e=MSC engineering. education. enterprise. 2009VPD virtual product development conference

What to do when f≠Ku

Material Model Calibration for Non-linear Materials in MSC.Software

Hubert Lobo, President, **Datapoint**Labs

DatapointLabs

expert material testing

Mechanical properties

Thermal properties

Flow properties

- About us

  Established 1995

  1000 materials tested/yr

  800 clients in 11 manufacturing verticals

  ISO 17025 Quality System

  Globally available

  - www.datapointlabs.com
  - visit | browse | buy | download

tensile
compressive
flexural
stress-strain
Poisson's ratio
high strain rate
bulk modulus
fatigue
visco-elasticity
stress relaxation
creep
friction
hyperelasticity
thermal expansion
thermal conductivity
specific heat

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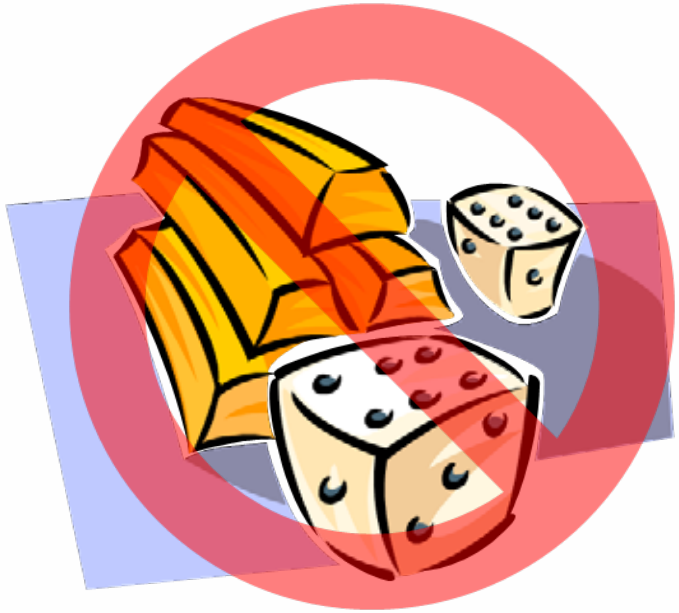
TestPaks® for CAE

