AETC Conference 2011

Understanding Valve Spring Science and Selection, for Optimization, Performance, and Longevity

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PAC Racing Springs

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Key Spring Life Factors Overview

- Static Stress and Design
- Dynamic Stress and Design
- Other Finite Components
- It's all in the details

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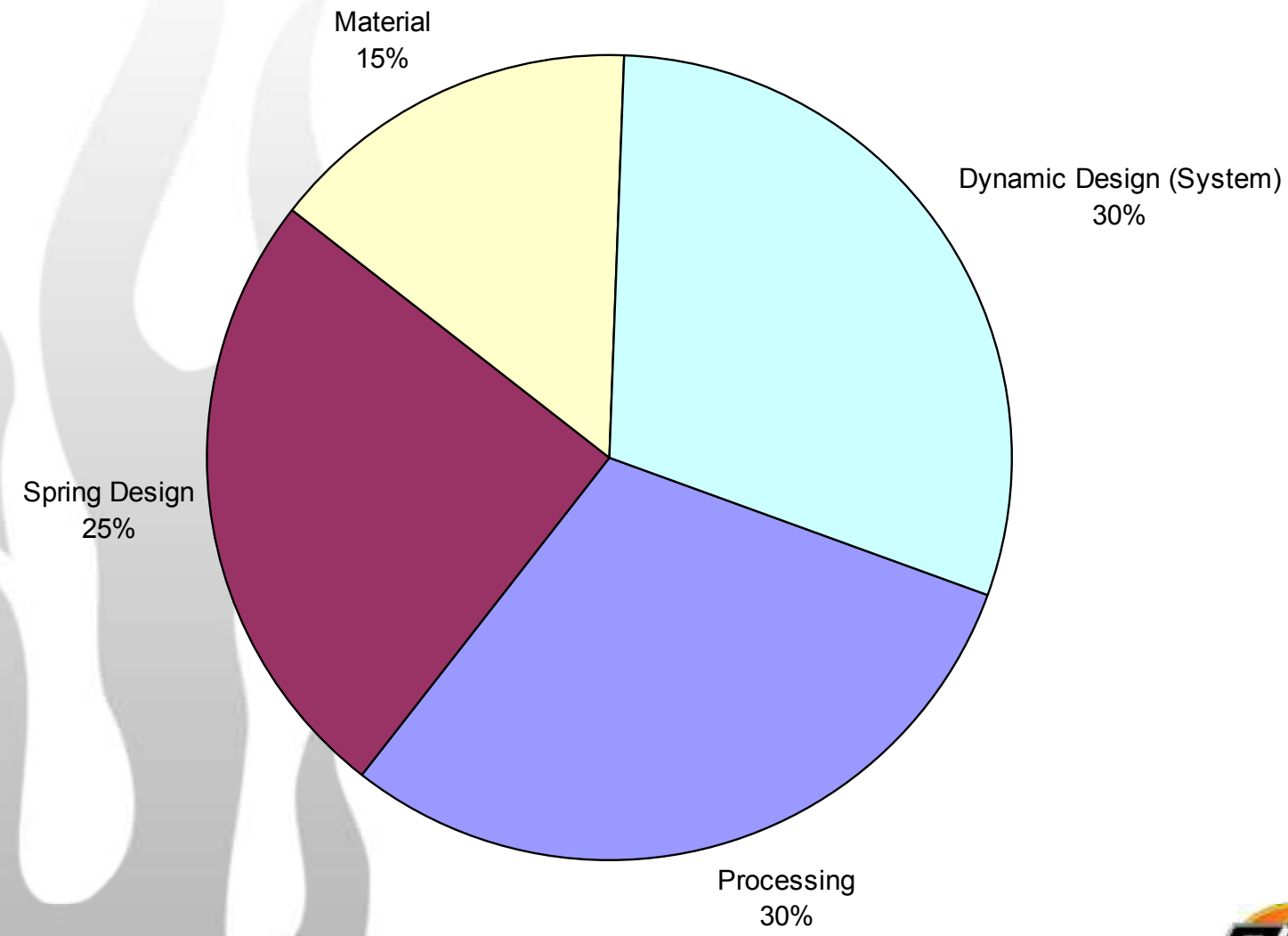
Spring Design and Application



Spring Life Design Factors (Static)

Spring Design Overview Application Performance

- Material Selection (Alloy)
- Processing Selection (Recipe)
- Spring Type: Single, Beehive, Dual, Dampers, Triple
- Wire Shape
- Stress Range Comparisons
- Fatigue Requirements or Performance Requirements
- System Design inputs (RPM, Valve Lift Profile, Mass, other)

Spring Life Design Factors (Static)

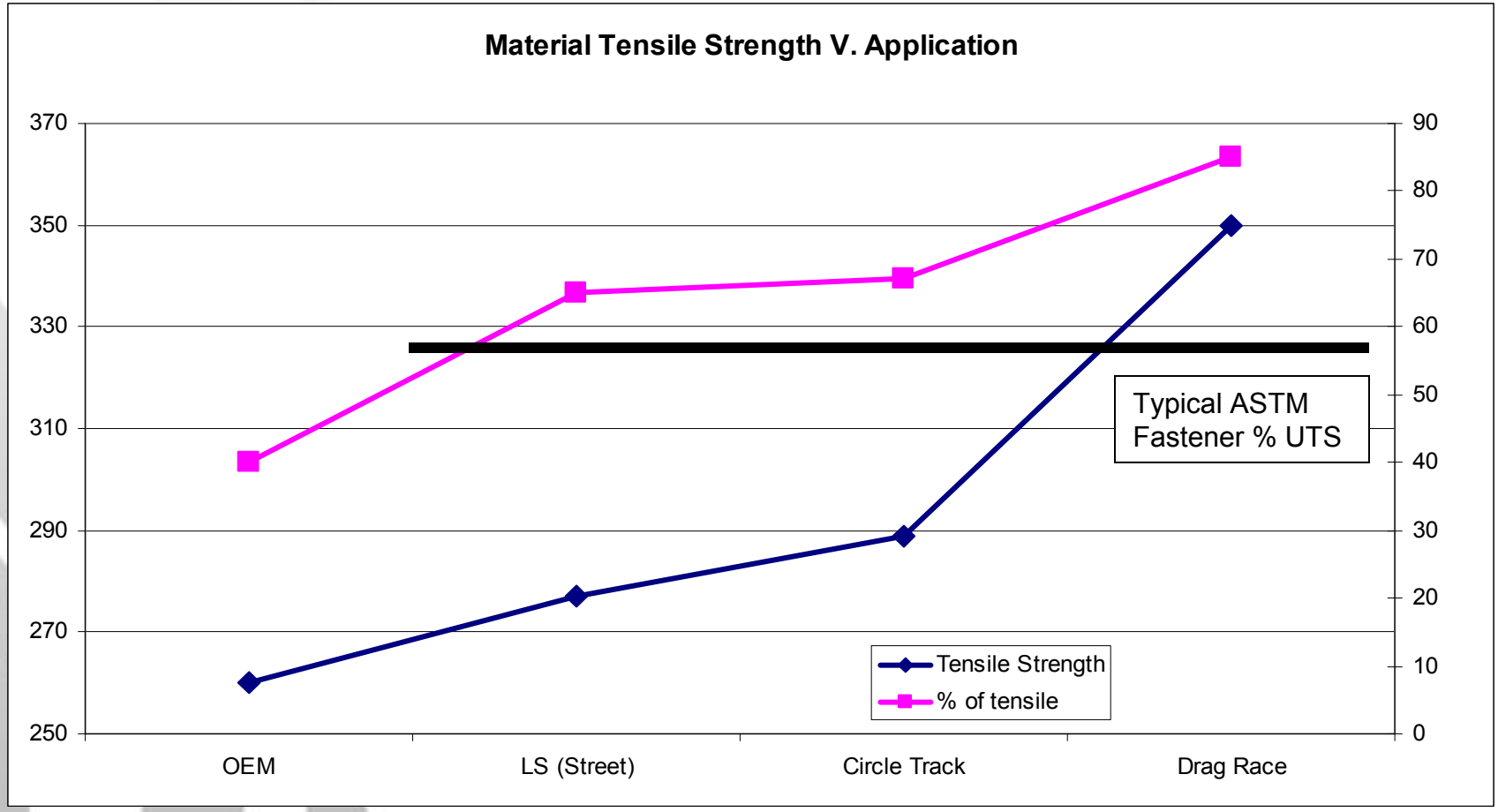
Spring Design Factors for Stress/Life Management

