Dynamisches (*zeitabhängiges* = *viskoses*) Werkstoffverhalten

„*unrühmliches Beispiel*“

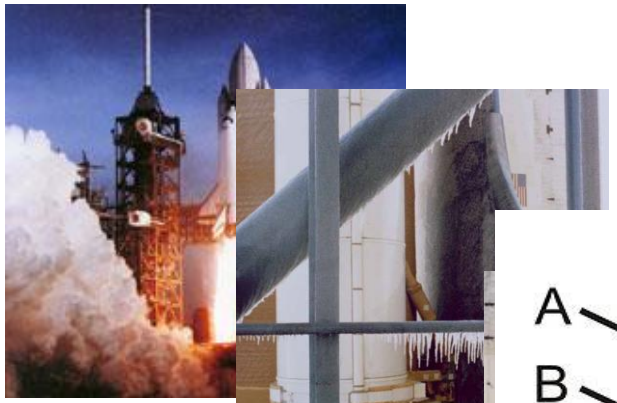
Google

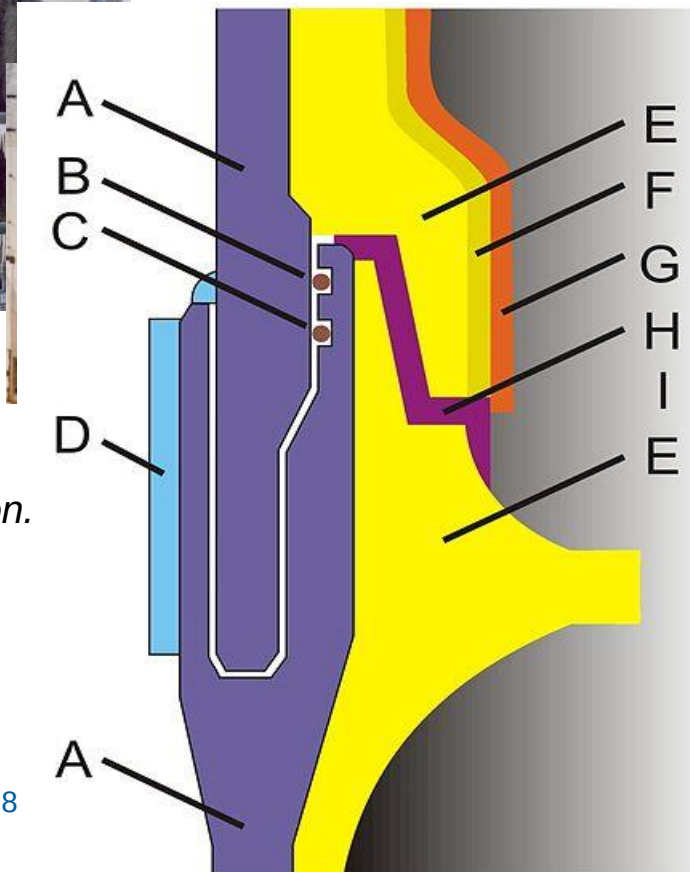
Suche:

→ „`o ring 1986`“

Erste beiden Treffer *(09.12.2012)**:***

http://dssresources.com/cases/spaceshuttlech
http://en.wikipedia.org/wiki/Space_Shuttle_Ch

