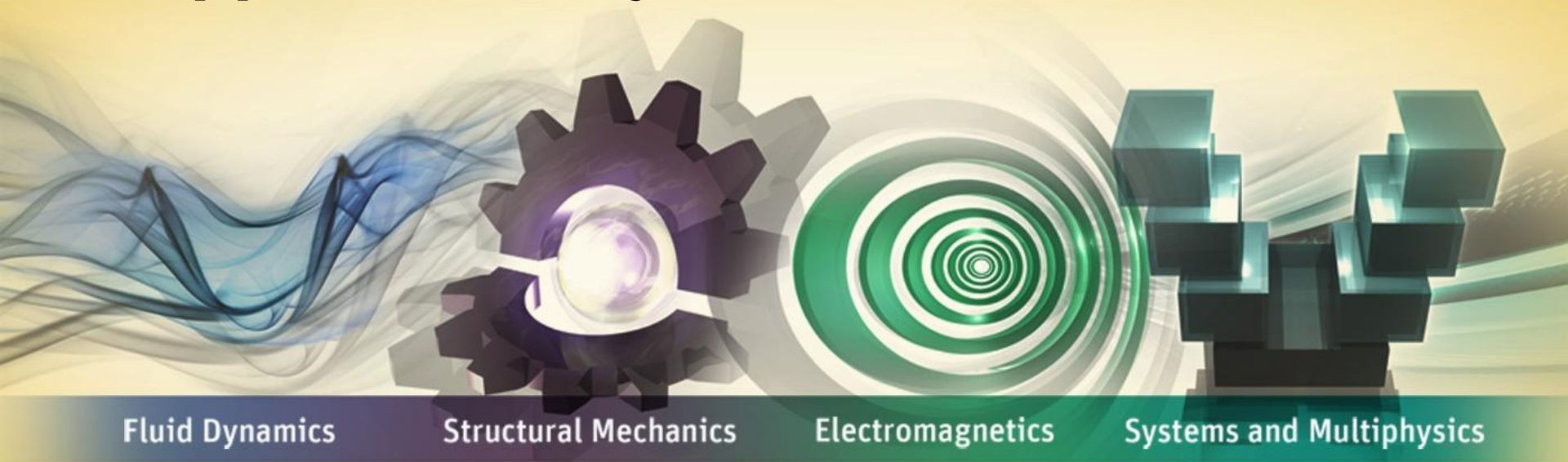




2013 Regional Conference

Realize Your Product Promise®

Testing of Elastomers and Plastics in Support of Analysis



Fluid Dynamics

Structural Mechanics

Electromagnetics

Systems and Multiphysics

Kurt Miller, Axel Products, Inc.

www.axelproducts.com

Testing Services

▪ Elastomer (hyperelastic) Characterization

- Simple Tension
- Pure Shear
- Equal Biaxial Extension
- Volumetric Compression (Bulk Modulus)
- Simple Compression
- Elastomer Specimen Preparation

▪ Plastic Characterization

- Tensile Test
- Tensile Test with Transverse Strain Measurement
- Loading and Unloading Experiments
- Short Term Creep Experiment
- Shear Test
- Plastic Film Experiment
- Compression
- Plastic Specimen Preparation

▪ Sponge Elastomer Characterization

- Compression Test
- Simple Shear Test
- Tensile Test with Lateral Strain Measurement

▪ Vibration and Viscoelastic Experiments

- Viscoelastic Decay
- Dynamic Vibration

▪ High Strain Rate Experiments

- High Strain Rate Tensile Test
- High Strain Rate Compression Test
- High Strain Rate Bend Test
- High Strain Rate Shear Test

▪ Medical Material Testing in Saline

- Testing in Saline Solution
- Testing Materials at Low Forces

▪ Friction Testing

- Sled Style Friction Experiment
- High Pressure Friction Experiment

▪ Fabric Characterization

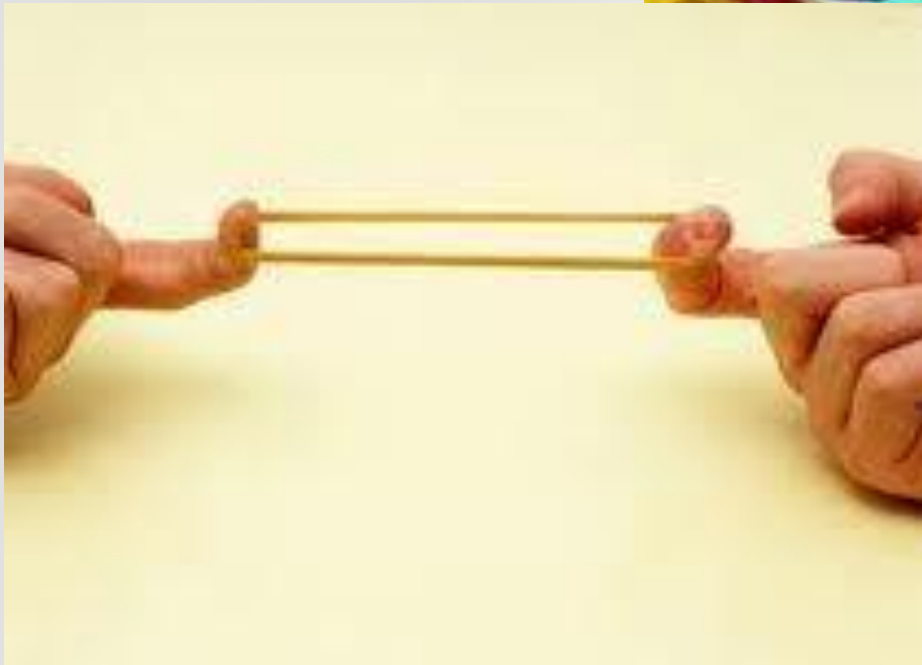
- Fabric Tensile Test with Imaging
- Fabric Specimen Preparation

▪ Wire Testing

▪ Component Tests

- Relaxation and Thermal Recovery Sequence
- Bushing and Mount Characterization
- Load Deflection Tests
- Axial + Torsional Testing