- Increase Tensile Strength
  - Alloy Selection
  - Heat Treating

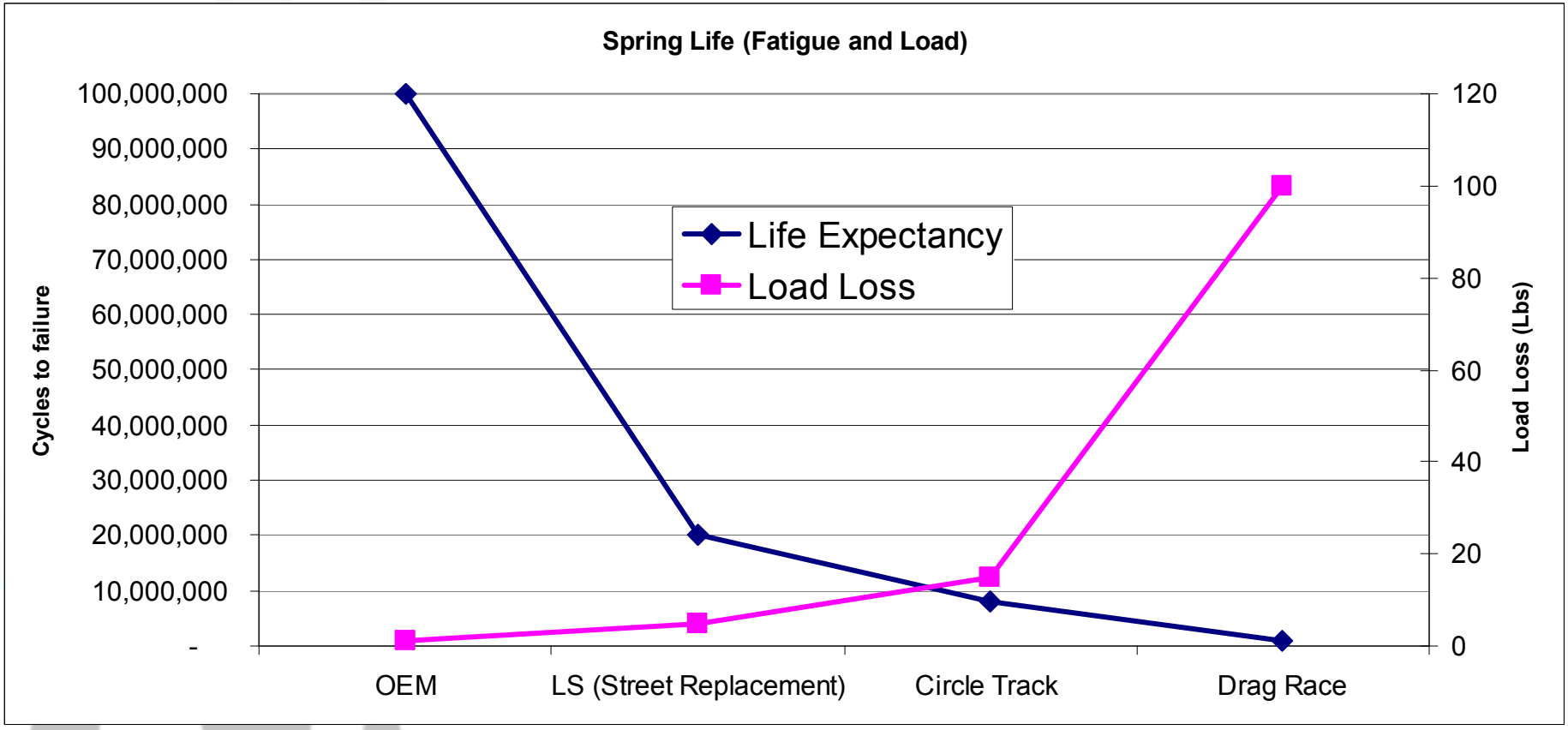
- Metal Improvement with Addition of Compressive Stress or reduction in Tensile Stress
  - Shot Peening
  - Stress Relieving
  - Polishing (removes stress risers)

- Spring Design Considerations
  - Wire Shape
  - Space and Application Considerations
  - Required Load (Dynamic Control)

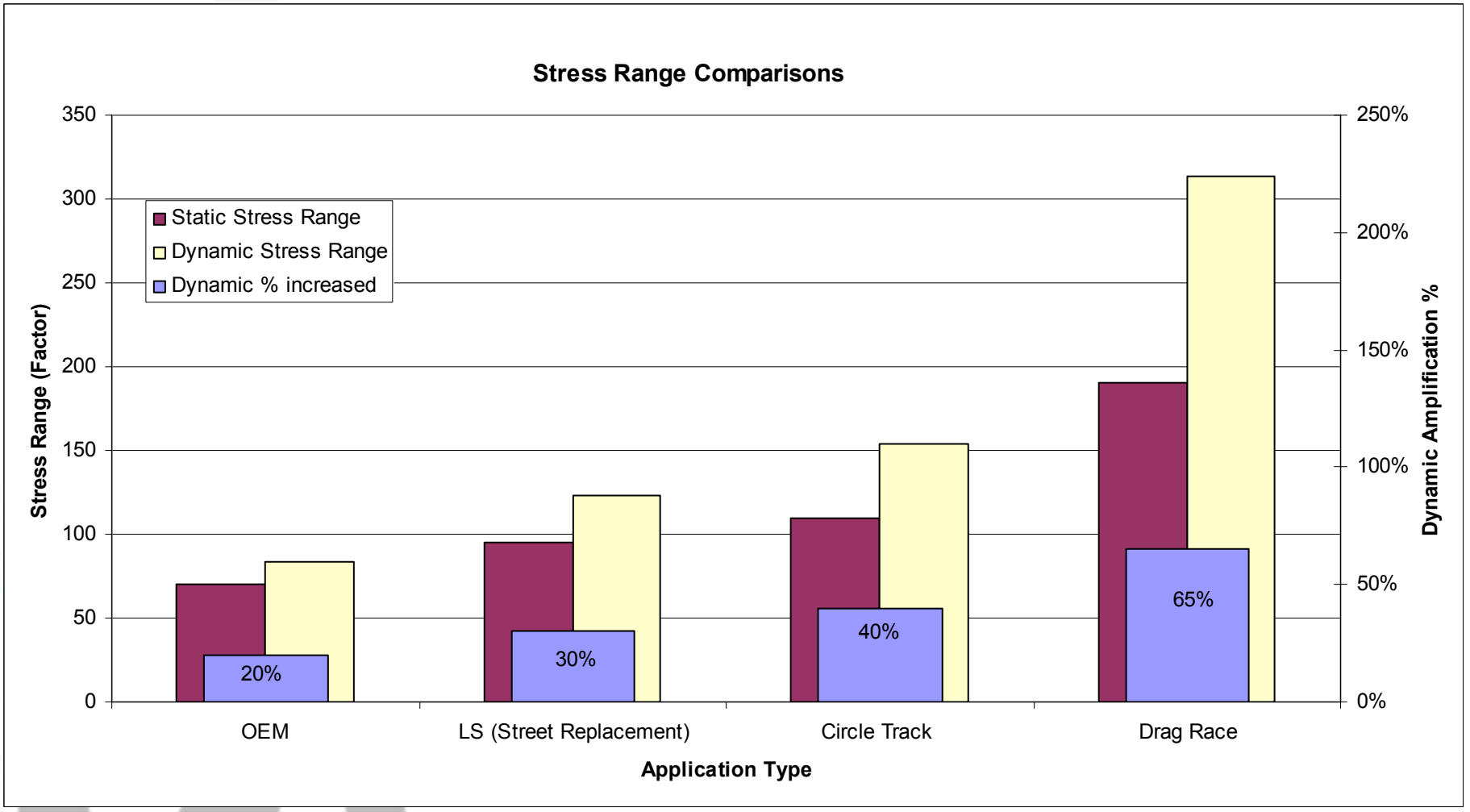
Spring Life Design Factors (Static)