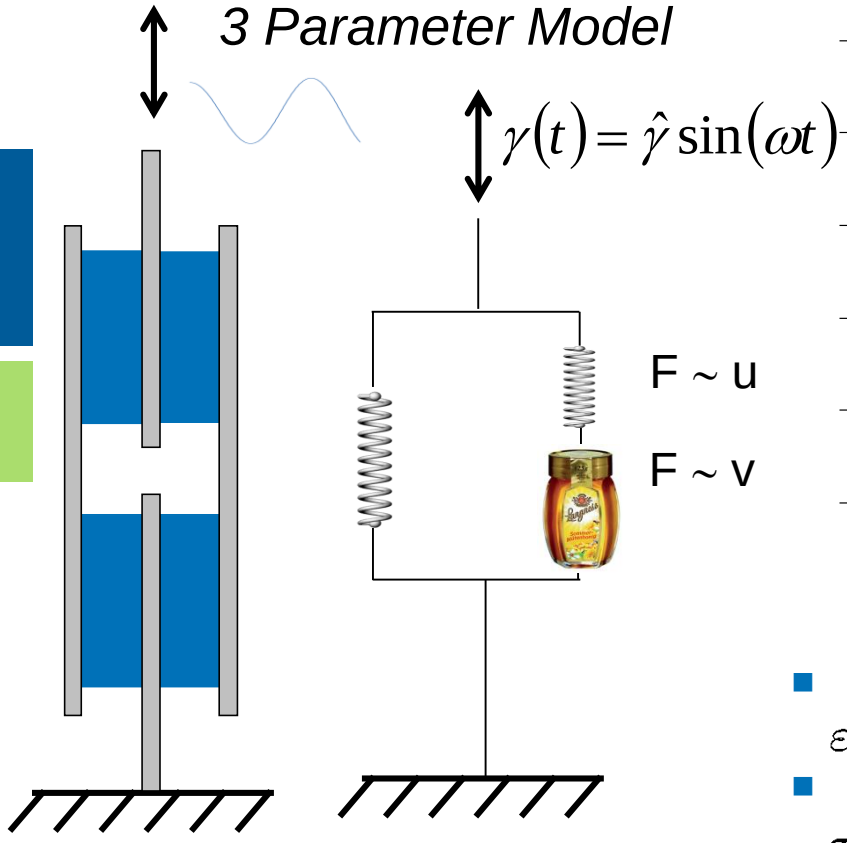


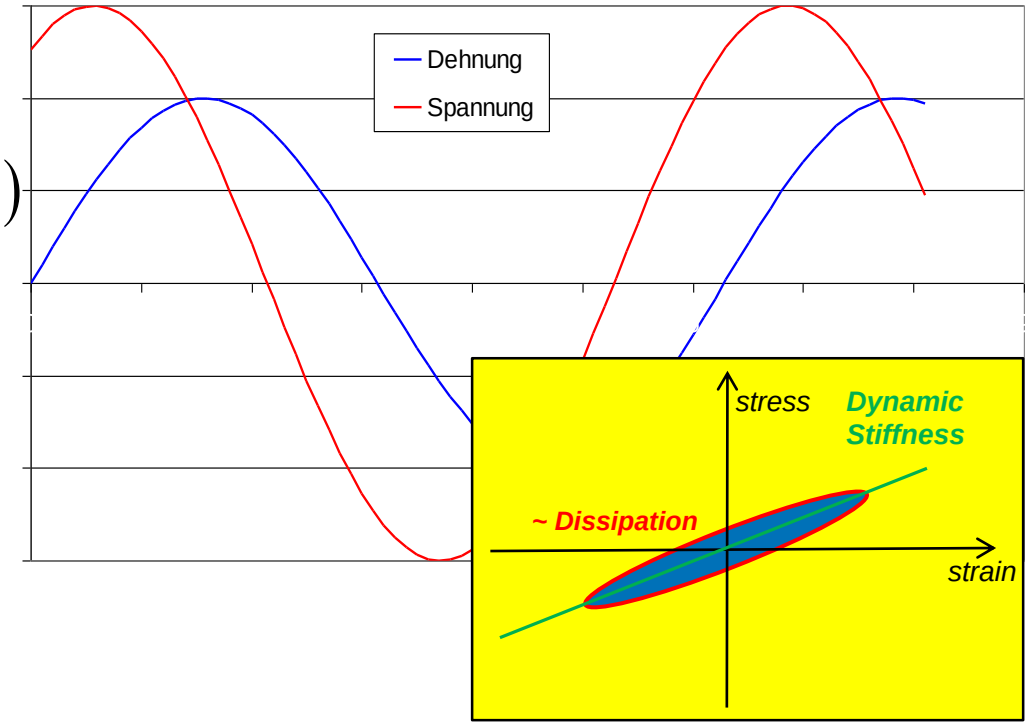


*I took this stuff that I got out of your seal and I put it in ice water, and I discovered that when you put some pressure on it for a while and then **undo** it, it does **not** stretch back. It stays the same dimension. In other words, for a few seconds at least and more seconds than that, there is **no resilience** in this particular material when it is at a temperature of 32 degrees. ”*
—Richard Feynman