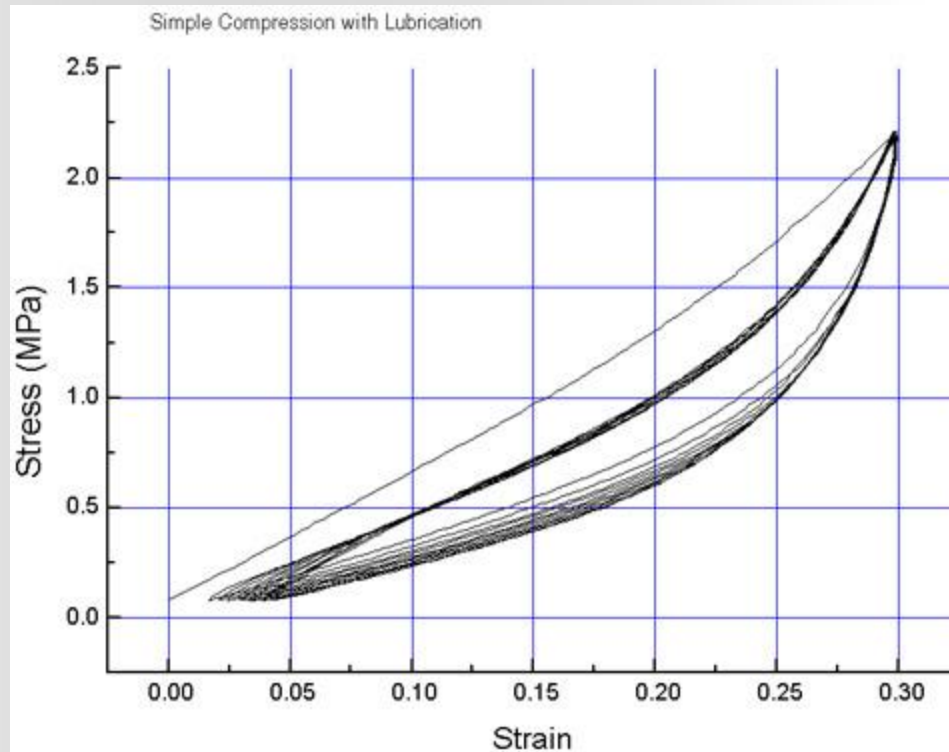
Rubber Bands



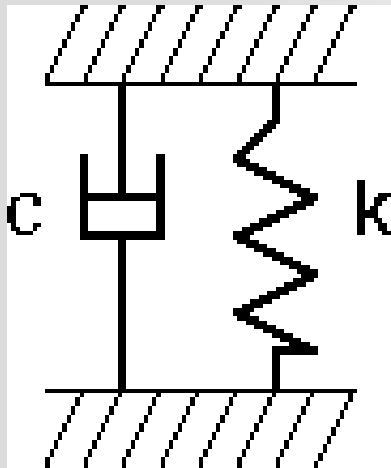
Compression



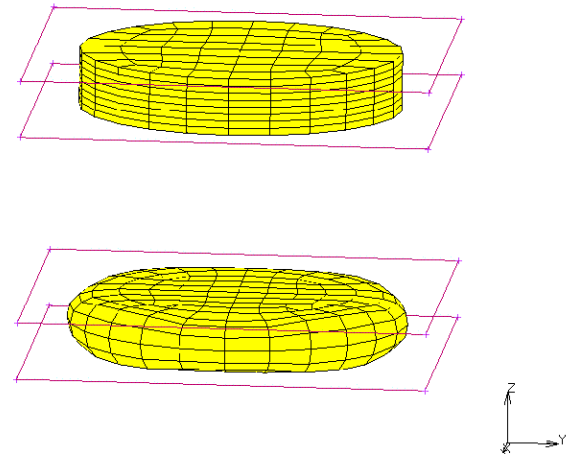
Compression



A Spring and a Dashpot?

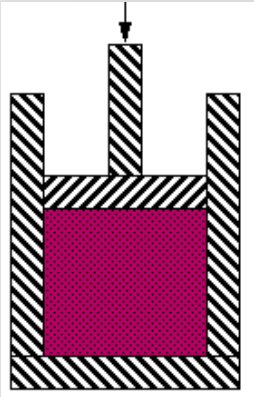


Inc : 12
Time : 1.000e+00



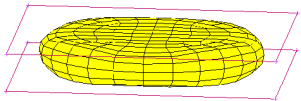
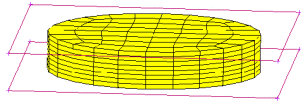
Uniaxial vs "Button" Compression

What does Incompressible Mean?