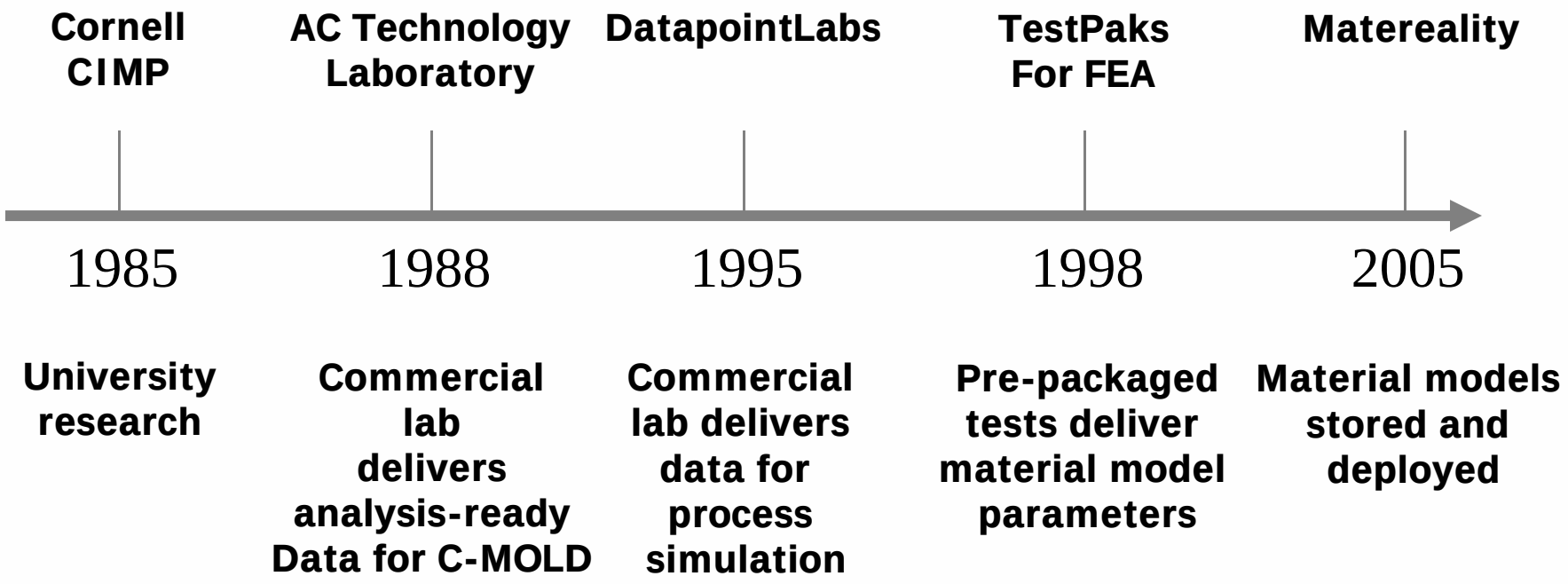
material model calibrations

- Simple to order
- Global availability
- Testing to CAE requirements
- Data in CAE-ready format
- Fast 5 day delivery
- Available via Matereality
- 120 material models supported



no gamble

Material model calibration- a history



Nature in non-linear[1]… think virtual do real!

- Need for quantitative simulation
- Multi-physics: modeling of complex behaviors
- Increased use of non-linear materials: plastics, foam, rubber..
- Need for consistent use of material data in the enterprise

1. http://www.mscsoftware.com/assets/3093_MSC-NonLinear_Fnot=Ku.pdf

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Non-linear strategy – pragmatism

- Focus on behaviors that are of greatest consequence to the real life problem
- Place limits on the material model based on the desired outcome
- Weight toward greatest potential sources of failure
- Seek simplest model that achieves a reasonable approximation of reality.

? can I do without hyper-elasticity ?

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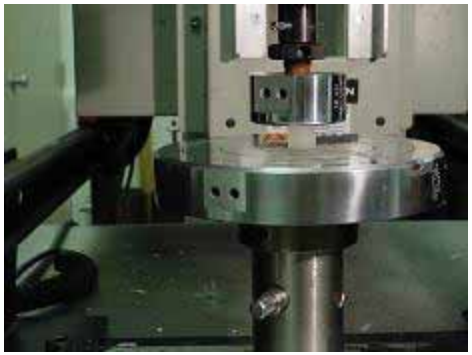
Hyperelastic