Spring Life Design Factors (Static)



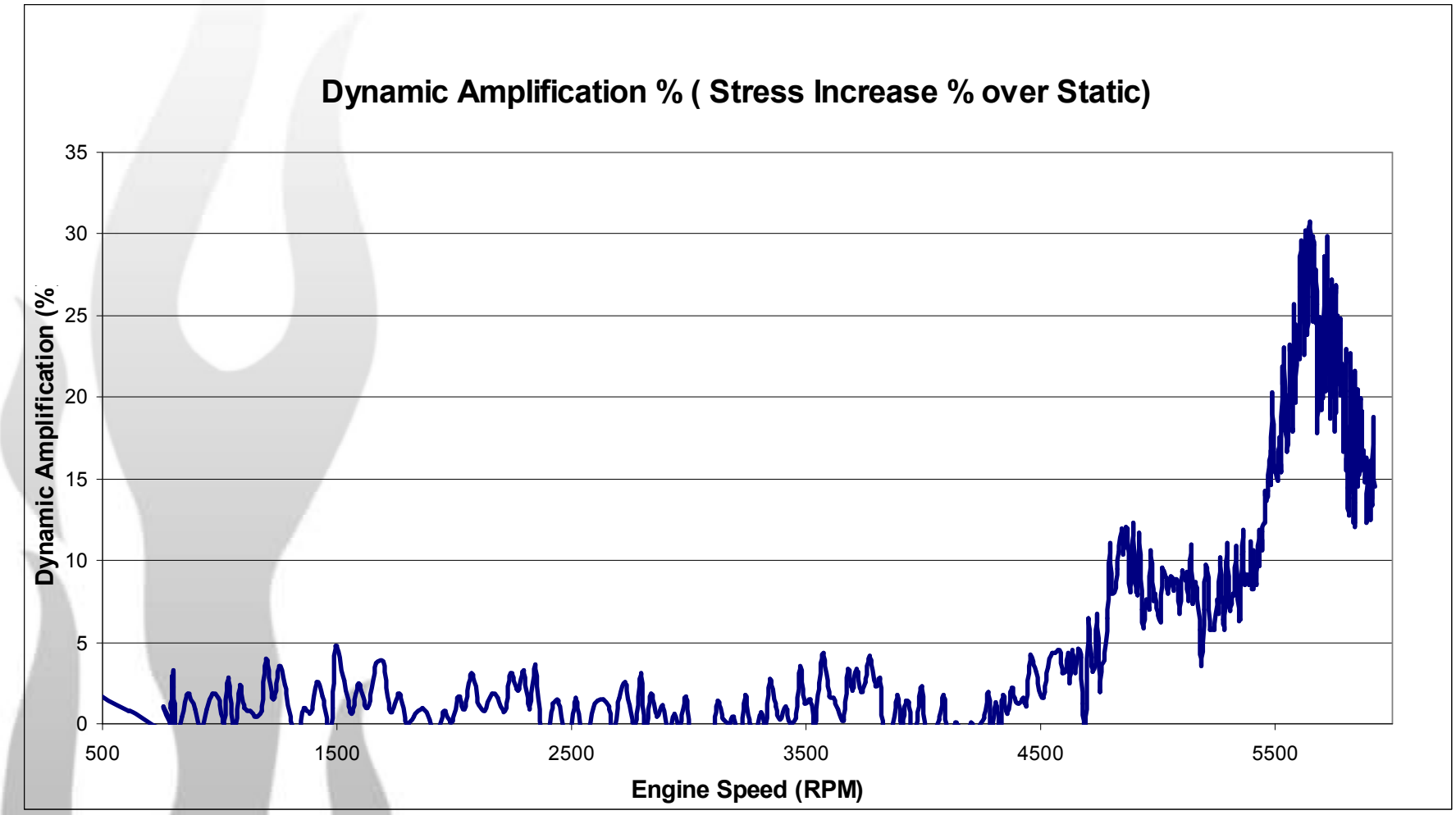
Spring Life Design Factors (Static)



Spring Life Dynamic Stress Factors

- Dynamic Stress Range
- Impact Force (Surge)
- Load Loss Impact (maintain dynamic robustness)
- Cooling and Heat
- Interference
- Damping (designed or external)
  - Rate Curve (progressive, dual, linear)
  - Frictional Damping (ribbon damper, interference of stacked springs, or external damper)