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Time : 1.000e+00

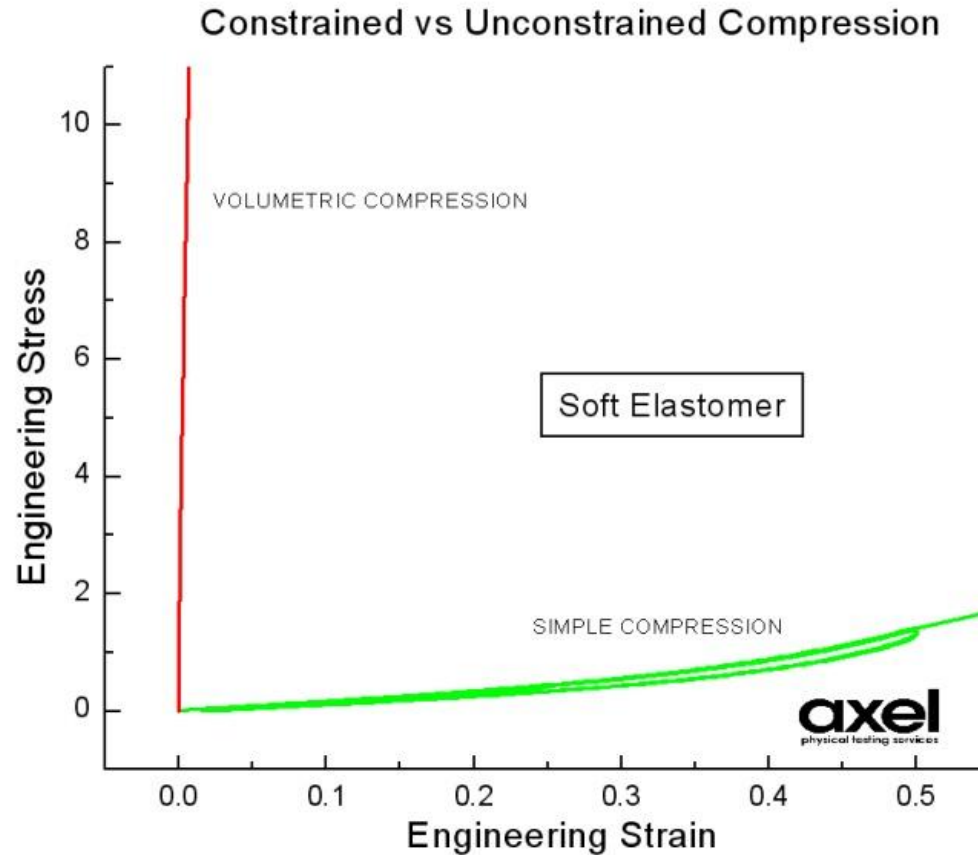
CMARC



Uniaxial vs "Button" Compression



1

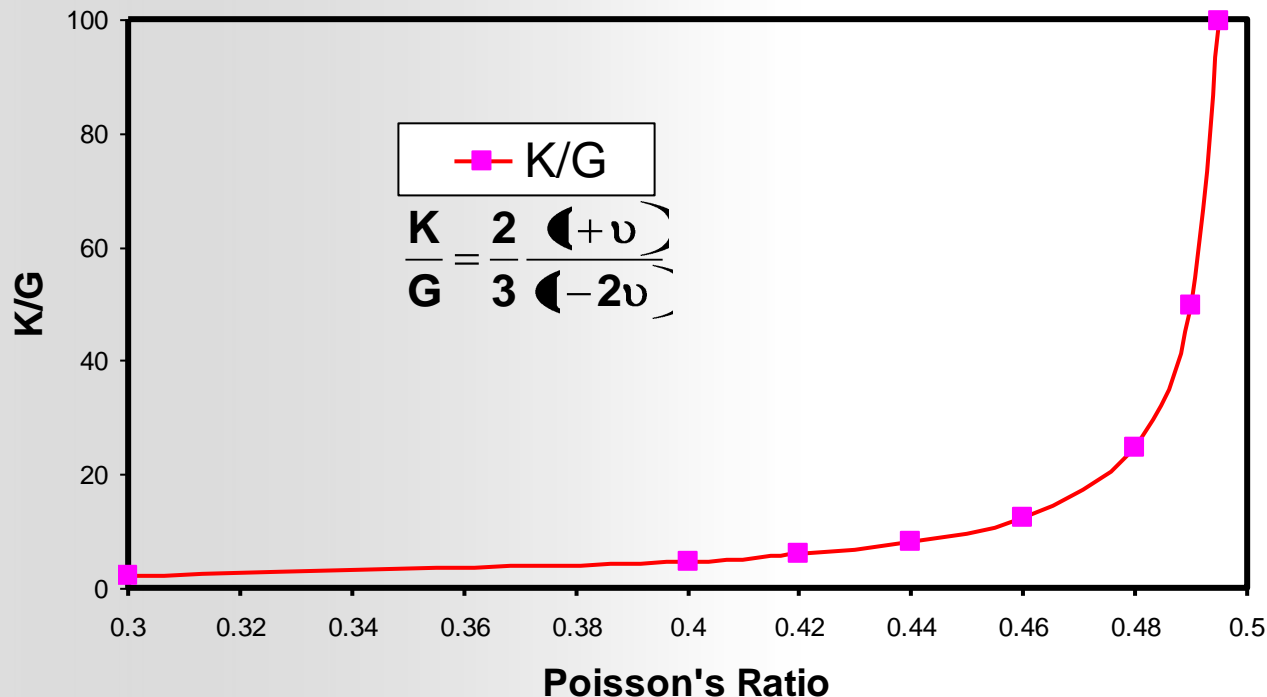


Volumetric Compression

Poisson's ratio approaching 0.5 means infinite bulk modulus, K

For elastomer materials Poisson's ratio is difficult or impossible to measure accurately. For plastic materials, it is hard to measure VC accurately. Measure Pressure-Volume directly, compute K (or D_1 in ABAQUS)

