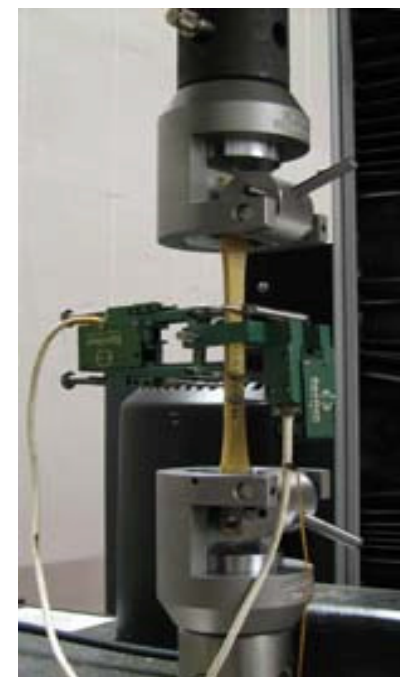


Physical Testing of Thermoplastics for Input into DIGIMAT

Kurt Miller, Axel Products, Inc.
www.axelproducts.com



Axel Products, Inc.

Provides testing services for engineers and analysts. The focus is on the characterization of nonlinear materials such as elastomers and plastics for users of ABAQUS, ANSYS, Marc, ALGOR and Dyna.

Testing Services

Related experiments, downloads and pricing by application.

- [Elastomer \(hyperelastic\) Characterization](#)
- [Plastic Characterization](#)
- [Sponge Elastomer Characterization](#)
- [Vibration and Viscoelastic Experiments](#)
- [Thermal Properties Measurements](#)
- [High Strain Rate Experiments](#)
- [Medical Material Testing in Saline](#)
- [Friction Measurements](#)
- [Fabric Characterization](#)
- [Wire Testing](#)
- [Component Tests](#)
- [Durability and Crack Growth](#)
- [Long Term Creep and Stress Relaxation Tests](#)

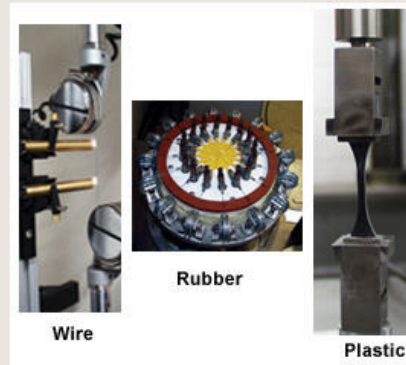
Technical Downloads

Popular downloads.

- [Testing Elastomers for Hyperelastic Models \(PDF\)](#)
- [Testing Plastics for FEA \(PDF\)](#)
- [Testing at High Strain Rates \(PDF\)](#)
- [Measuring Friction for Analysis \(PDF\)](#)
- [Factors that Affect the Fatigue Life of Rubber \(PPT\)](#)
- [Measuring Dynamic Properties \(PDF\)](#)
- [Elastomer Rate-dependence: A Testing and Material Modeling Methodology \(PDF\)](#)
- [More](#)

Location and Contact Information:

Axel Products, Inc.
2255 S. Industrial Hwy.



Training Courses



[Testing and Analysis of Elastomers with Abaqus](#)

- September 27-29, 2011

[Testing and Analysis of Plastics with Abaqus](#)

- To be determined



[Testing and Analysis of Elastomers with Marc](#)

- To be determined



[Testing and Analysis of Elastomers with ANSYS](#)

- To be determined



[Testing and Analysis of Elastomers using ALGOR](#)

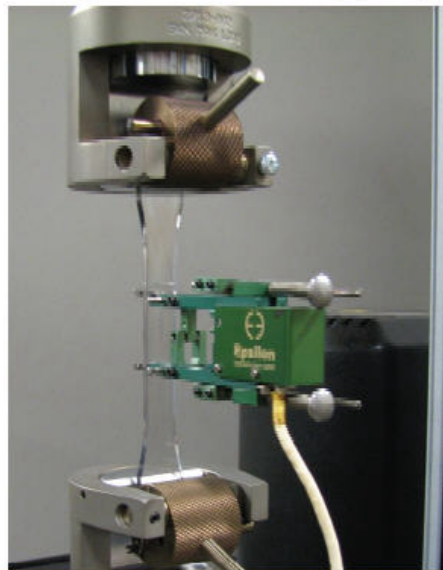
Testing and Analysis

Testing Plastics for Material Models in Finite Element Analysis

By Kurt Miller, Axel Products, Inc.
Andy Poli, Axel Products, Inc.

Introduction

The physical testing of plastic materials for the purpose of defining material constitutive models in finite element analysis can be very simple or incredibly complex depending on the objective of the analysis. Linear analysis of structural parts is routinely performed using only a couple simple parameters. More complex analysis may involve elevated temperatures, severe plastic deformation and strain rate sensitivity requiring customized material model development and rigorous experimentation. The purpose of this discussion is to introduce laboratory experiments that may be used to evaluate the physical properties defined in material constitutive models.



Plastic parts in service may stretch, bend, creep or break. It is impractical to measure all of the properties of the plastic in use. It is also impractical to build a material model that represents all of the material properties. Good engineering judgment by the analyst is needed to model the properties relevant to the analysis at hand.