Spring Life Dynamic Factors



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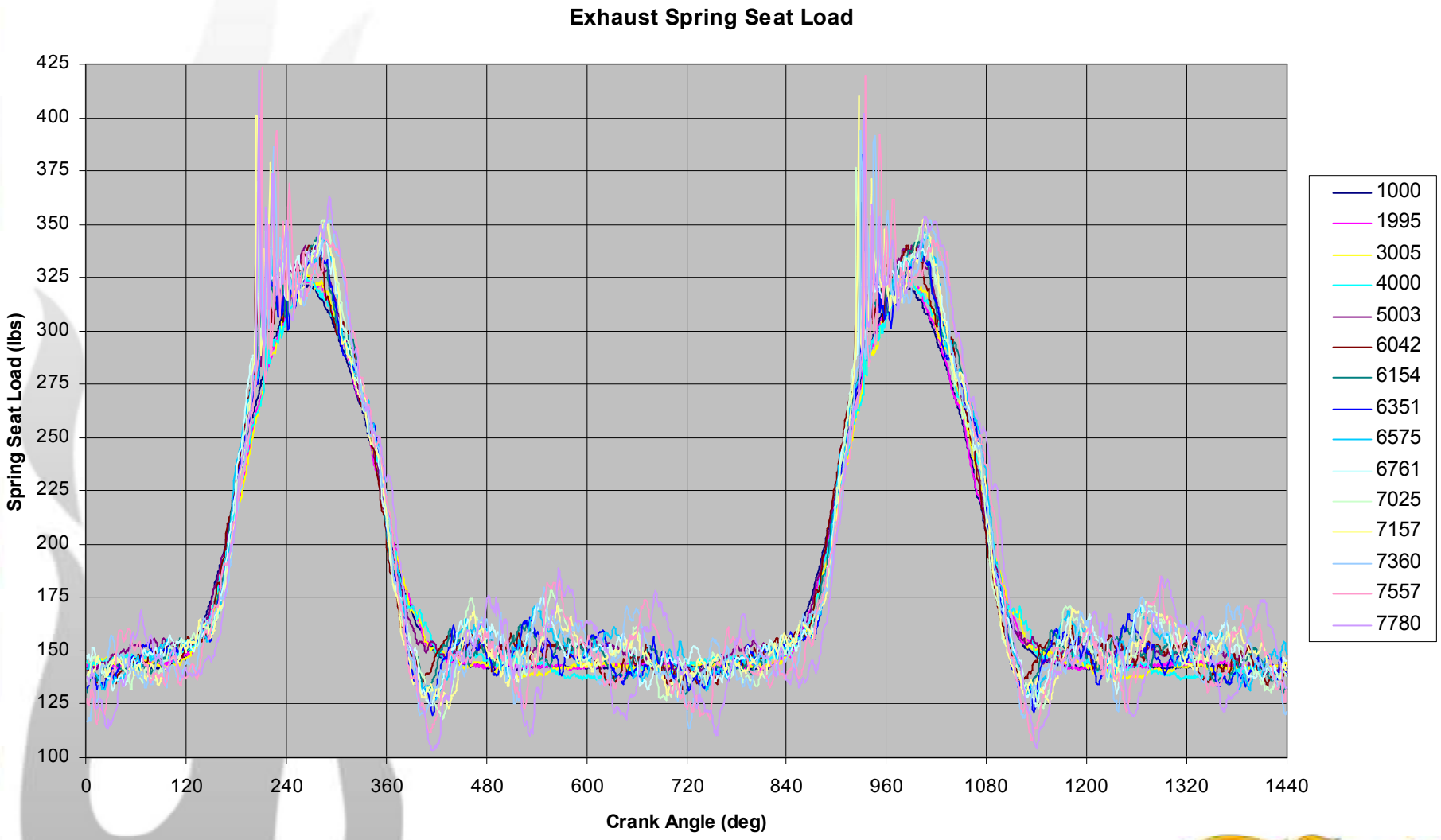
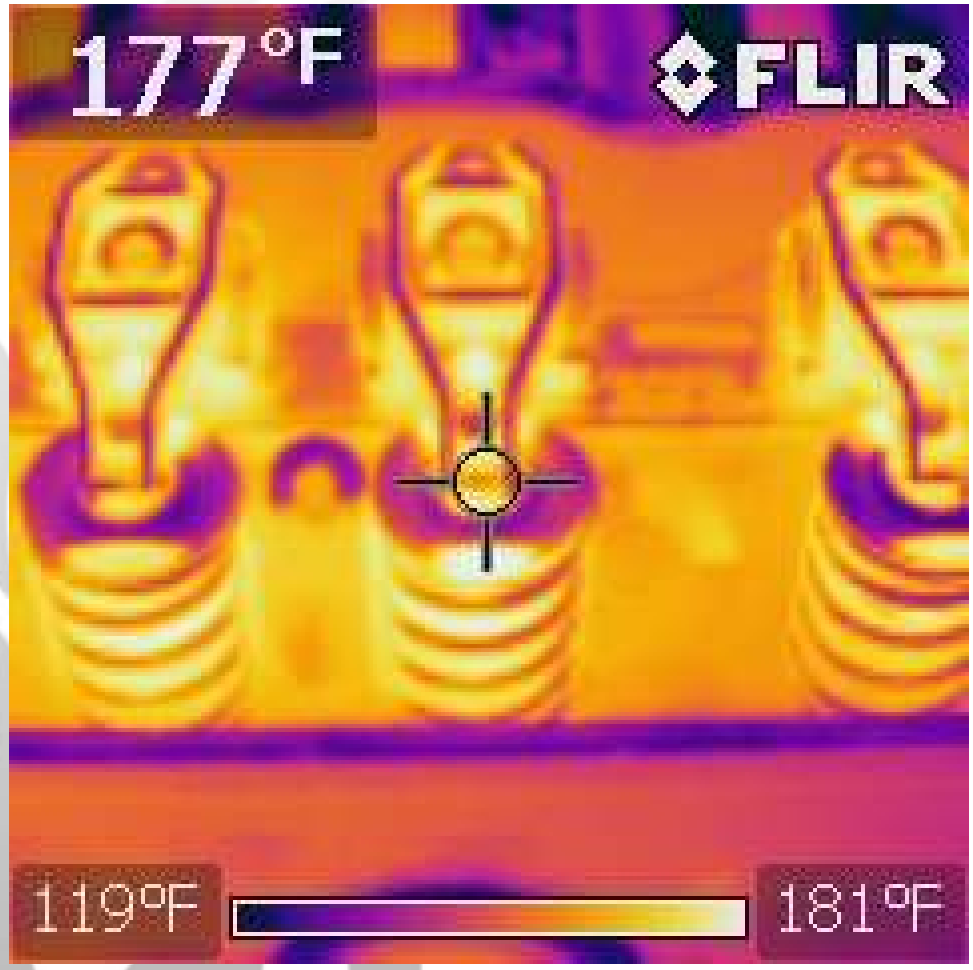
Spring Life Dynamic Factors



Spring Life Dynamic Stress Factors



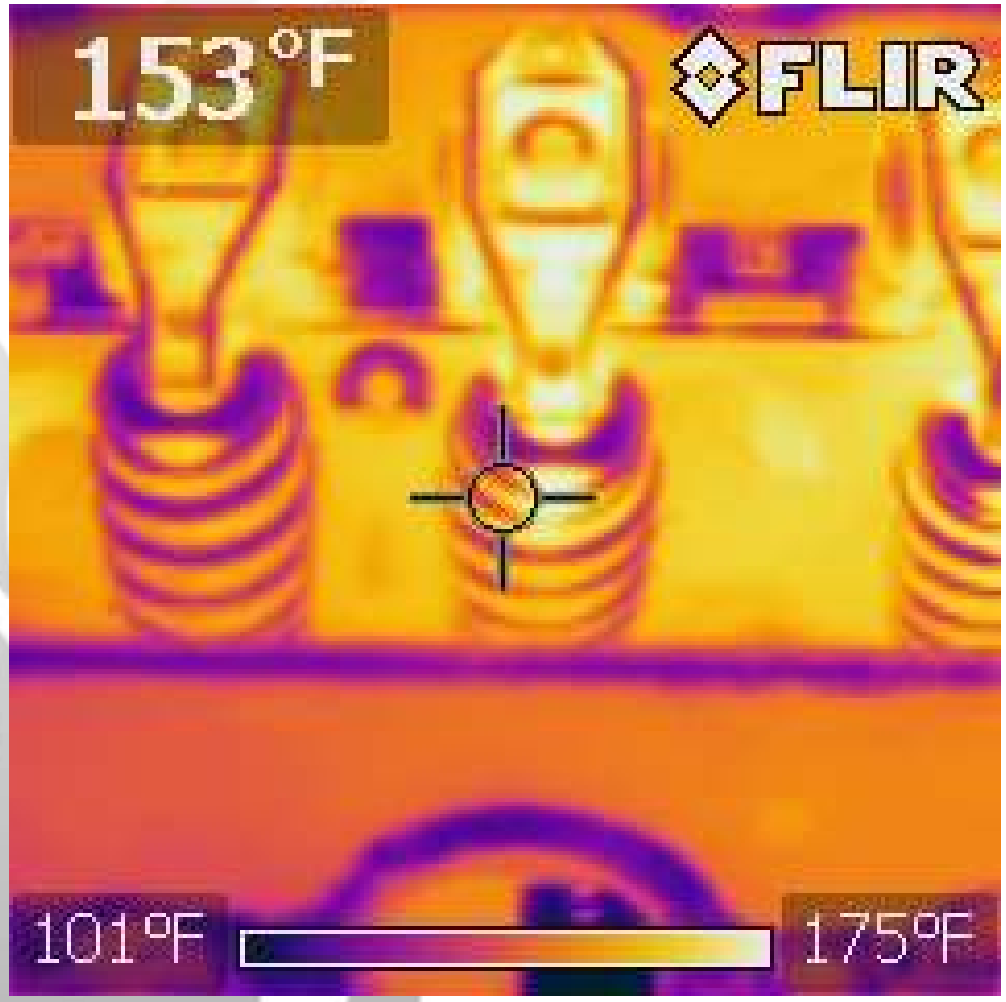
Dual LS Spring (Right Bank)

After 3 Hrs Steady Run Non-Fired Engine

(no external heat or cooling)