K/G Relationship to Poisson's Ratio



Incompressibility



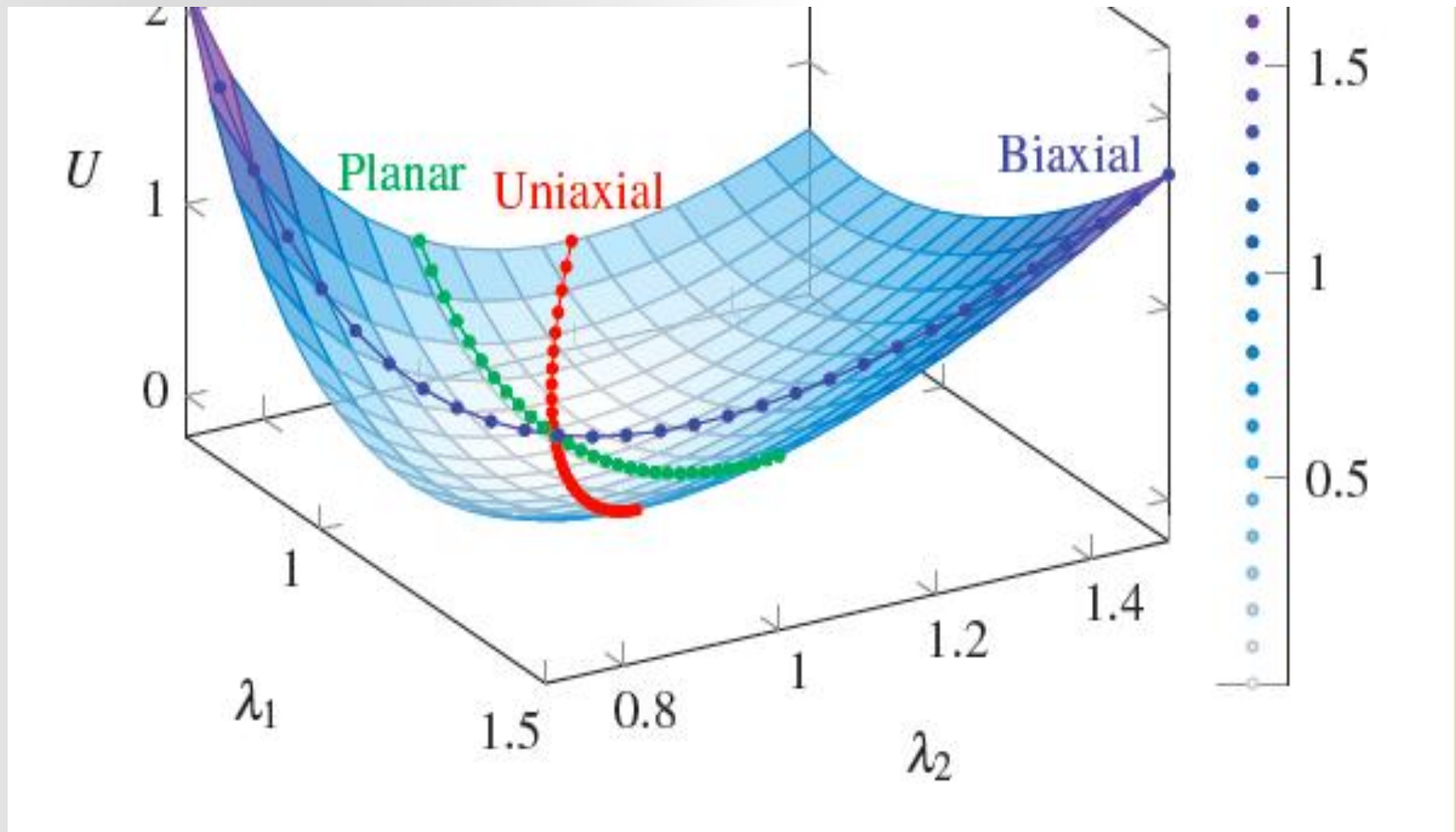
Not a spring and dashpot

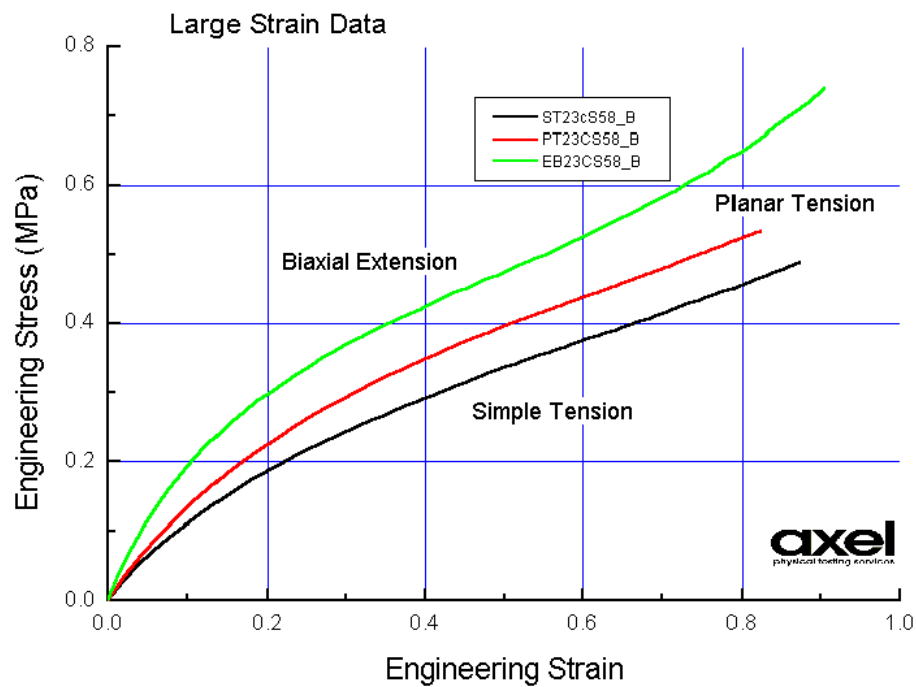
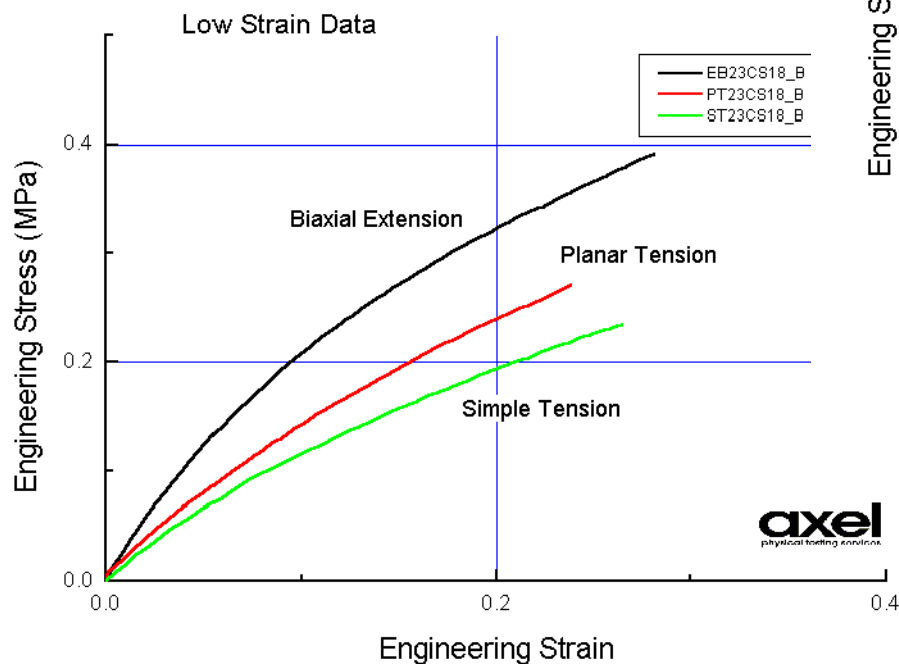


Confinement can be Significant



Hyperelastic Models Define a Surface

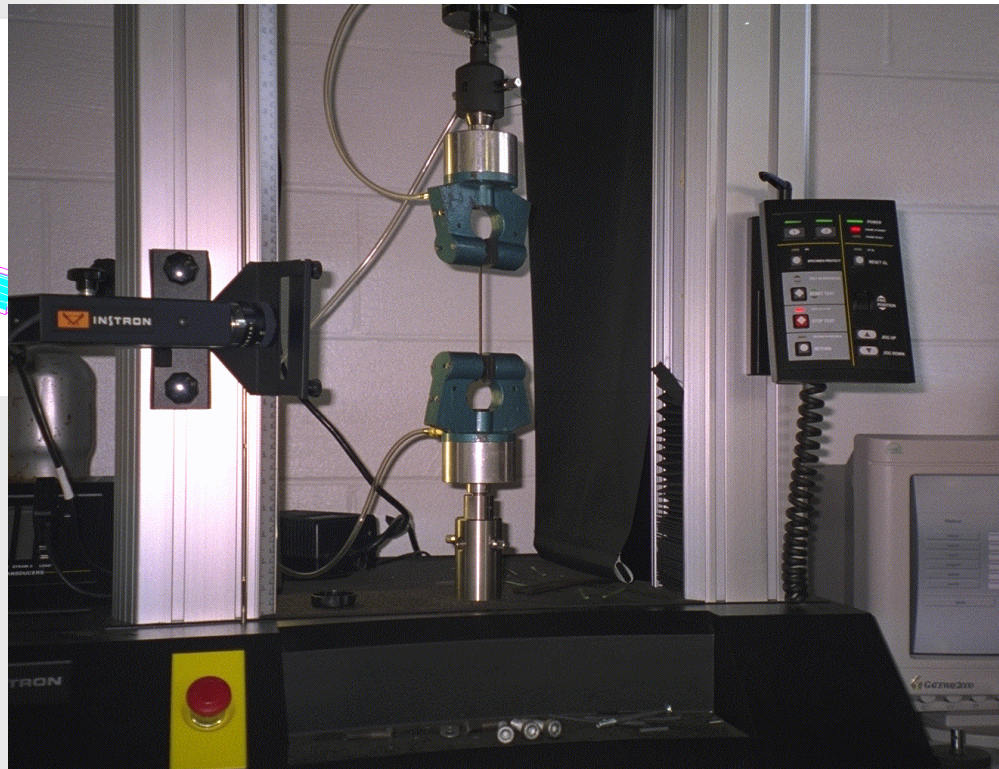
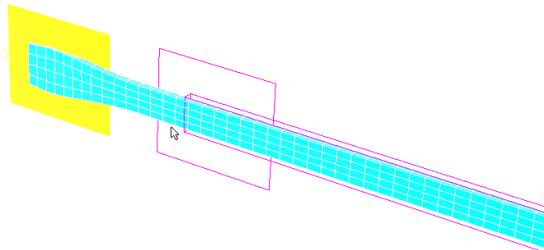
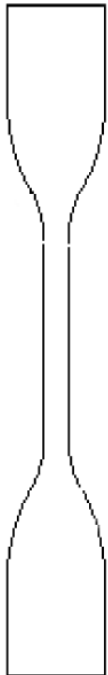




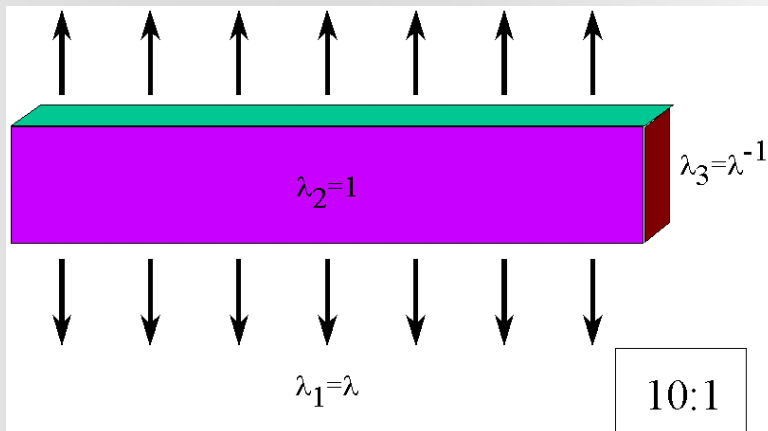
Simple Tension

- Uniaxial loading
- Free of lateral constraint

Gage Section:
Length:Width
>10:1



1. Uniaxial loading
2. Perfect lateral constraint
3. All thinning occurs in one direction



Equal Biaxial Extension

Why?