- Tensile
- Compressive
- Planar
- Volumetric

- Range
  - -50 to 200 C
  - pre-cycled or first pull
  - rate dependency



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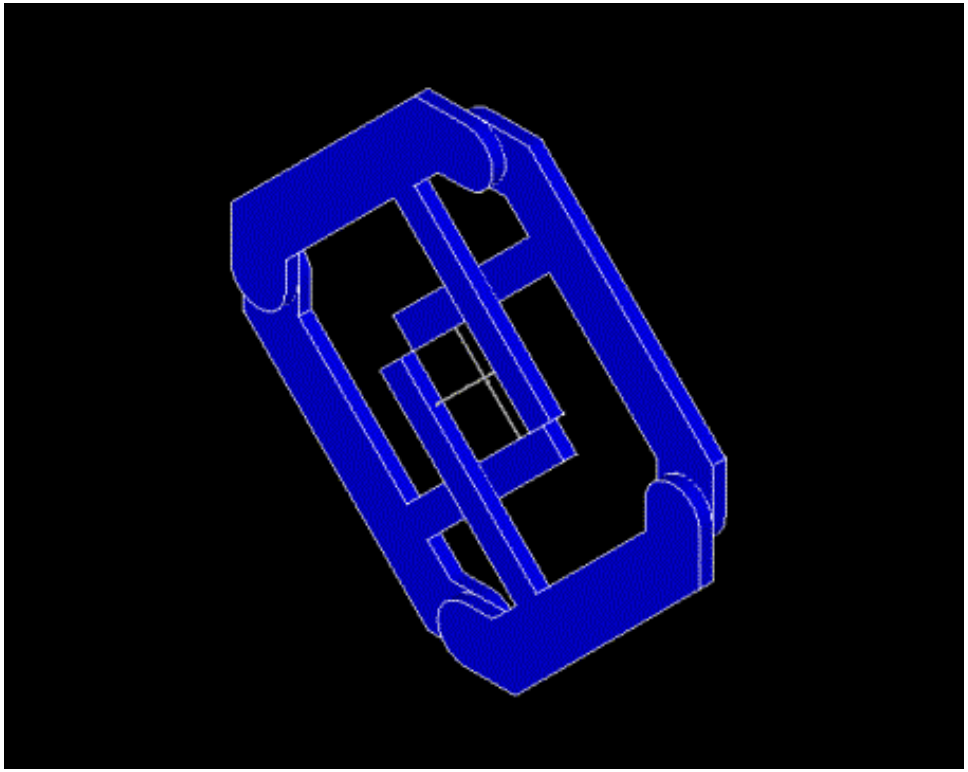
Equibiaxial testing

- Alternate to compressive test for Hyperelastic models
- Works best with
  - sheet materials
- Use
  - inflation
  - stretching
  - bending



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Modeling strategy

- Depends on magnitude of deformation
  - Small deformation
    - Use neo-hookean models
  - Large deformation
    - Use hyperelastic models.
- Valid material models
  - Mooney Rivlin
  - Ogden
  - AB
- Applicability – Nastran, Marc, Dytran

know your real life strains before you test

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Tensile measurements

- Uniaxial stress-strain measurements
- Poisson's ratio
- Range
  - -40 to 200 C
  - 0.001 to 100/s strain rate
  - Orientation
  - Environmental exposure

MARC Non-linear model

DatapointLabs Report # PC

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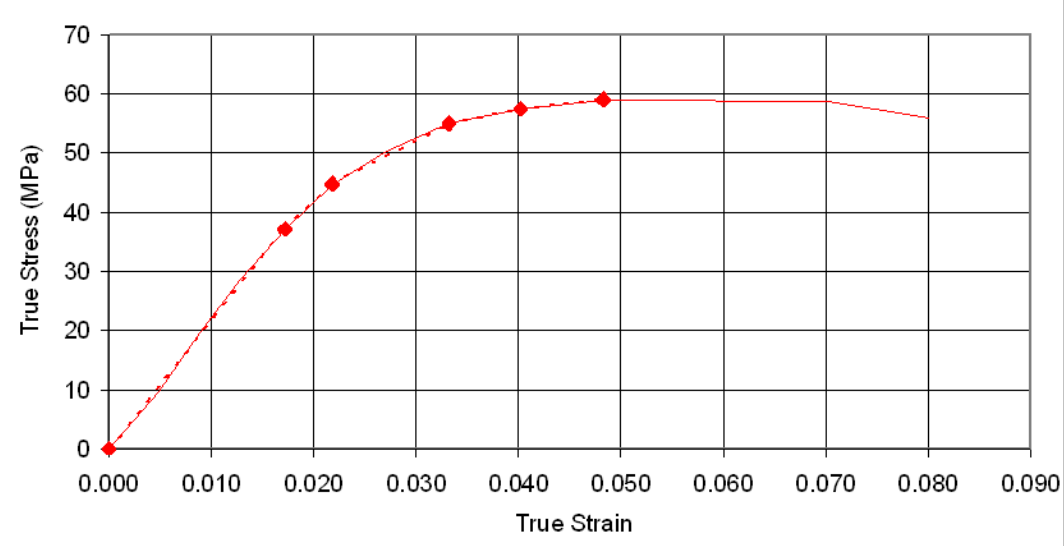
MARC Strain Hardening *TestPak* ™

PC

The model uses the isotropic work hardening model to describe the non-linearity of the stress-strain curves. True strains and true stresses have been used to derive the model. Unloading the model during the analysis may results in inaccuracies.