„Dynamics - Harmonic Material Response

Dynamic-Mechanical-Analysis @ Shear Buffer





- Strain:

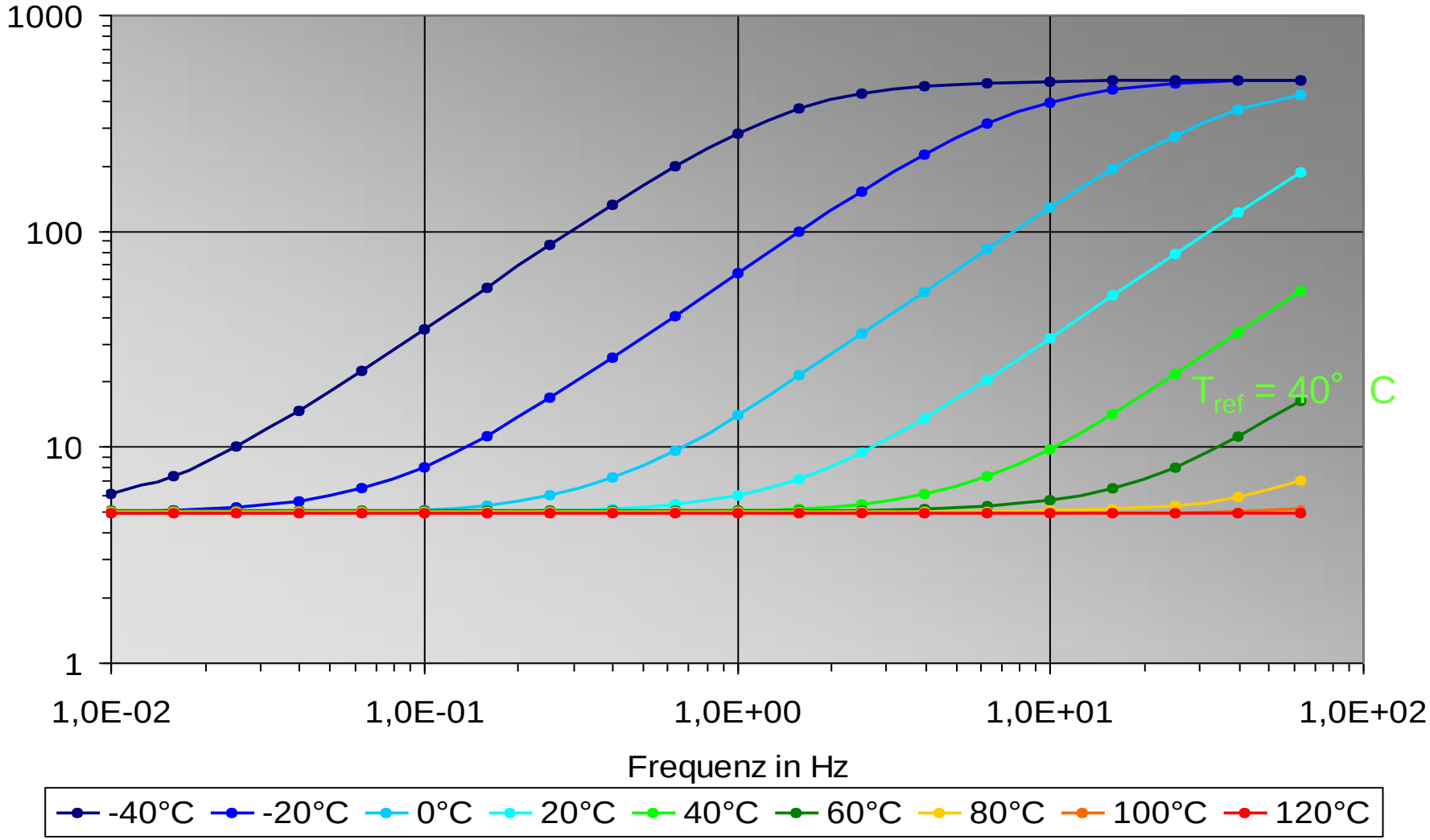
$$\varepsilon(t) = \varepsilon_0 \sin(\omega t)$$