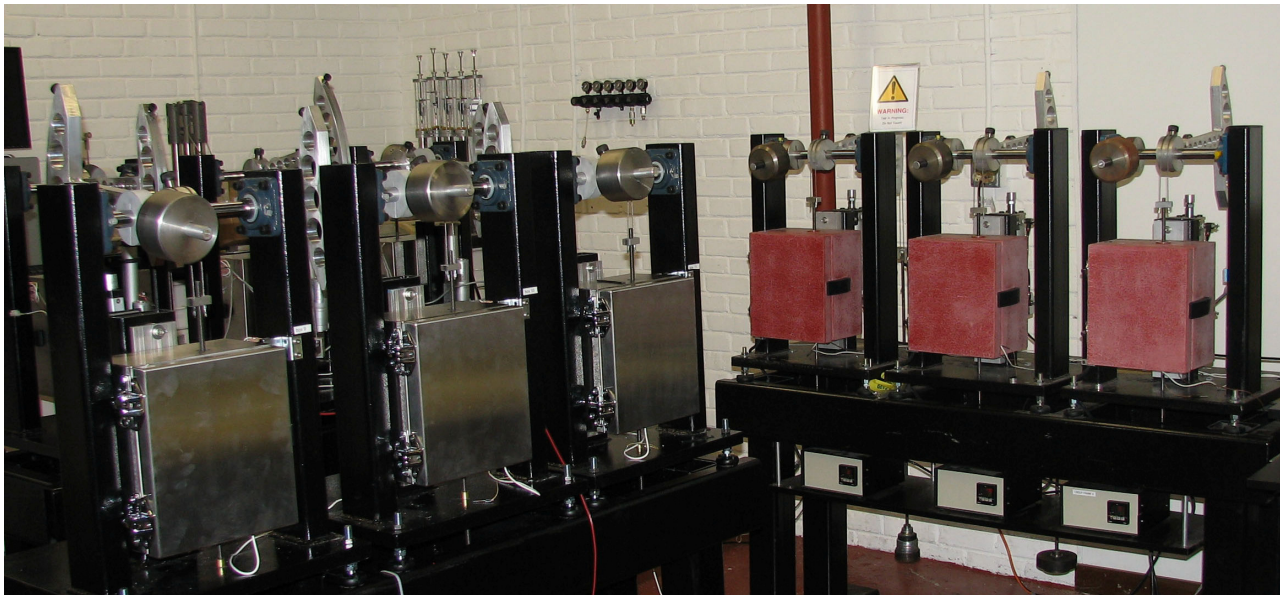
The objective in testing for analysis is to perform experiments that put the material in a known state of strain such that there is a closed form analytical solution which describes the stress-strain condition in the test specimen. This allows us to generate experimental data that may be used to calibrate the material constants in material constitutive models.

The Tensile test

The tensile test is probably the most commonly used for plastics because the desired state of strain is relatively straightforward to achieve in modern tensile testers and the experiment provides valu-

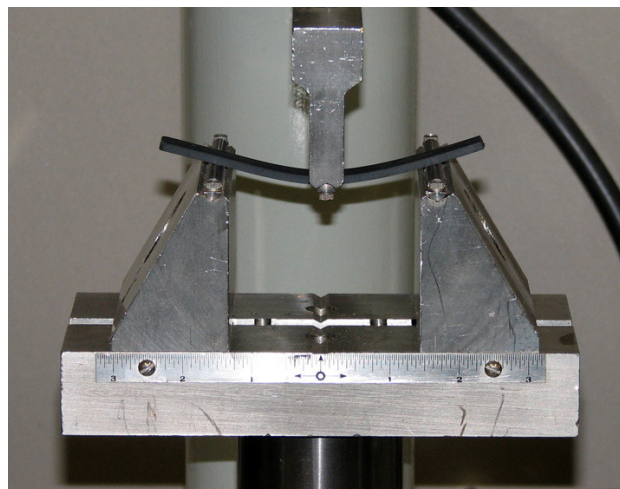
Overview

- Analysis drives the physical testing
- Tests are not always to standards (minimized)
- Sometimes really hard tests are worth the effort

