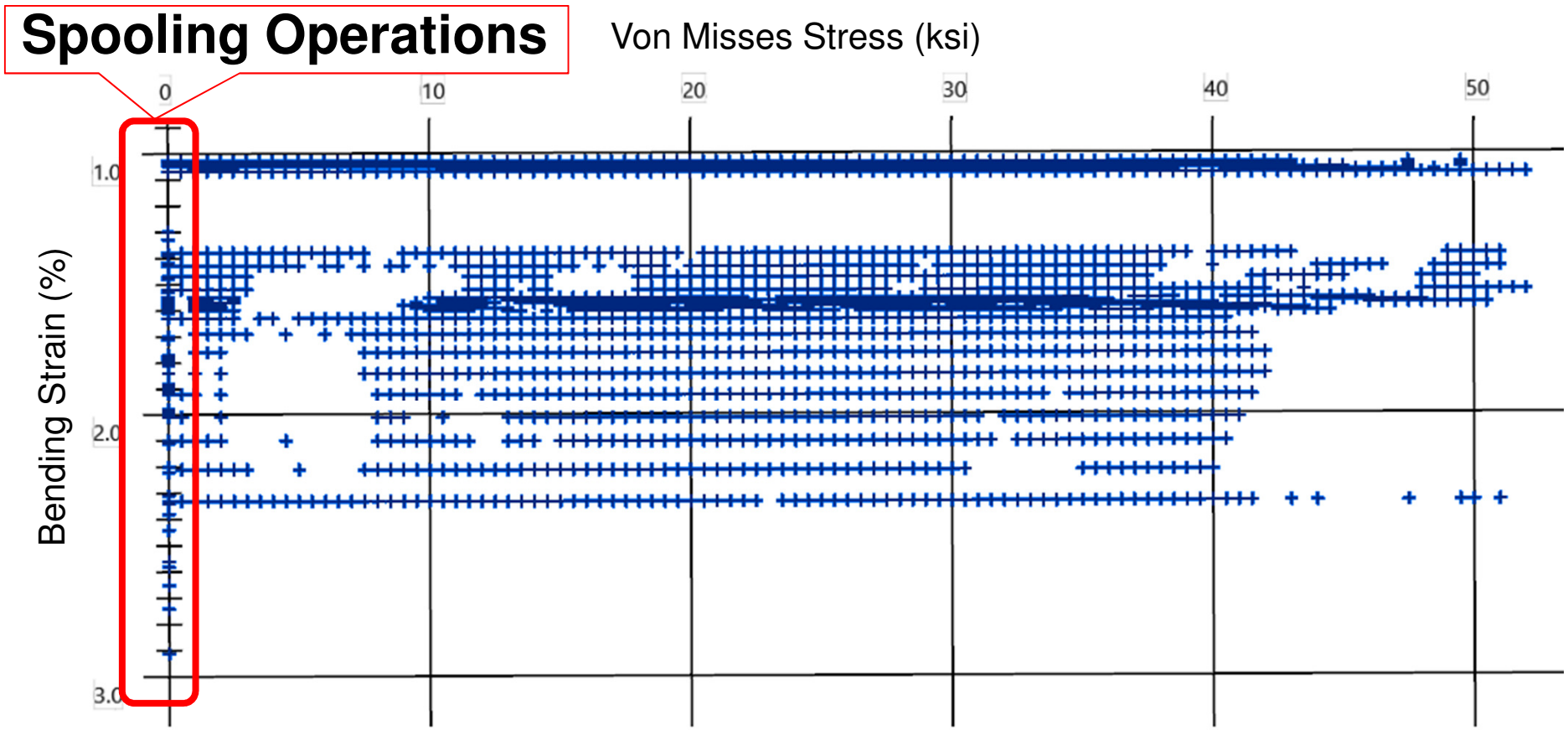
2 5/8” OD String Case Study

- Bending Strain
  - $\varepsilon = r/R$
    - 2 5/8” CT over a 110” Radius Gooseneck: $\varepsilon \approx 1.2\%$
    - 2 5/8” CT over a 96” Core Diameter Reel: $\varepsilon \approx 2.7\%$
- Stress due to pressure
  - Von Misses Stress
    - 2 5/8” CT at 4,000 PSI: VMStress ≈ 25-35 ksi
    - 2 5/8” CT at 8,000 PSI: VMStress ≈ 50-60 ksi