Mode	Tensile Rep 1	
Temperature, °C	23	
Strain Rate, /s	0.07	
Poisson's Ratio	0.40	
Elastic Modulus, MPa	1979	
Secant Modulus, MPa	2163	
Yield Stress MPa	37	
	Plastic Strain	**Workhard Slope**
	0.0000	7080
	0.0011	1516
	0.0078	429
	0.0136	210
	0.0210	21

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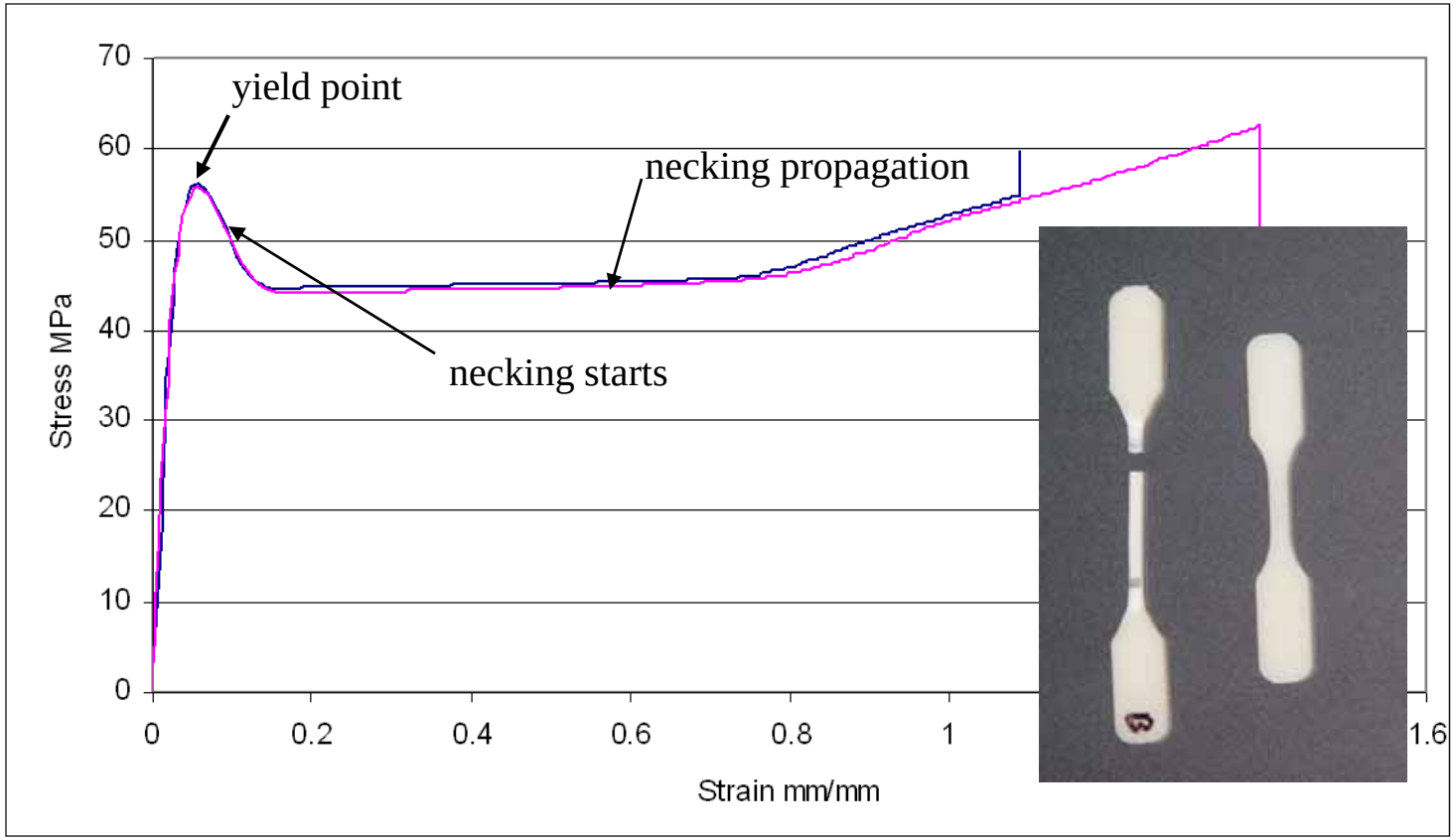
Post yield ductile behavior