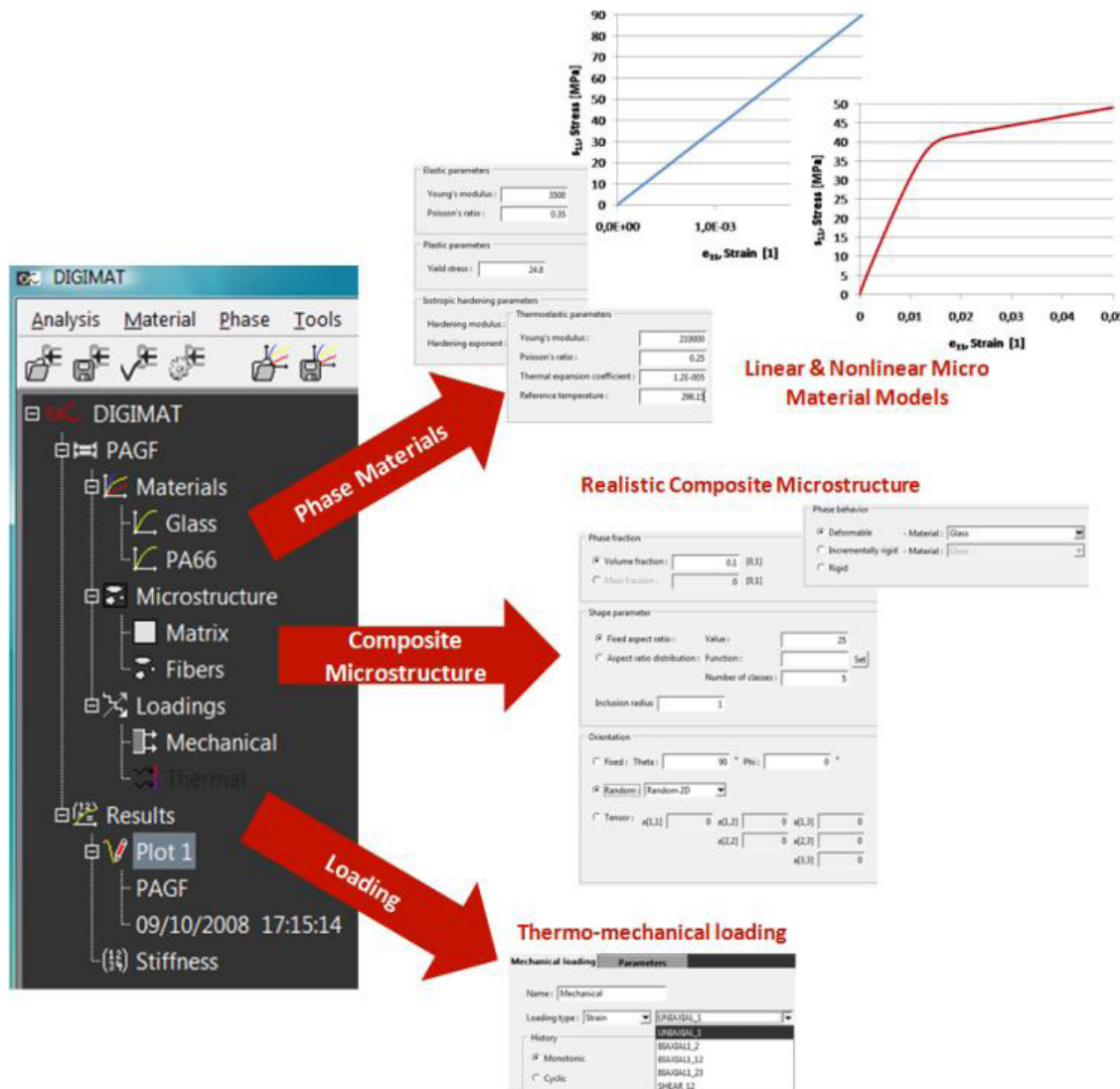


Analysis Drives the Physical Testing

- Testing used to calibrate material models
 - ➔ Defining mean field properties
 - ➔ Reverse engineering using MX
- Testing used to verify a material model

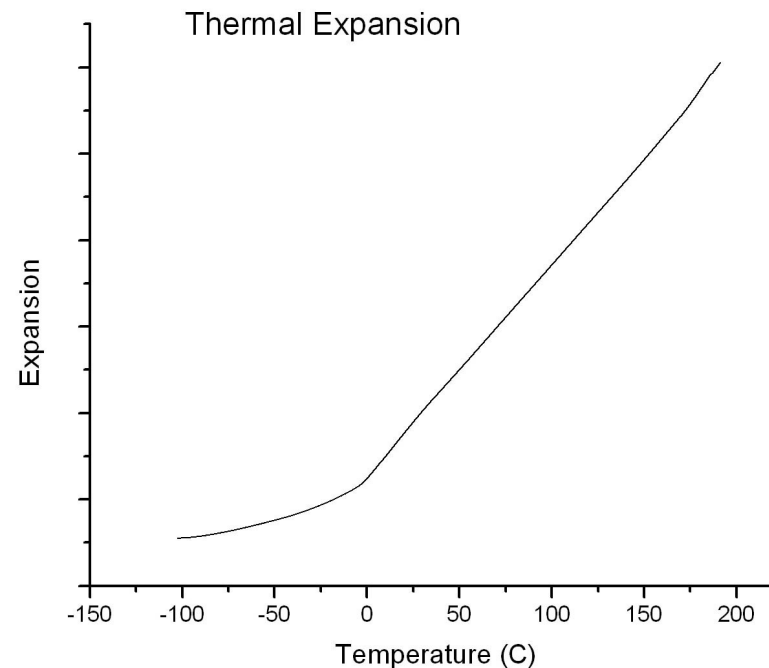


Analysis Drives the Physical Testing



Analysis Drives the Physical Testing

- One cannot model all behaviors
- Must select based on application and material model



Analysis Drives the Physical Testing

- One cannot model all behaviors

∞ Reverse Engineering

- RE of one phase elastic, elastoplastic, elastoviscoplastic and viscoelastic model parameters based on stress-strain curve(s):
 - Of the composite or matrix behavior,
 - At different strain rates,
 - At different orientations.

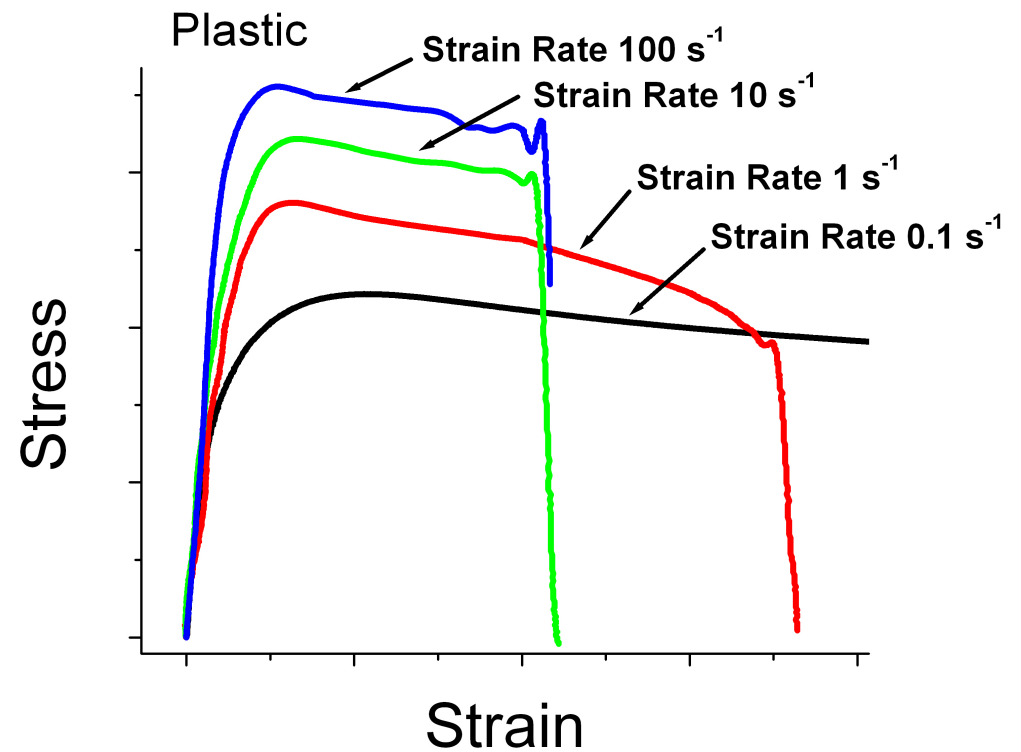
∞ Identification of material model parameters from stress-strain curve(s)

- elastic, elastoplastic, elastoviscoplastic and viscoelastic models of homogeneous materials.