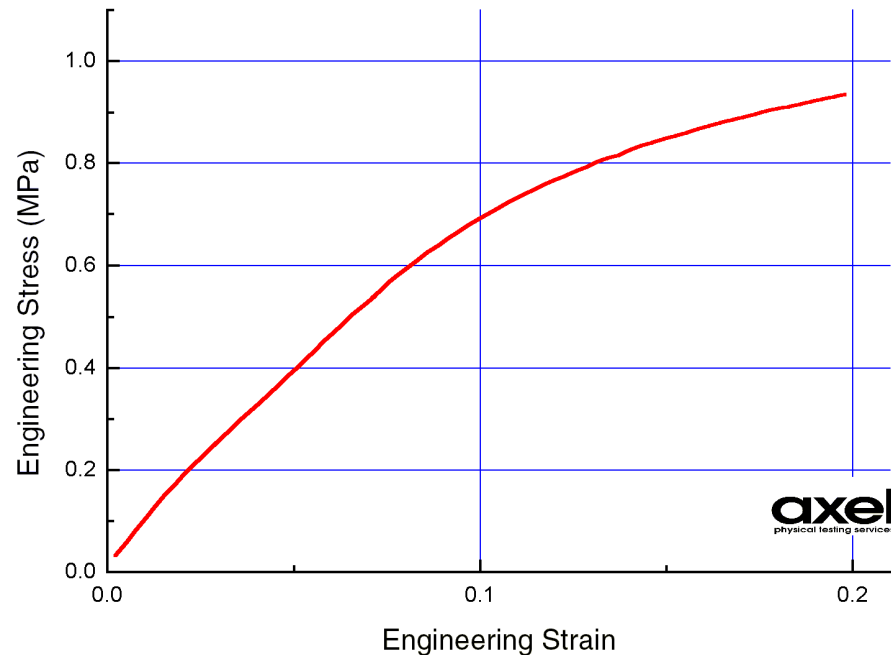
1. Same Strain State as Compression
2. Can Not Do Pure Compression
3. Can Do Pure Biaxial



Some common Elastomers exhibit dramatic strain amplitude and cycling effects at moderate strain levels

Conclusions:

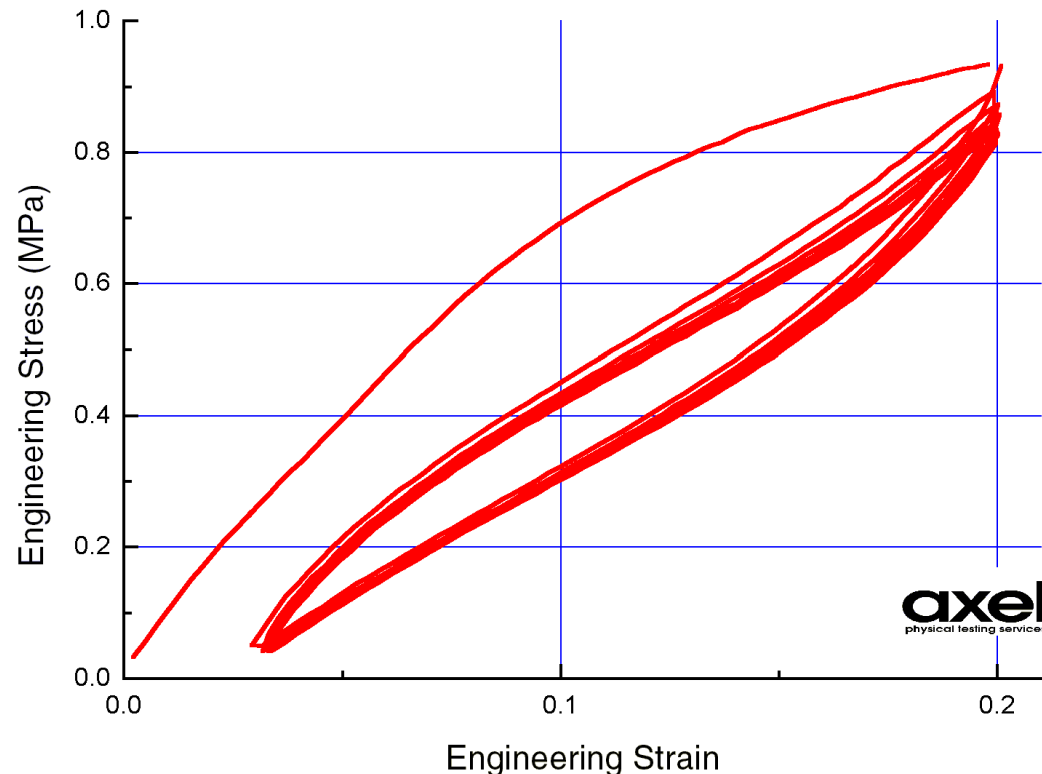
1. Test to Realistic Strain Levels
2. Use Application Specific Loadings to Generate Material Data
3. Need to load and unload to separate elastic from plastic



Some common Elastomers exhibit dramatic strain amplitude and cycling effects at moderate strain levels

Conclusions:

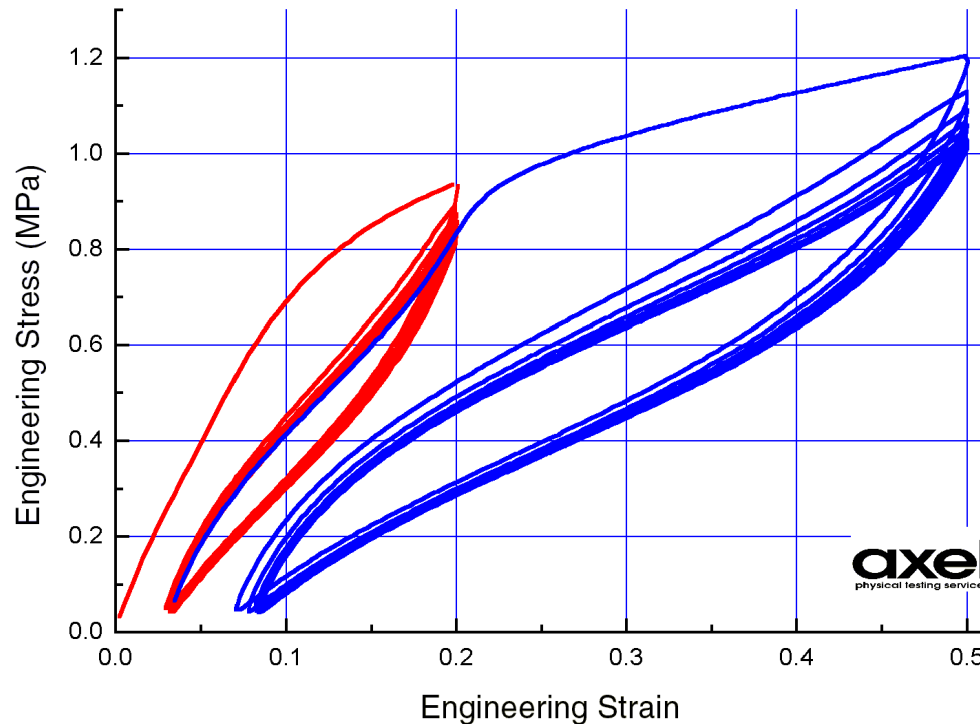
1. Test to Realistic S Levels
2. Use Application Specific Loading Generate Material
3. Need to load and to separate elastic plastic



Some common Elastomers exhibit dramatic strain amplitude and cycling effects at moderate strain levels

Conclusions:

1. Test to Realistic Strain Levels
2. Use Application Specific Loadings to Generate Material Data
3. Need to load and unload to separate elastic from plastic