***Note increased thermal profile from inside spring

Spring Life Dynamic Stress Factors



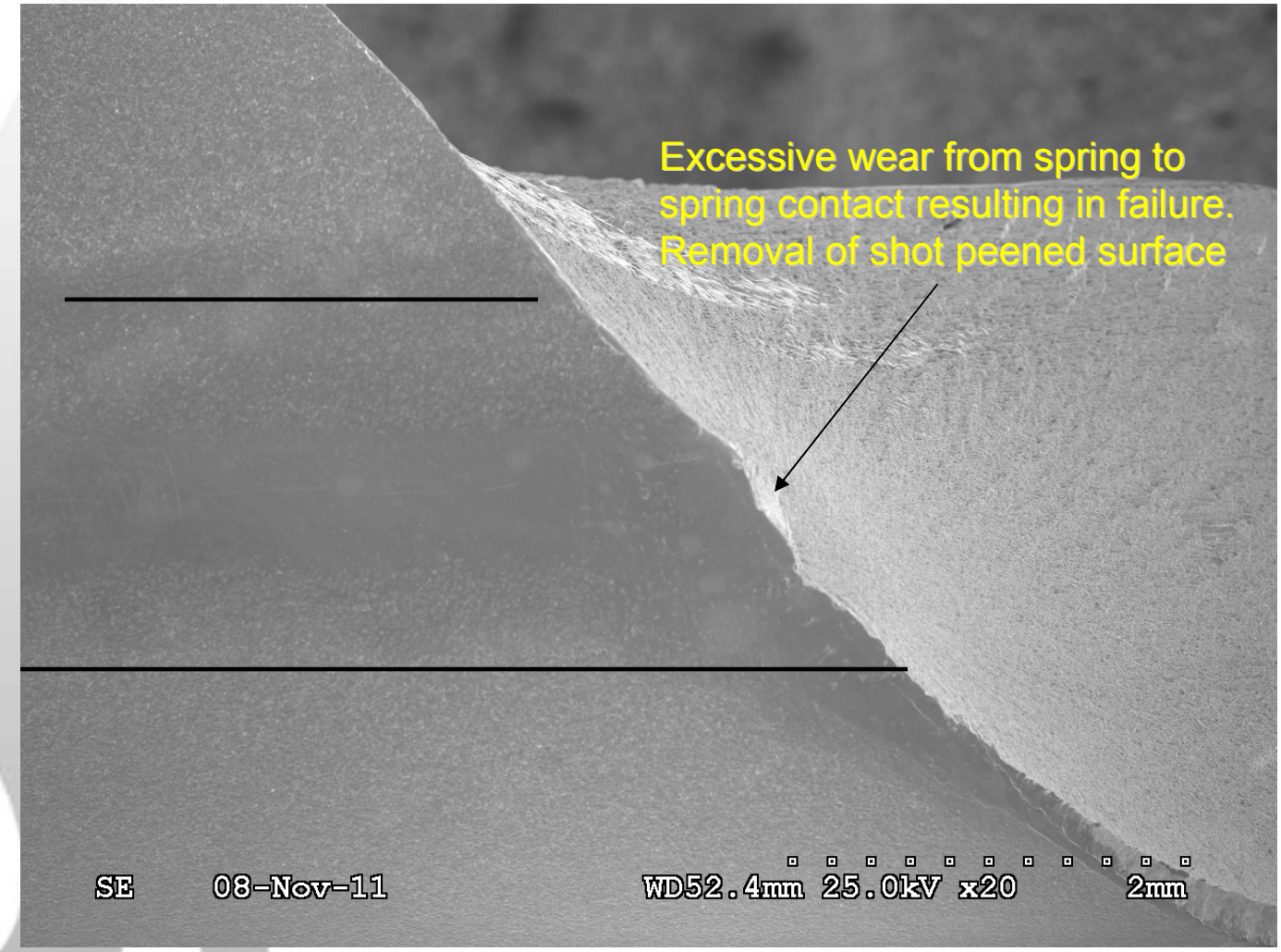
Beehive LS Spring (Left Bank)

After 3 Hrs Steady Run Non-Fired Engine

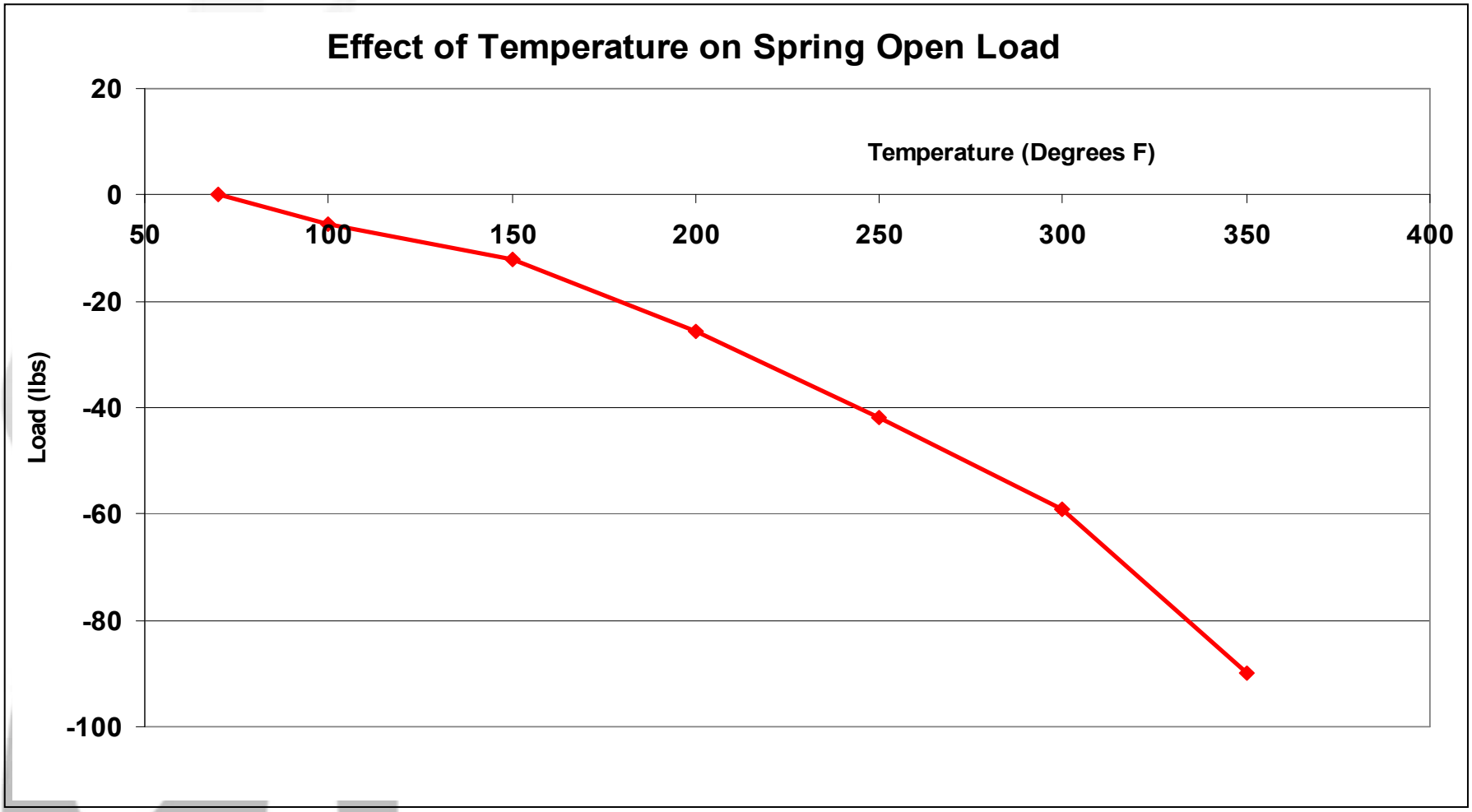
(no external heat or cooling)