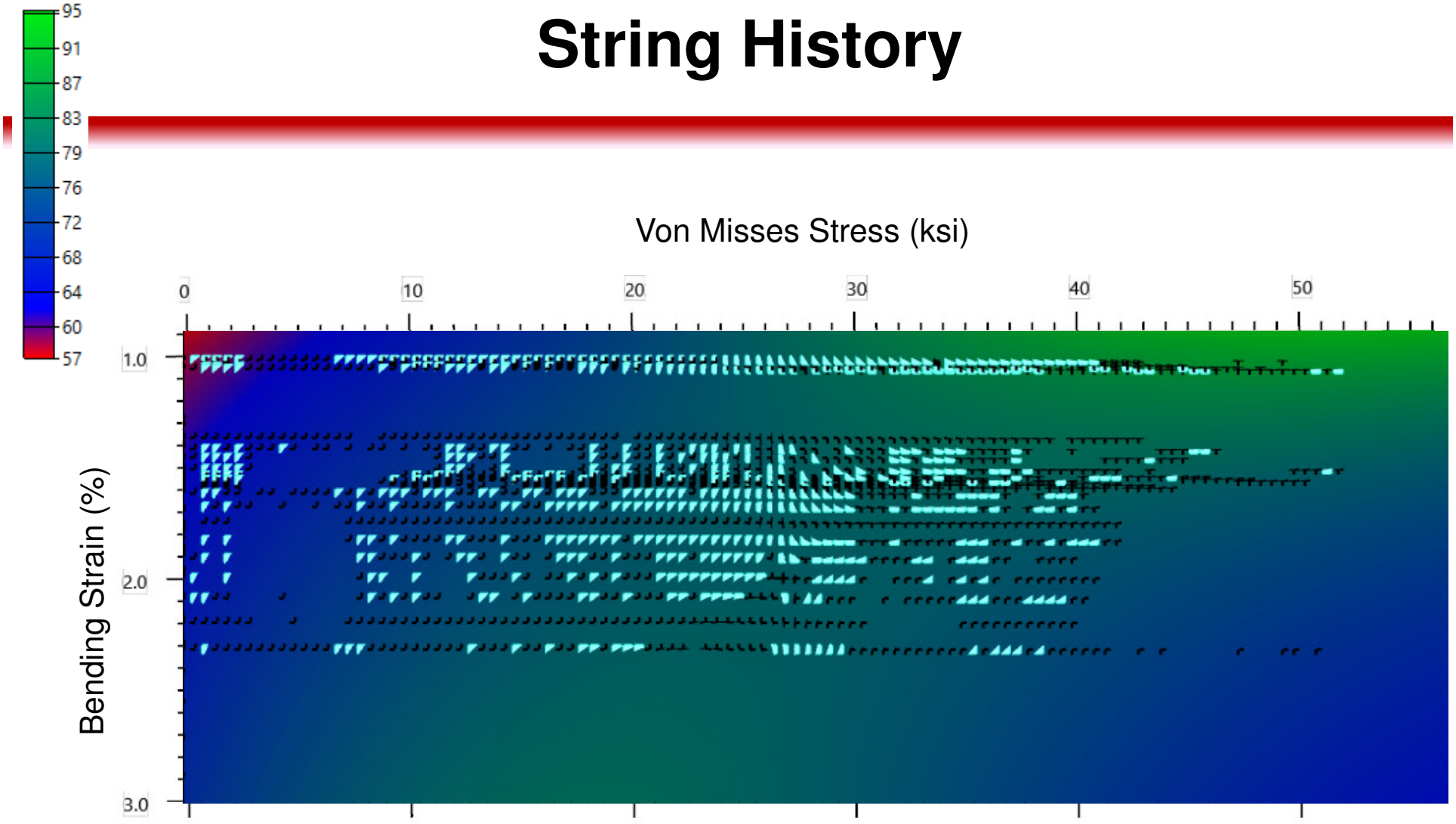
String History



String History



Bias Weld Performance with String History



Conclusions

- ***Historical bias weld derating system does not accurately cover the full stress/strain range***
- ***Bias weld models eliminate the 'derating guessing game'***
- ***Over 350 bias weld fatigue tests in the past 2 years***
- ***5 models currently available, with additional in development***

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Thank You

Questions?