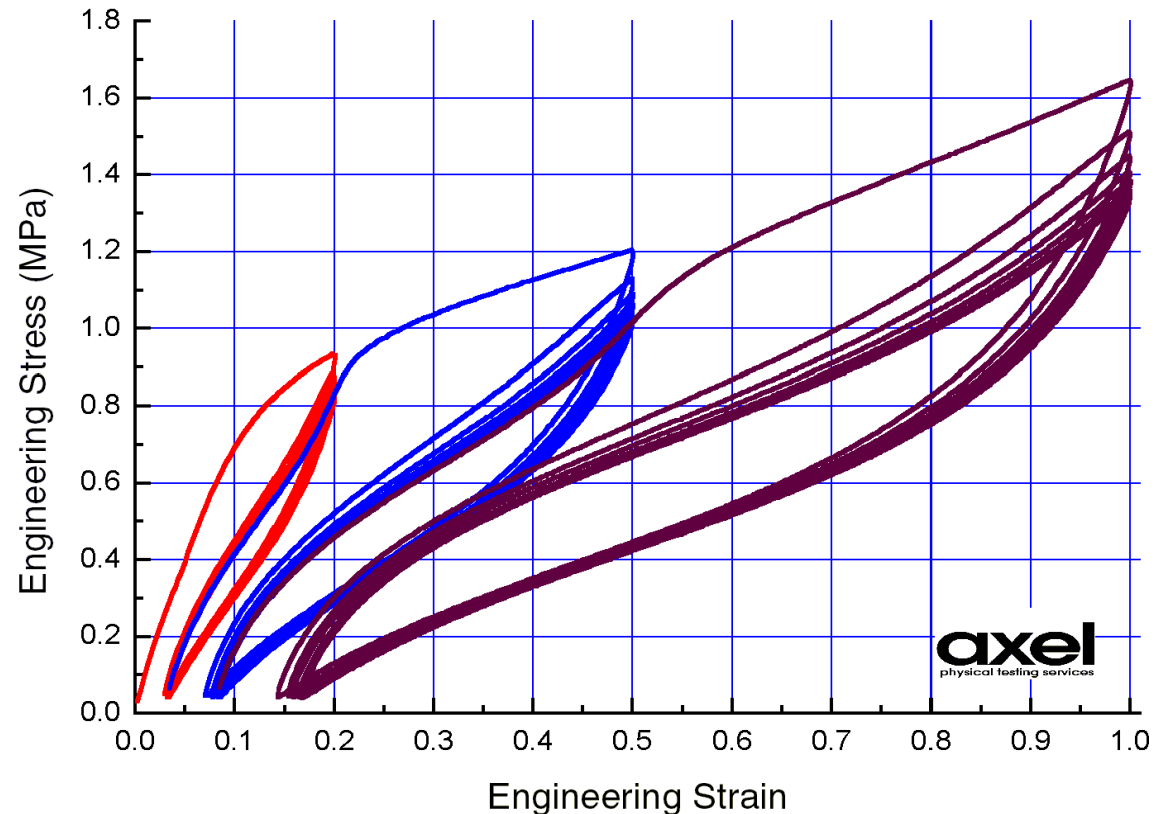


Loading Conditions

Some common elastomers exhibit dramatic strain amplitude and cycling effects at moderate strain levels

Conclusions:

1. Pick one level
2. Use Mullins Model
3. Use FeFp
4. Use large strain hysteresis model



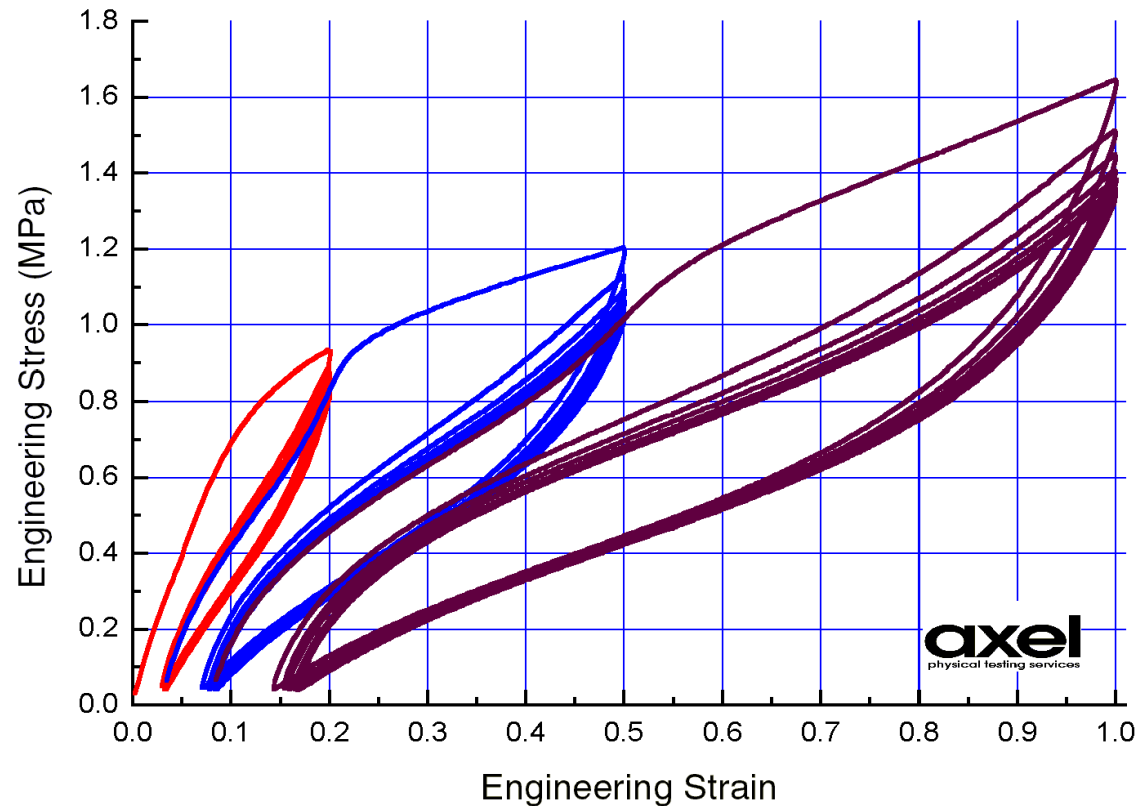
Increasingly used to replace elastomers

Rubber inside of plastic

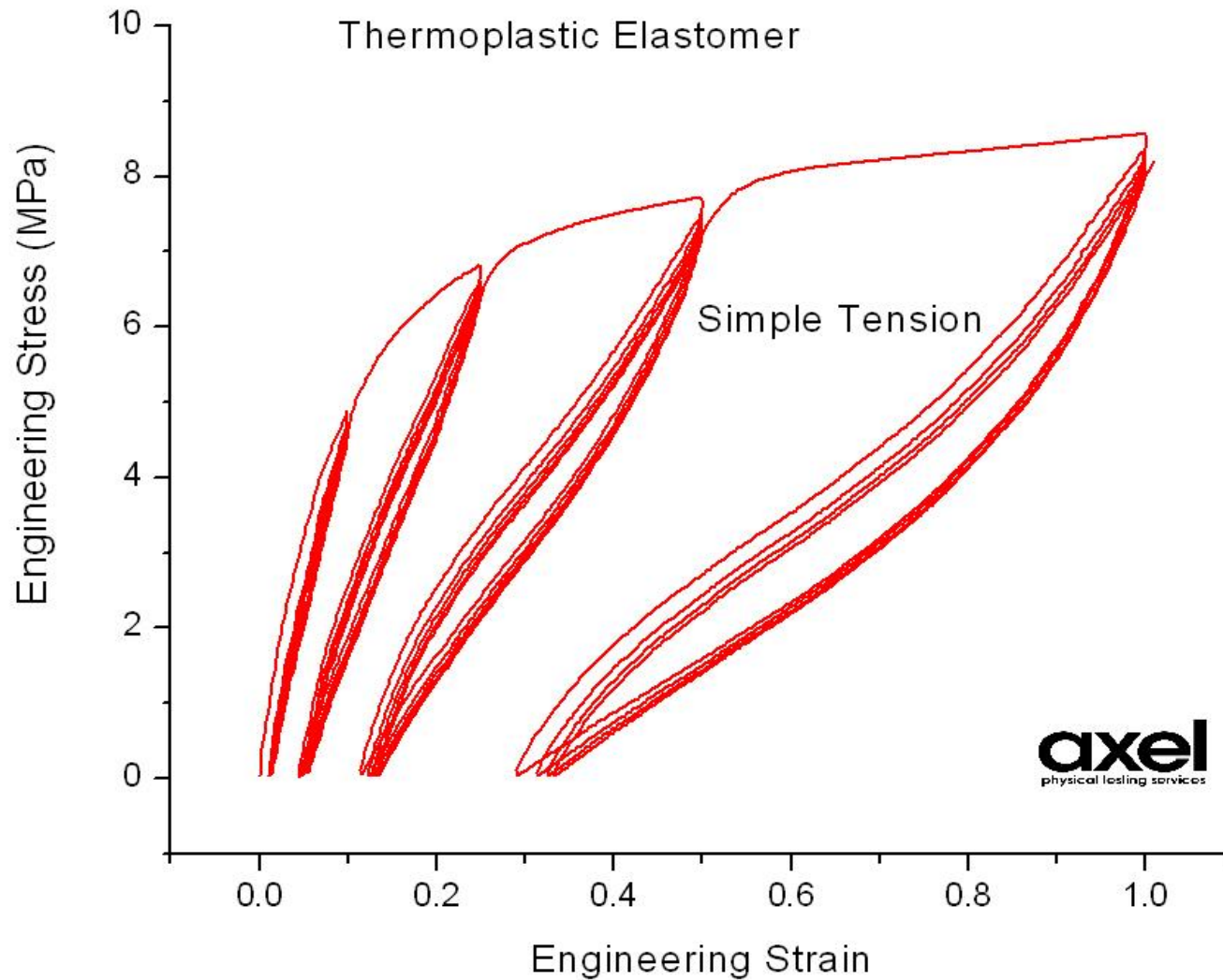
Plasticity and Flow

Conclusions:

1. Pick one level
2. Use Mullins Model
3. Use Viscoelastic
4. Use large strain hysteresis model

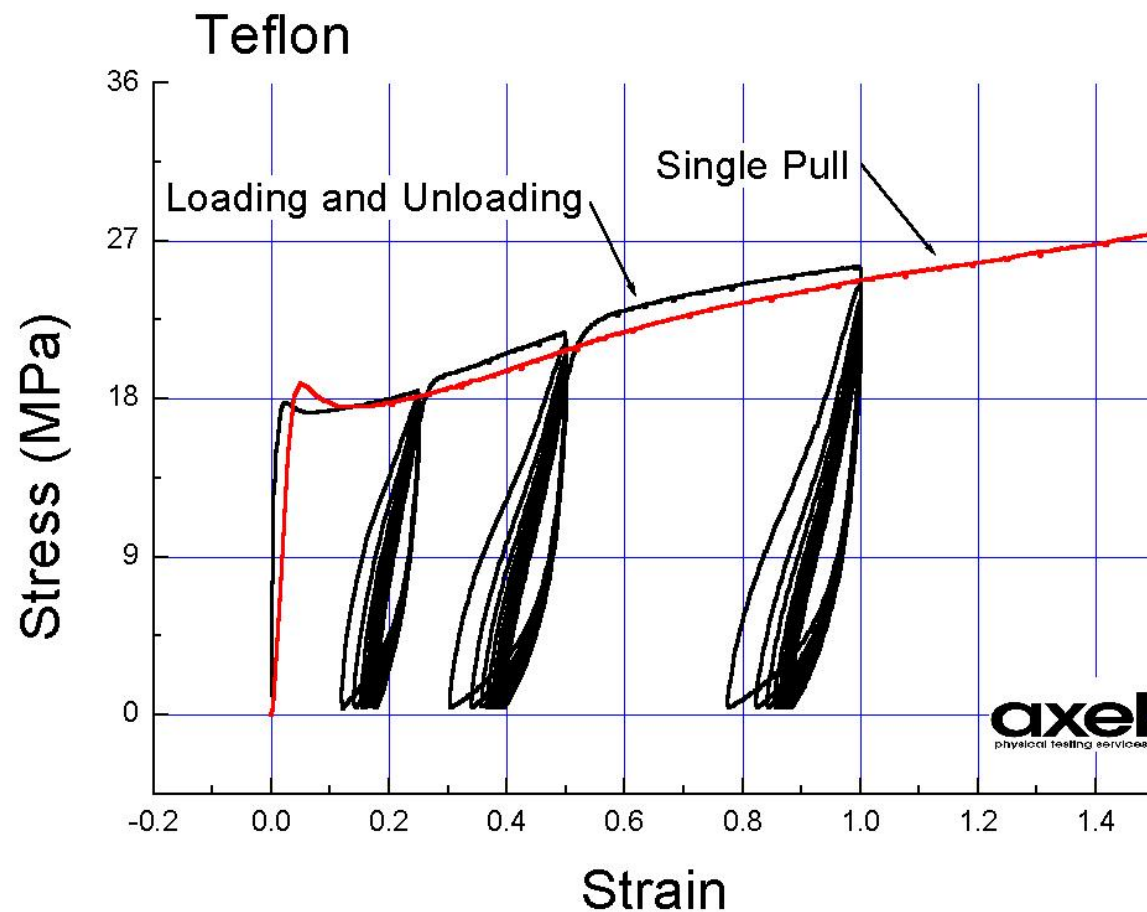


Thermoplastic Elastomers



Conclusions:

1. Pick one level
2. Use FeFp

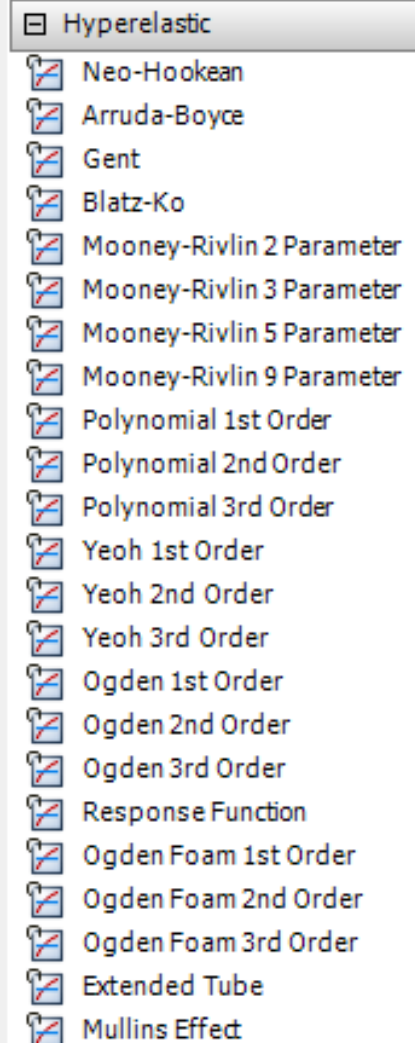


Hyperelastic Models

- Material response is isotropic, isothermal, and elastic and is assumed fully or nearly incompressible.
- There are many hyperelastic models available in ANSYS which can cover wide varieties of elastomers used in Industries.