***Note reduction in heat from inside spring

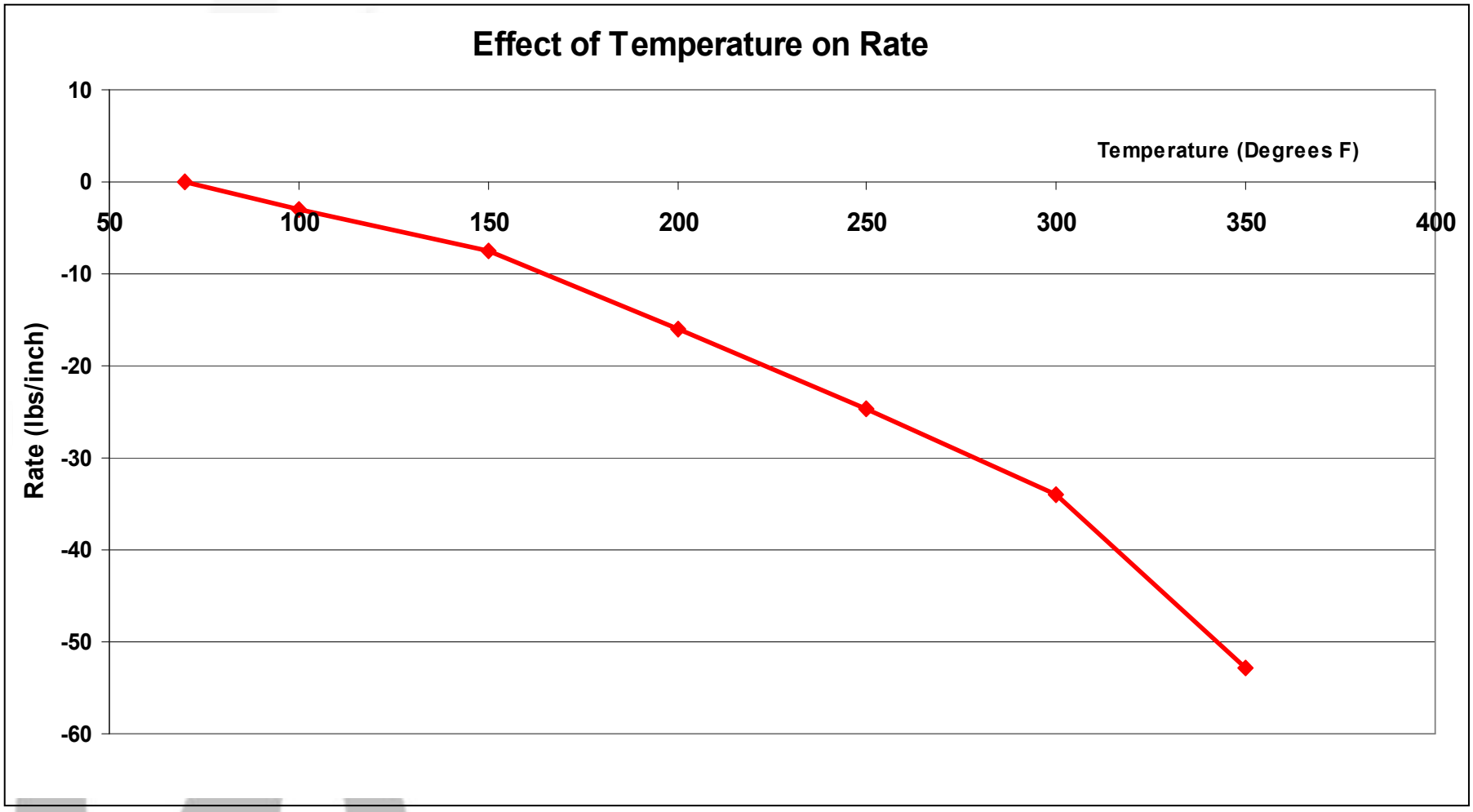
Spring Life Analysis



Spring Life Dynamic Performance



Spring Life Dynamic Performance



Spring Life Dynamic Control (Hysteresis)

Hysteretic Loop - is the difference vs. the static applied load (input) vs. the measured output or response (in this case interference).

We use this method to gage interference and frictional damping coefficients.

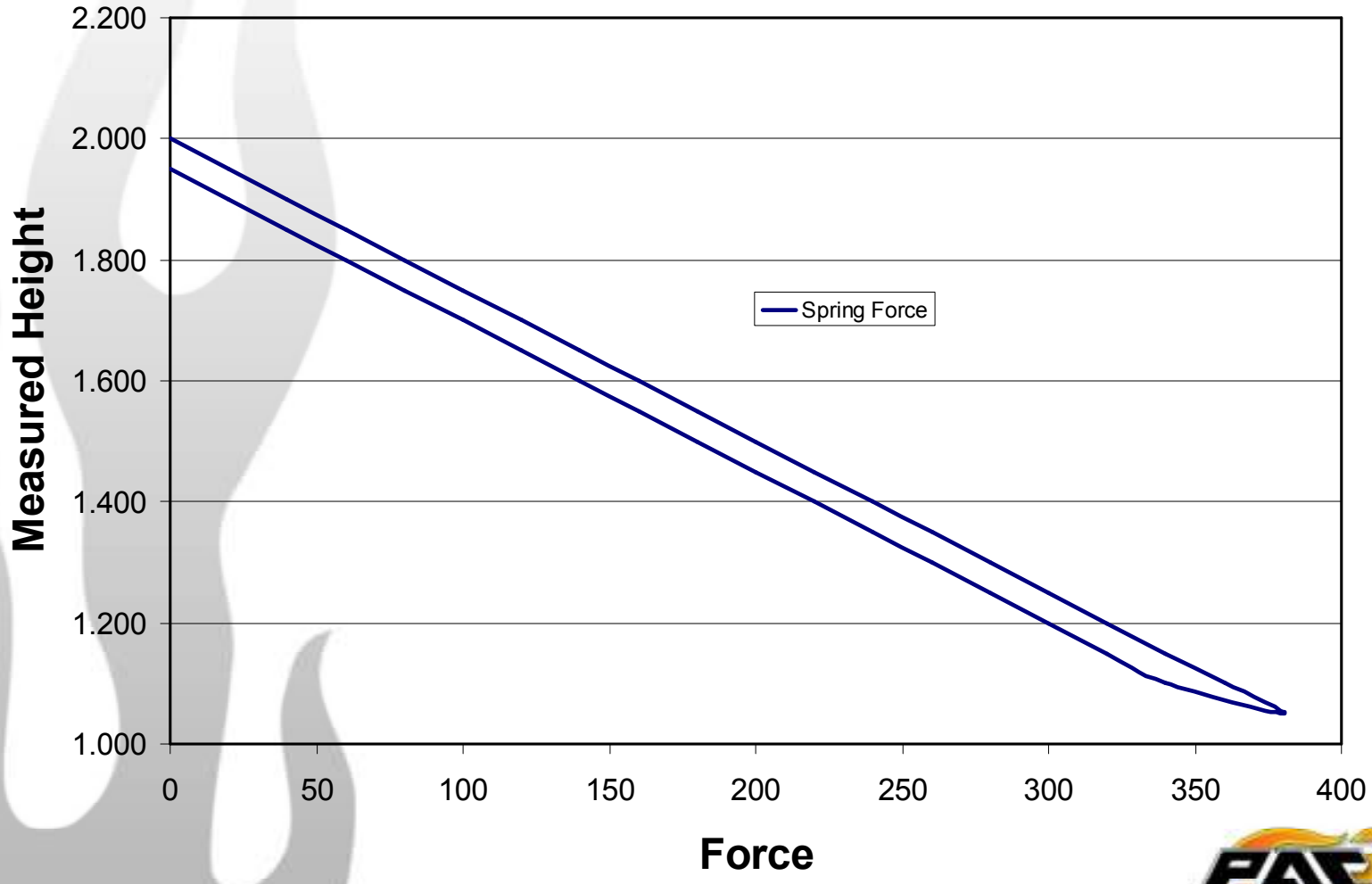
This method is also used in industry to determine system rigidity and compliance.

Note**

This is essentially measuring the force in compression and overlaying the force in re-bound.