∞ Report generation

- Identification and Reverse Engineering report.

Analysis Drives the Physical Testing



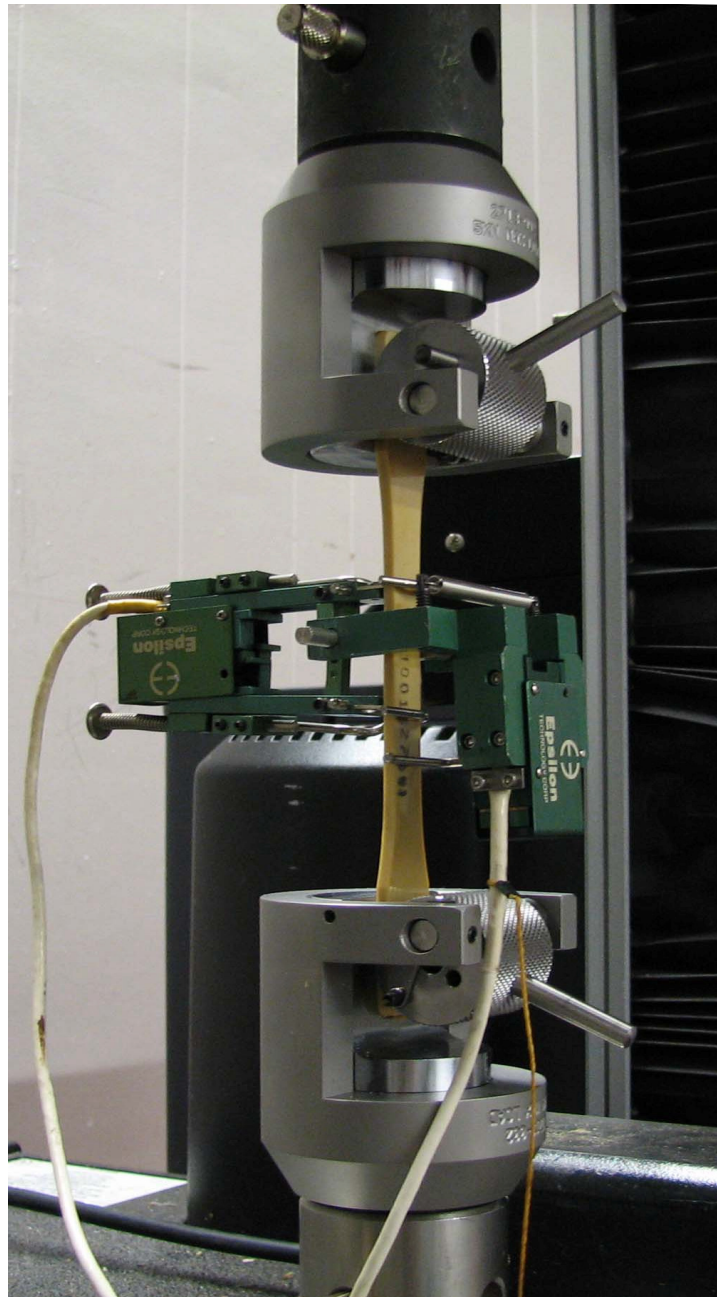
Analysis Drives the Physical Testing

- Reverse engineering
 - ➔ Composite behavior
 - ➔ Orientation



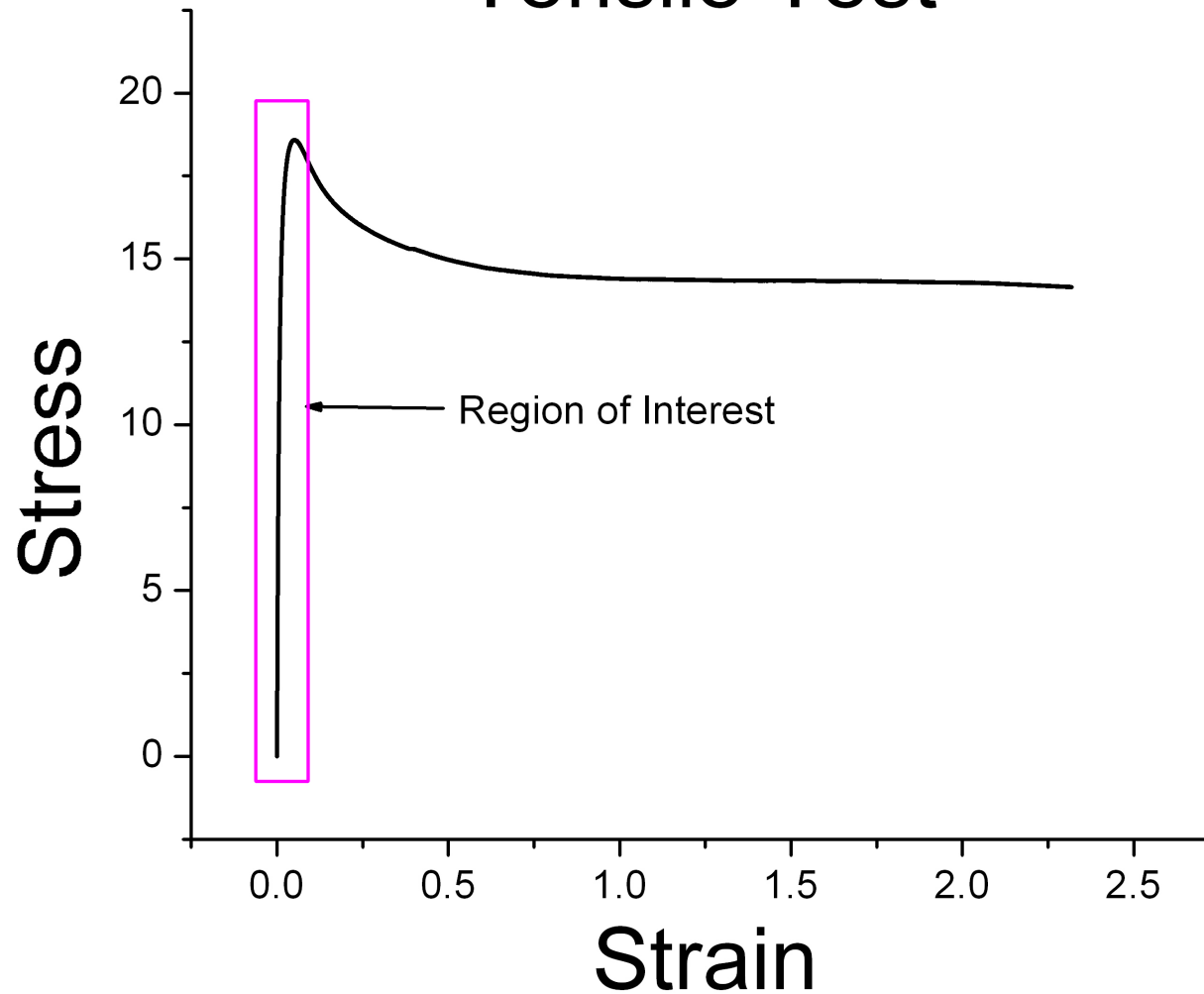
Tests Are Not Always to Standards

- Application based
 - ➔ Rates
 - ➔ Directions
 - ➔ Loading Pattern
 - ➔ Temperature