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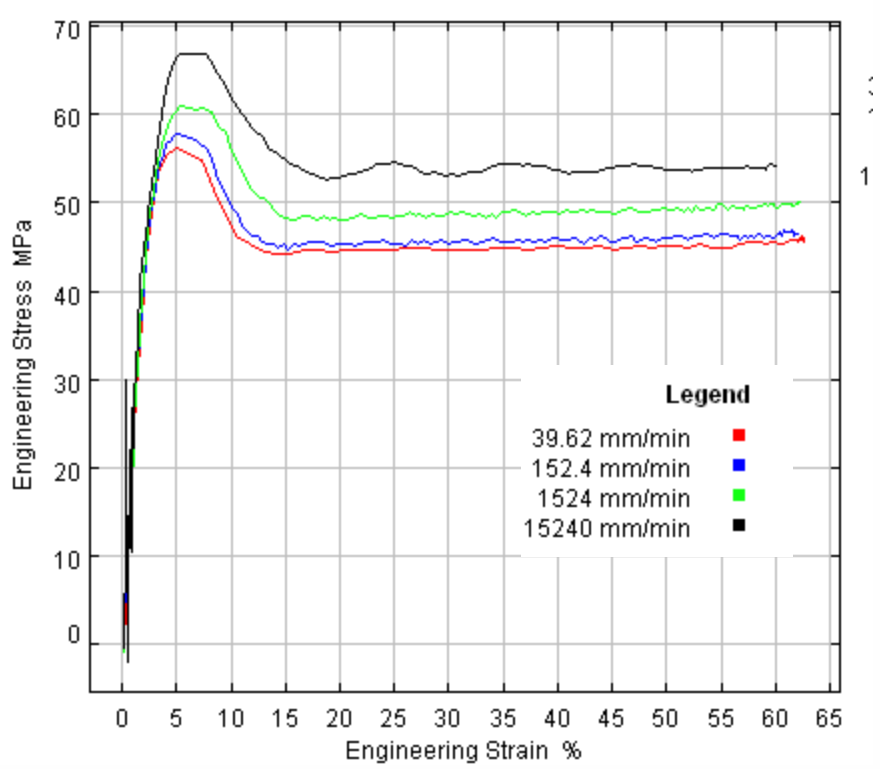
High strain rate data

- Needed for rate dependent models
- Use
  - crash
  - impact
  - drop testing
- Applicable software
  - Dytran