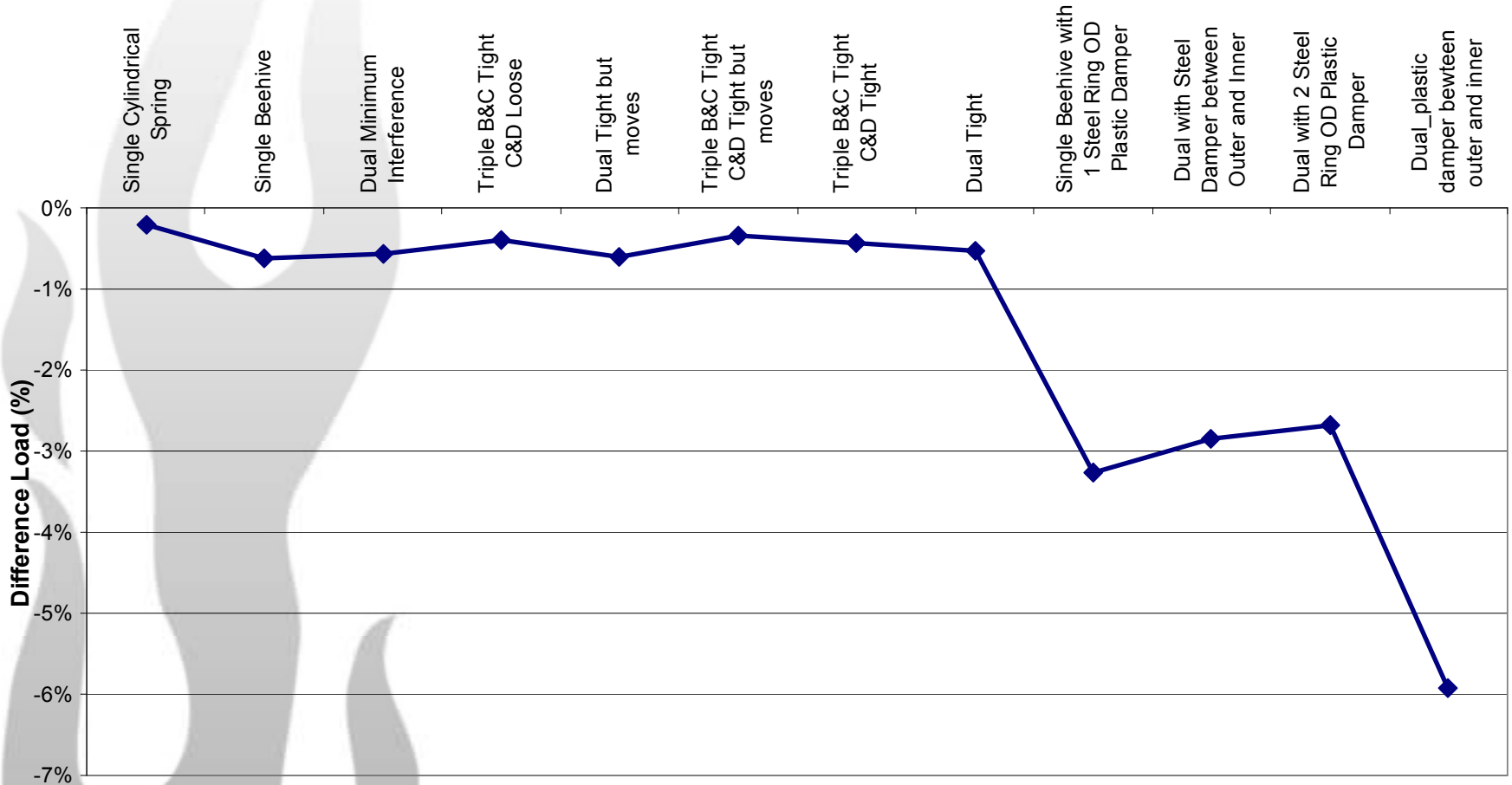
Spring Life Dynamic Control (Hysteresis)

Example of Hysteresis Loop



Spring Life Dynamic Control (Hysteresis)

Hystresis - Percent Difference of Load



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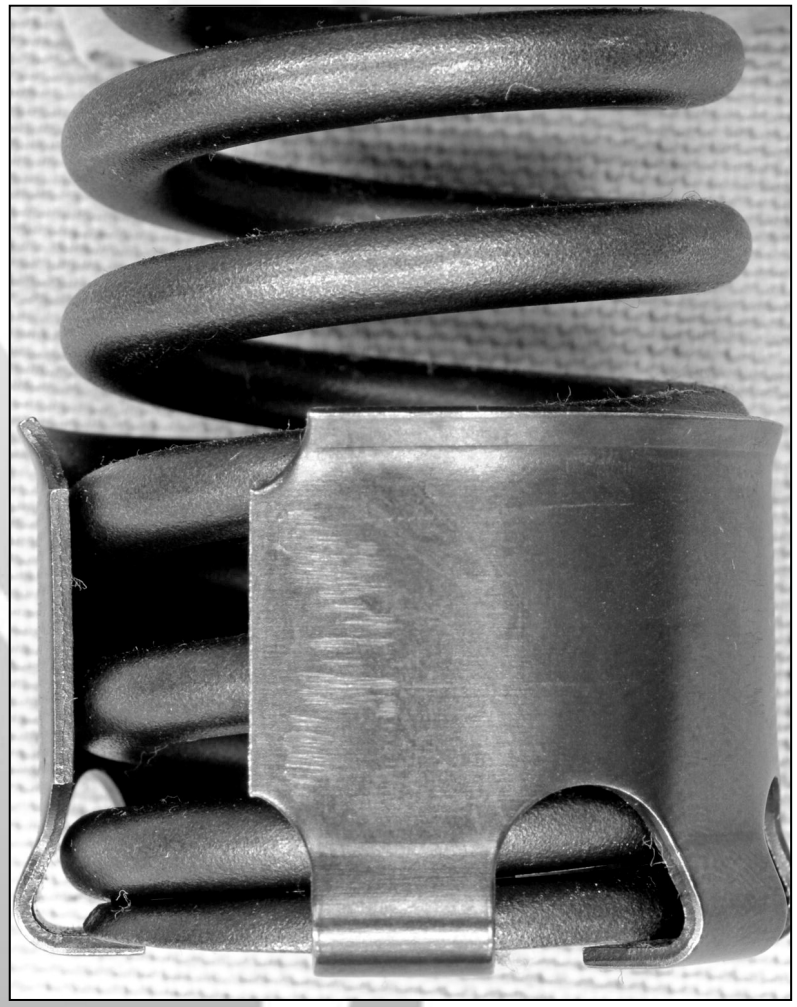
Spring Life Dynamic Control Alternatives