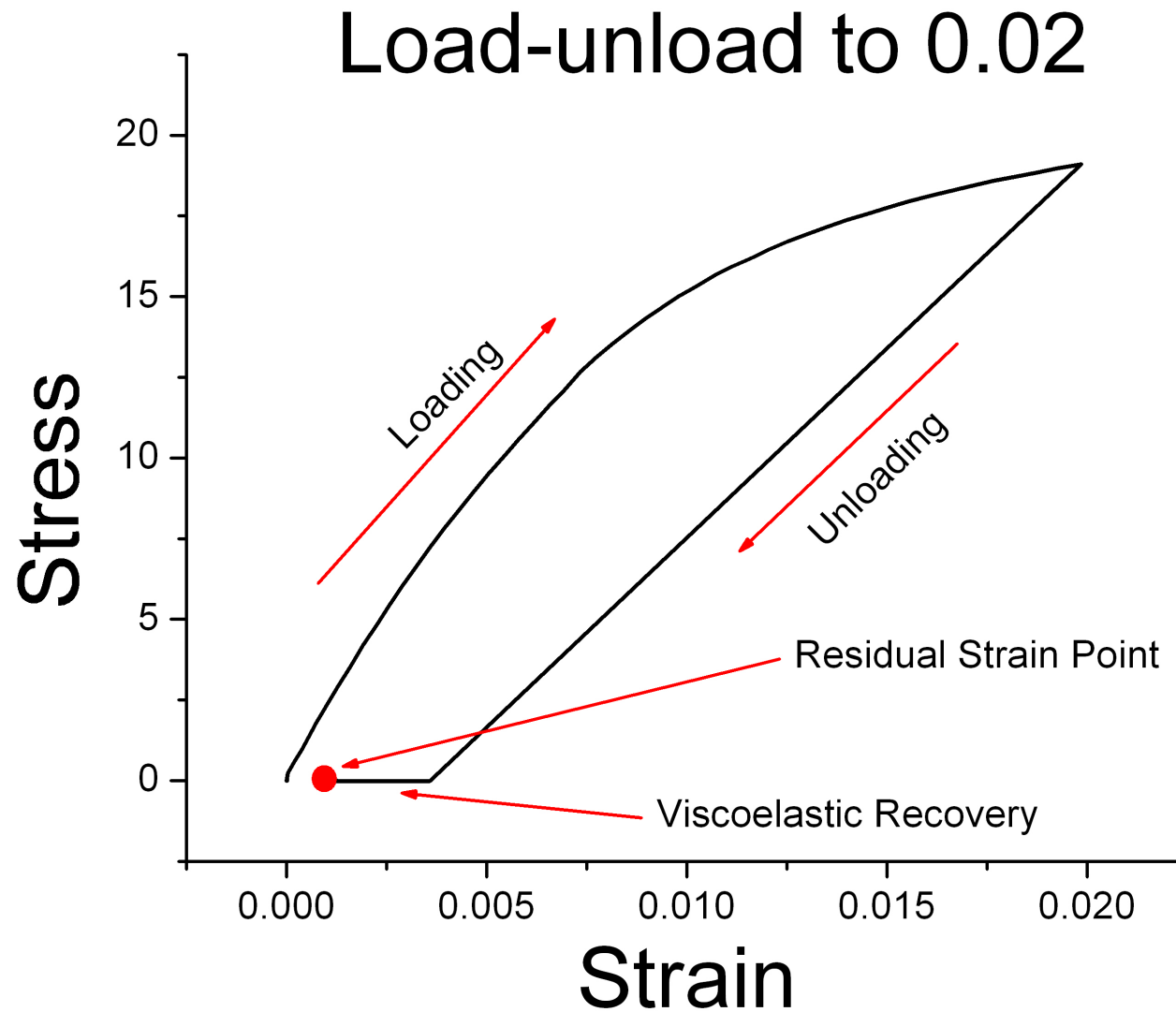


Tests Are Not Always to Standards

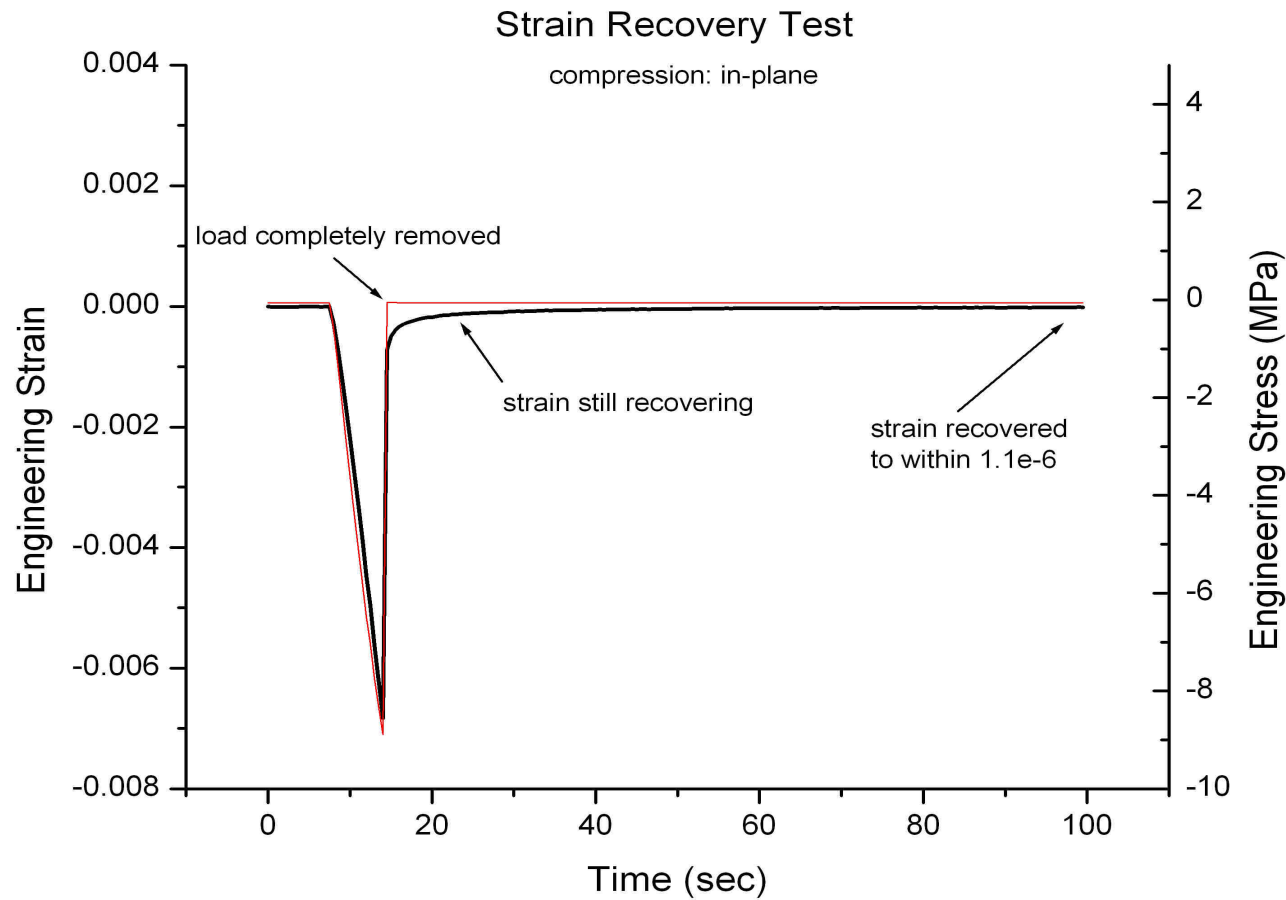
Tensile Test



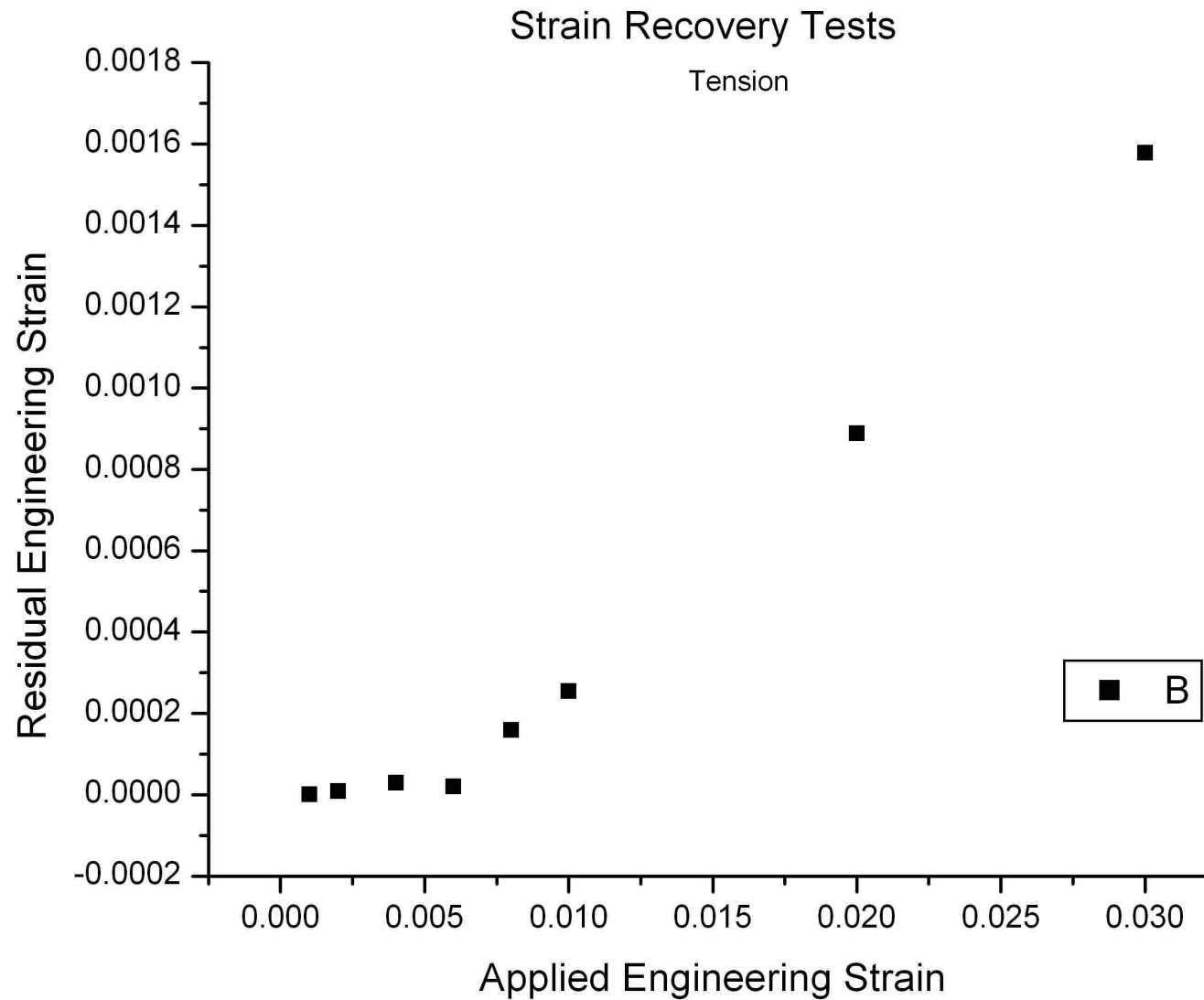