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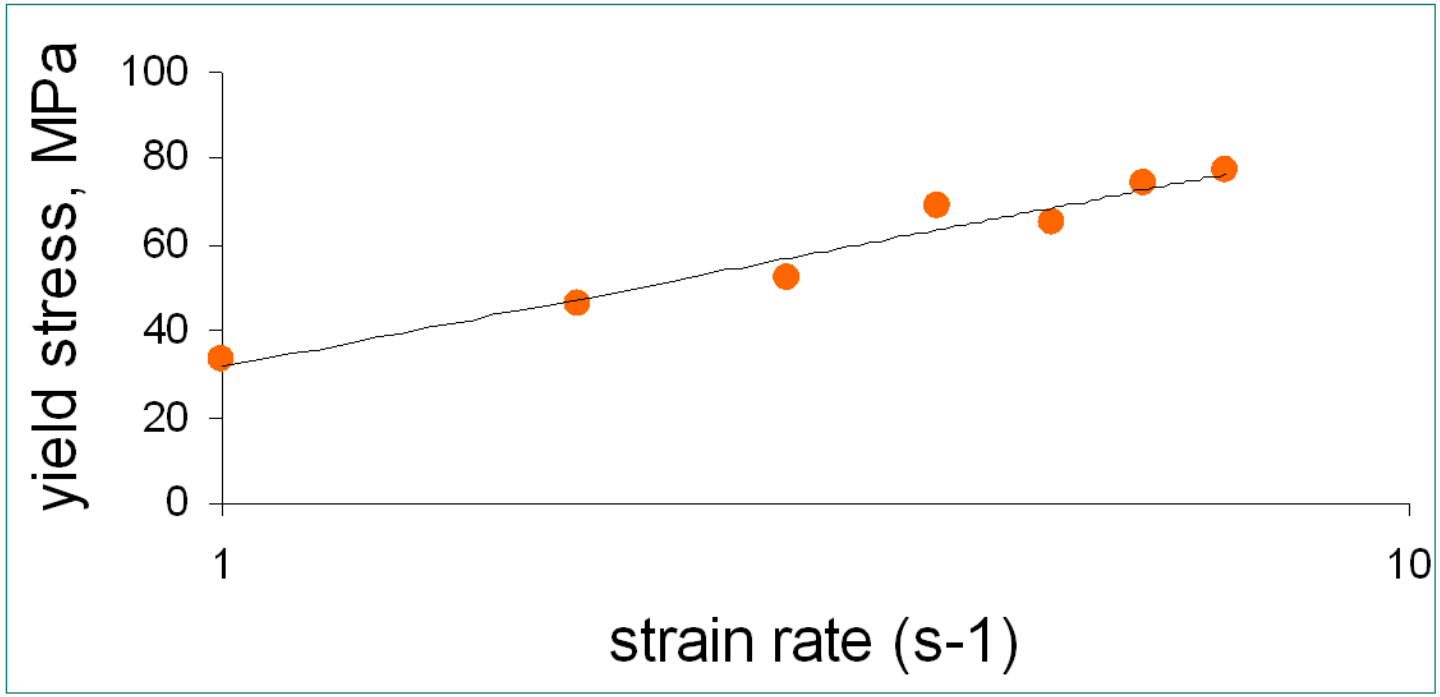
Rate dependence of yield



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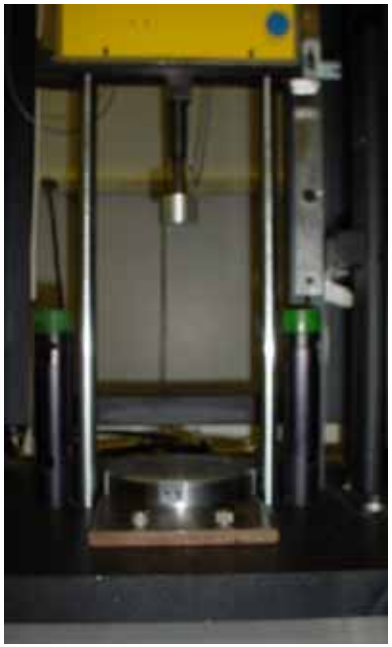
Modeling of Foam

- Foam type
  - Crushable
  - Elastic
  - Partial recovery
- Rate dependency
- Tensile cutoff stress