Typical Steel OD damper



Typical Steel Ribbon damper

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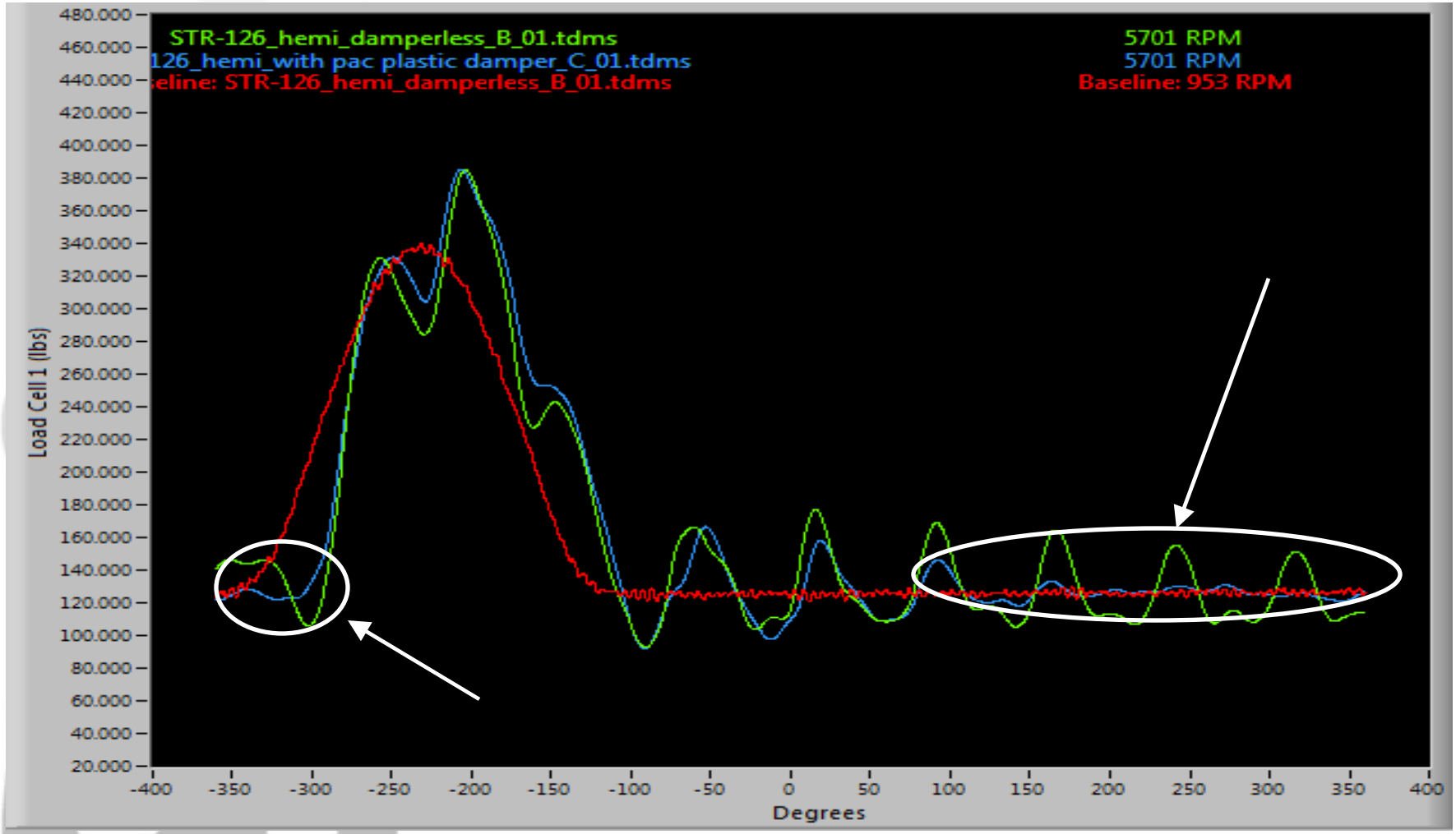
Spring Life Dynamic Control Alternatives



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Spring Life Dynamic Control Alternatives

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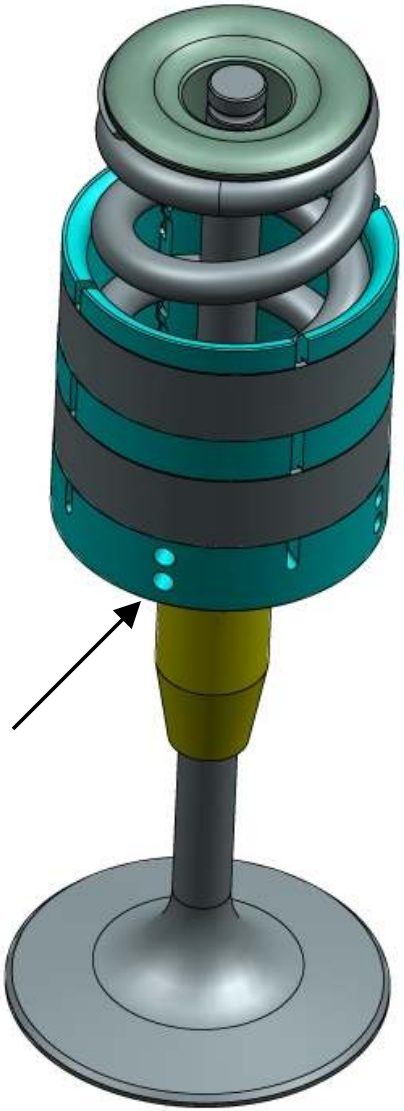

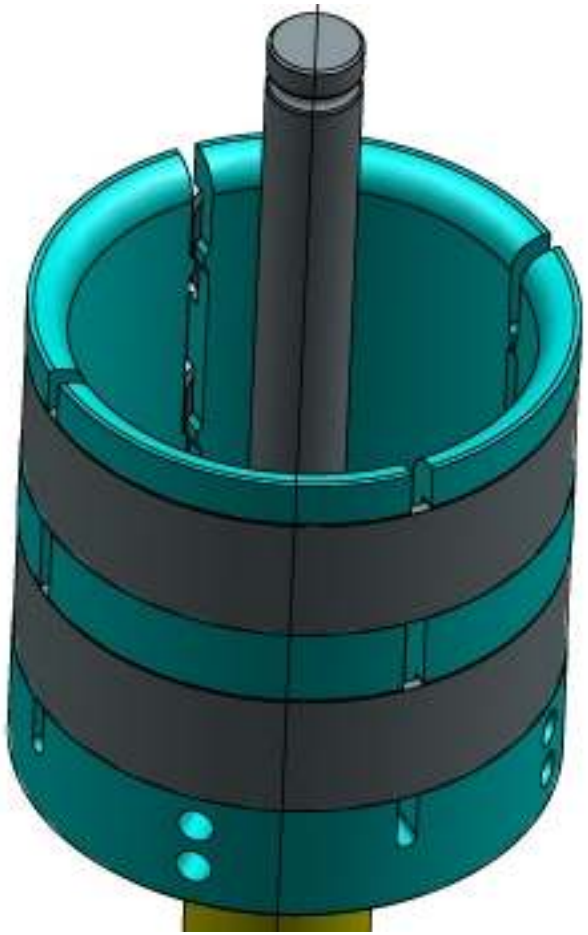

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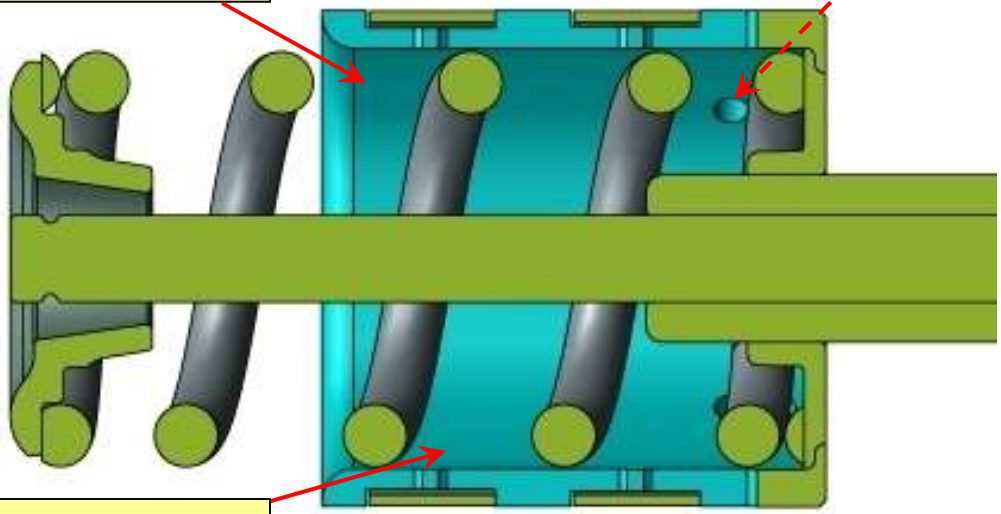
Spring Life Dynamic Control Alternatives

Engine Oil >in< through hydraulic action-oil captive with retainer.

Engine Oil >out< through hydraulic action-sized for volume-(hydraulic damping and cooling needed)



Engine Oil >in< through hydraulic action-oil captive with retainer.

Tension Rings

(provide damping force)

Spring Life Design Factors (Static)

Thank You!

For Attending the 2012 AETC Conference

For More information please contact PAC Racing Springs

www.RacingSprings.com

Special thanks to:

Kyle Kibbey

John Keteyian