Tests Are Not Always to Standards



Tests Are Not Always to Standards



Tests Are Not Always to Standards



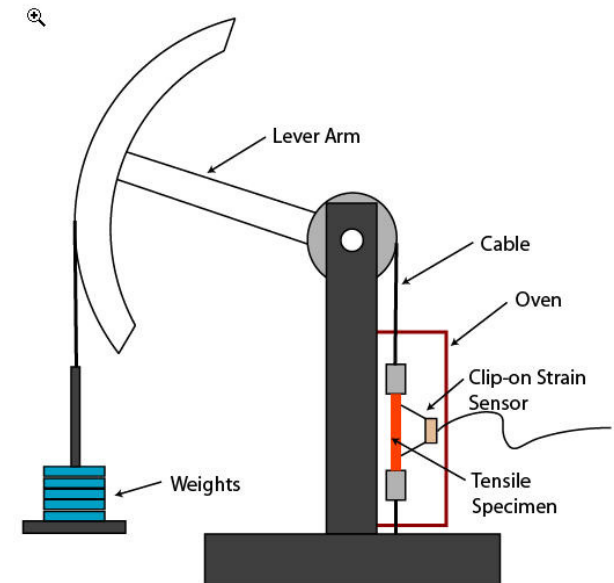
Sometimes really hard tests are worth the effort