Crushable foam test



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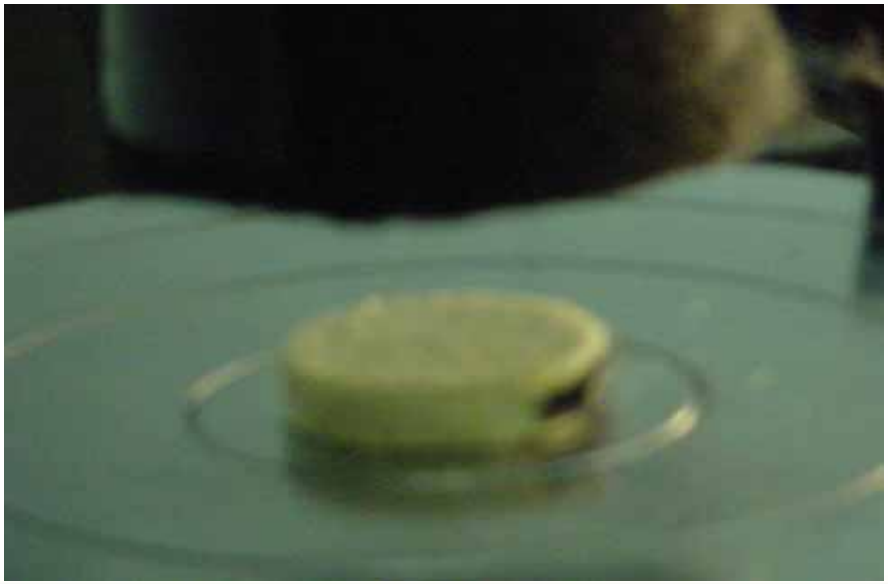
- Poisson’s ratio almost 0
- Rate dependency
- Range: up to 500/s, -40 to 150C



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Shear Properties

- Needed for foam models
- Materials
  - crushable foam
  - elastomeric foam

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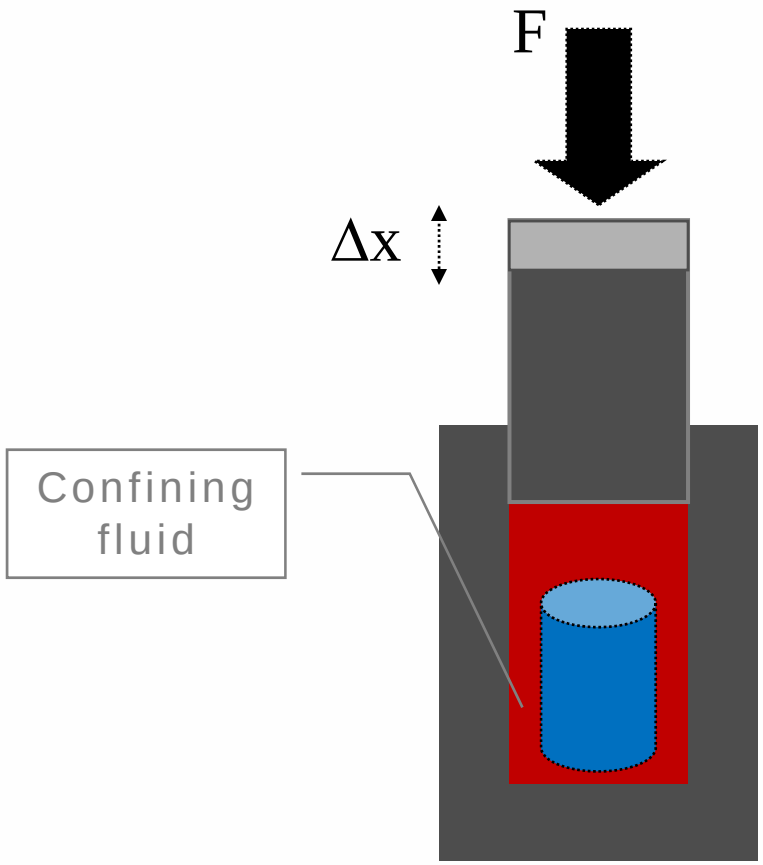
Hydrostatic compression

- Needed for Hyperfoam models
- Materials
  - crushable foam
  - elastomeric foam
- Works best with
  - closed-cell materials