Available Hyperelastic models:

- Arruda-Boyce Hyperelastic Material
- Blatz-Ko Foam Hyperelastic Material
- Extended Tube Material
- Gent Hyperelastic Material
- Mooney-Rivlin Hyperelastic Material
- Neo-Hookean Hyperelastic Material
- Ogden Compressible Foam Hyperelastic Material
- Ogden Hyperelastic Material
- Polynomial Form Hyperelastic Material
- Response Function Hyperelastic Material
- Yeoh Hyperelastic Material

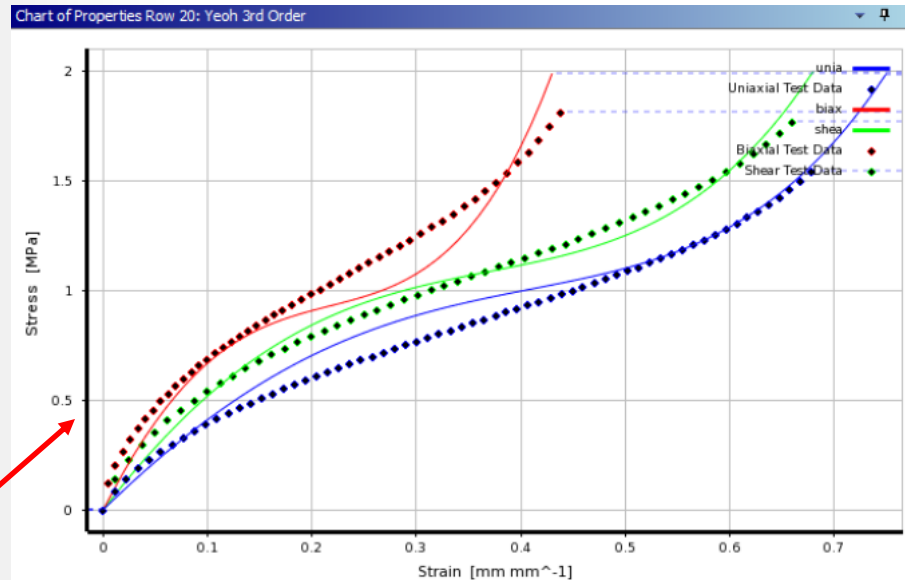
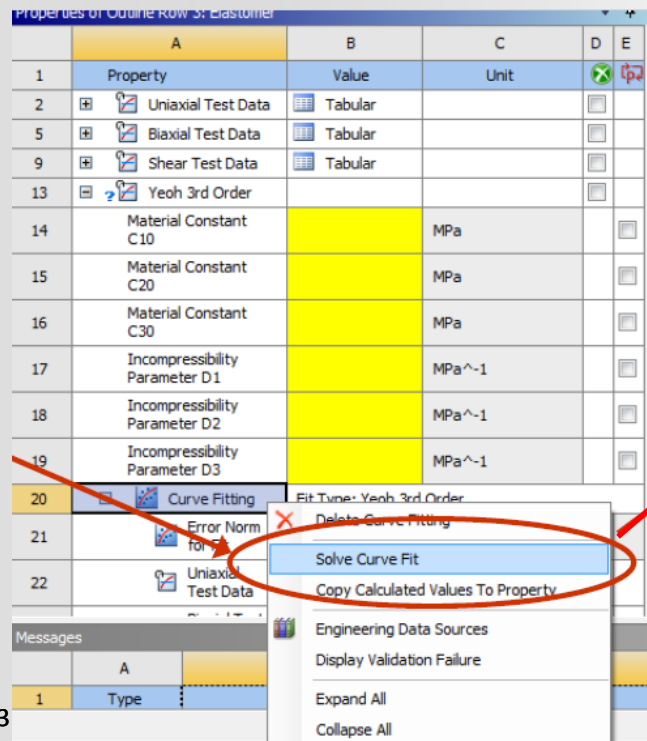


Specialized Hyperelastic models:

- Anisotropic Hyperelastic Material
- Bergstrom-Boyce Material
- Mullins effect
- User-Defined Hyperelastic Material

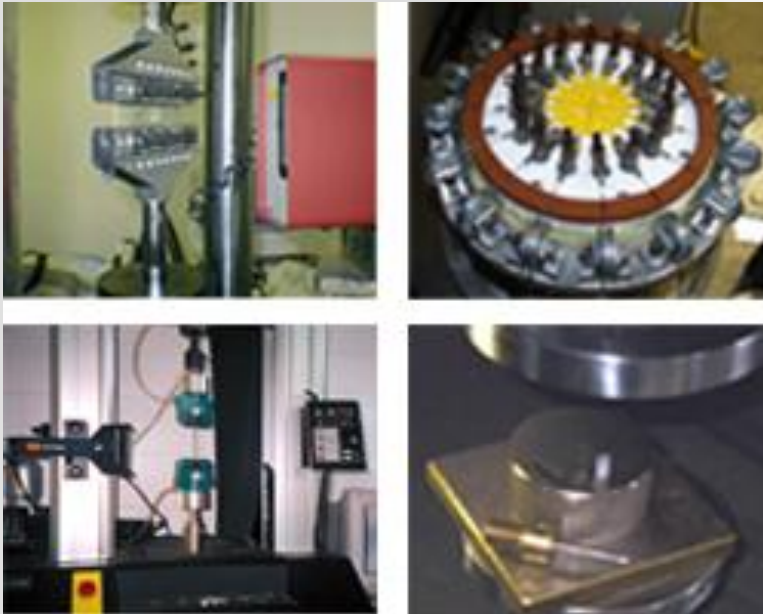
Curve Fitting feature

- Material curve fitting allows you to derive coefficients from experimental data that you provide for your material.
- With this capability, you compare experimental data versus program-calculated data for different nonlinear models and determine the best material model to use.
- ANSYS provides curve-fitting, based on experimental data, for all of the available hyperelastic models. Any of the hyperelasticity models in ANSYS can be used.



Experimental Elastomers Training at Axel Products

ANSYS teams with Axel Product, Inc. (www.axelproducts.com) to offer this course that covers material testing, material modeling and finite element analysis of elastomers.



Lecture 2

Hyperelasticity

14.0 Release



Fluid Dynamics

Structural Mechanics

Electromagnetics

Systems and Multiphysics

ANSYS Mechanical Experimental Elastomers

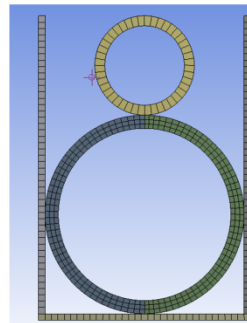
Workshop 6 – Axisymmetric Ring

Goal

- Run a viscoelastic analysis of an axisymmetric hyperelastic ring.
- Become familiar with performing viscoelastic curve-fitting.

Model Description

- 2D plane axisymmetric model
- Frictional contact between the rings
- Frictional contact between the bottom ring and side walls



A General Strategy

- 1. Understand the loading conditions of the part**
- 2. Understand the general behavior of the materials involved**
- 3. Select the significant material behaviors**
- 4. Use existing or develop material models to describe the behavior**
- 5. Verify the performance of the material model**