- Long Term Creep Experiments

- ➔ Cost
- ➔ Precision

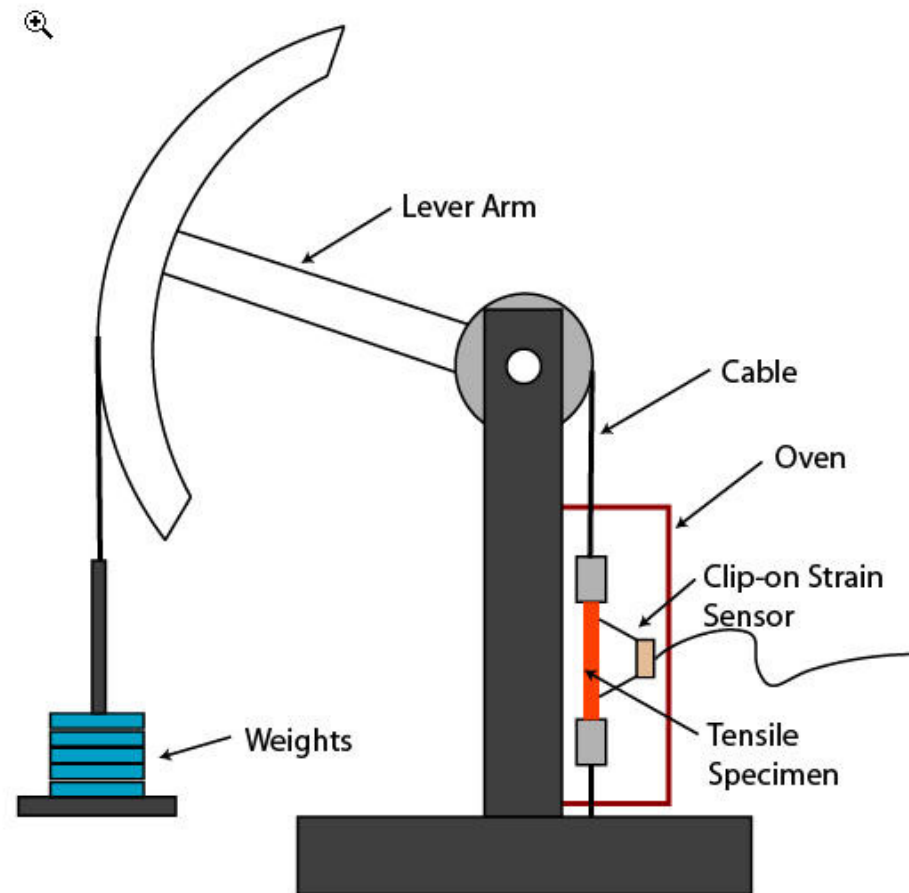
- High Strain Rate Experiments

- ➔ Technically challenging



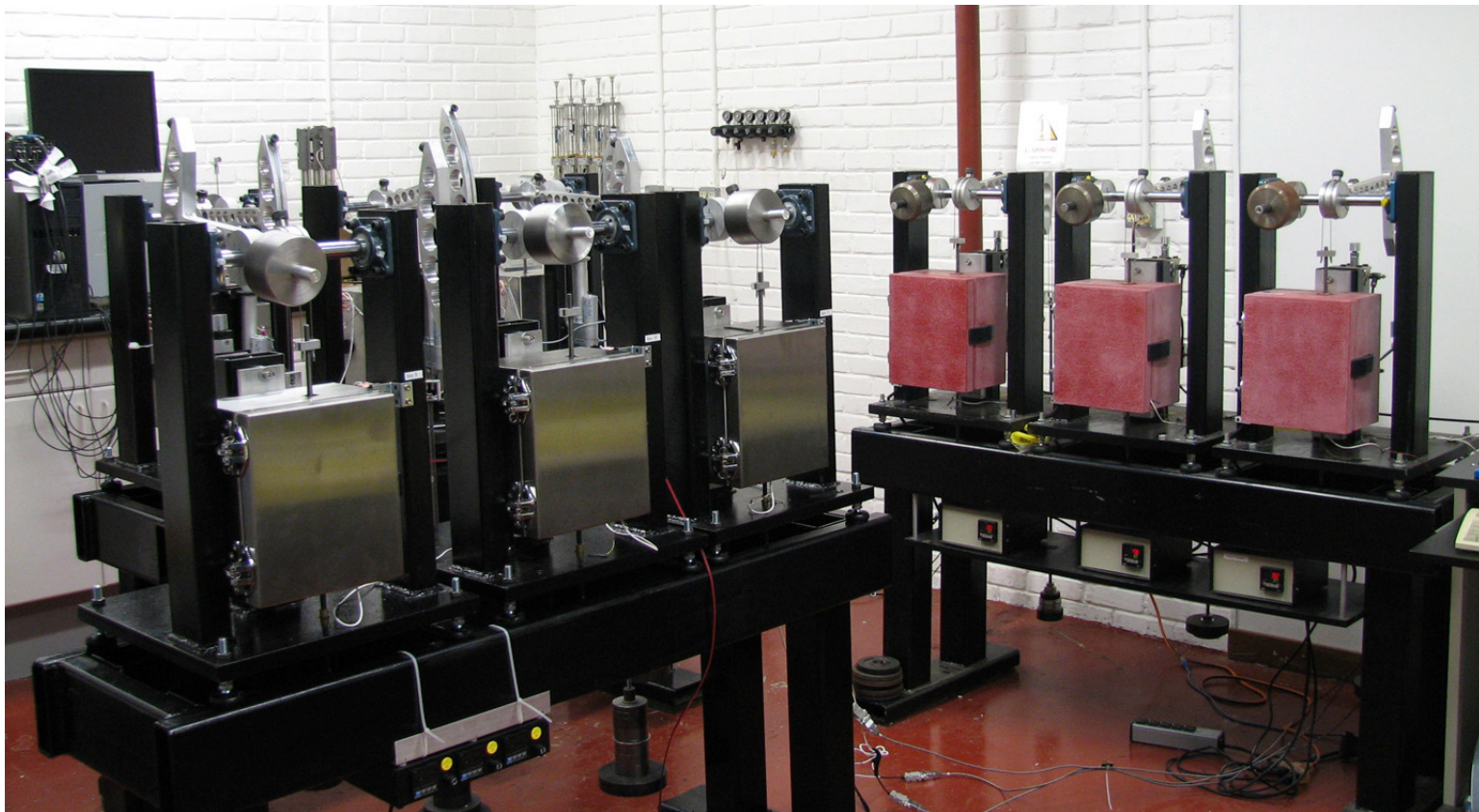
Sometimes really hard tests are worth the effort

- Long Term Creep Experiments



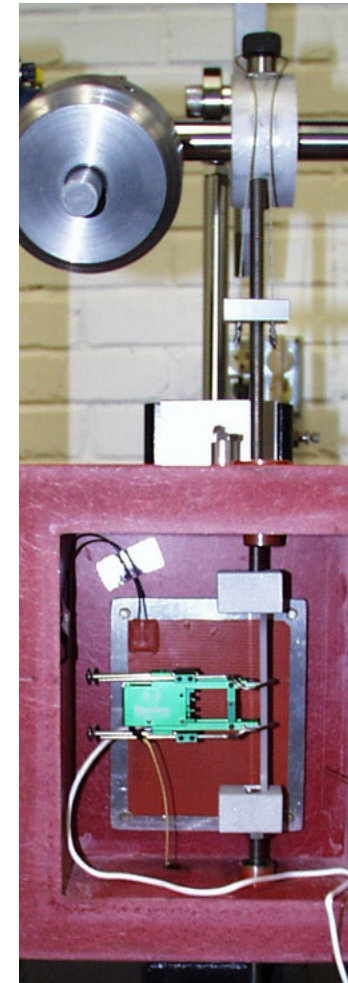
Sometimes really hard tests are worth the effort

- Long Term Creep Experiments



Sometimes really hard tests are worth the effort

- Long Term Creep Experiments
 - ➔ Decades of time
 - ★ Transducer range challenge
 - ➔ Stiff material creep test
 - ★ Extensometers creep
 - ➔ Elevated temperatures
 - ★ Special extensometers
 - ➔ Months of continuous operation
 - ★ Stable computers
 - ★ Stable power supplies
 - ★ Superior noise rejection



Sometimes really hard tests are worth the effort

- High Strain Rate Experiments



Sometimes really hard tests are worth the effort

- High Strain Rate Experiments
 - ➔ Not routine anywhere
- Instruments
 - ➔ Large, noisy and unreliable
 - ➔ Range of 1–100 s⁻¹ is tough
- Strain Measuring
 - ➔ Nonstandard
 - ➔ Mixture of strain gages, imaging and light sensing
- Force Measuring
 - ➔ Noise, oscillation and wave propagation problems



Sometimes really hard tests are worth the effort



Summary

- Analysis drives the physical testing
 - ➔ Use judgment, do what is needed
- Tests are not always to standards
 - ➔ Application based
- Sometimes really hard tests are worth the effort
 - ➔ Some kinds of tests are inherently difficult, yet needed for the analysis.