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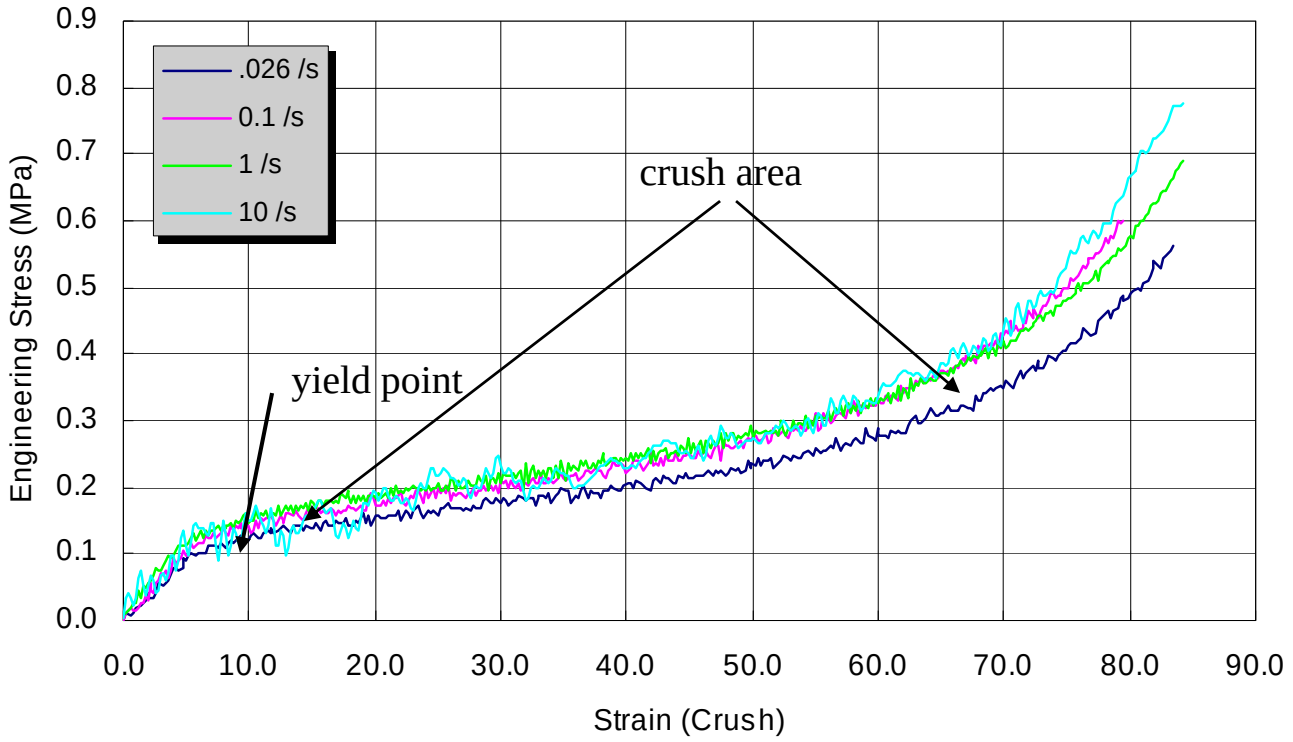
Raw data



Visco-elasticity

- Needed for MARC Isotropic Viscoelastic models
- Materials
  - plastics
  - foam
  - rubber
- Modes
  - Stress relaxation
  - Creep
  - Viscoelastic-dynamic

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Modeling strategy

- Models are small strain
  - Couple with linear elastic behavior.
- Hyperelastic coupling
  - May not be applicable for large strains
  - Localized solutions are possible for stress-relaxation analysis
- Large strain strategy
  - Consider using creep models when plastic deformation is expected
- Applicability – Marc

be cautious with large strain visco-elasticity

On-line resource at testpaks.com

- New CAE centric materials web-site
- Focus on material models
- Testing for CAE / simulation
- Supported by
  - DatapointLabs experts
  - CAE vendors
  - Expert users

Contact Details :

- For further information please contact

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- CAE/Material Modeling Information: www.testpaks.com