- Stress:

$$\sigma(t) = \sigma_0 \sin(\omega t + \delta) = \varepsilon_0 |G| \sin(\omega t + \delta)$$

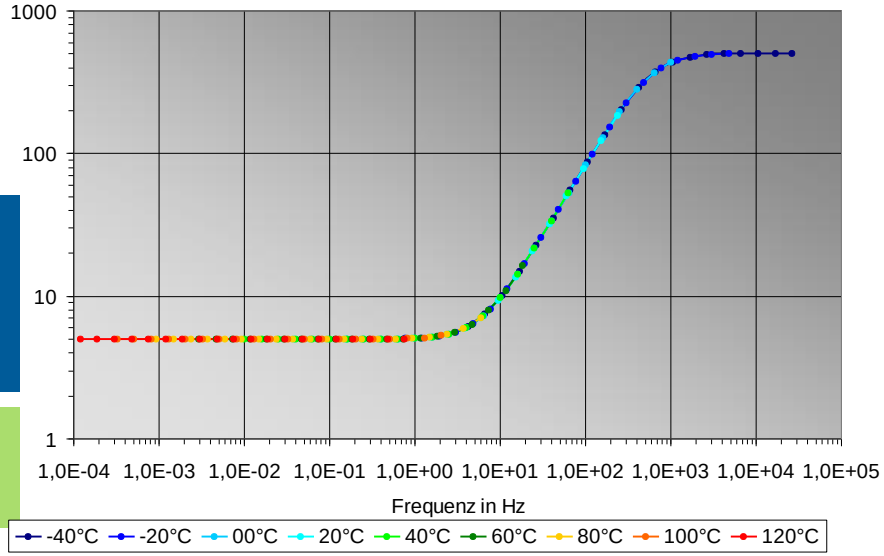
|G|: Modul (*G‘:* Storage-, *G“:* Loss-Modulus)
δ: Loss Angle

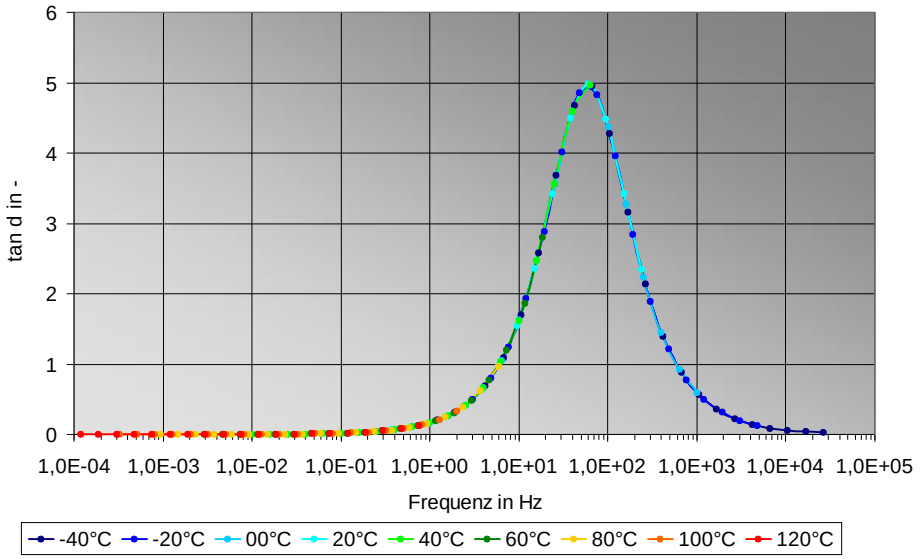
Dynamisches Werkstoffverhalten: Masterung



master curves

dynamic modulus G und phase shift δ for large frequency range



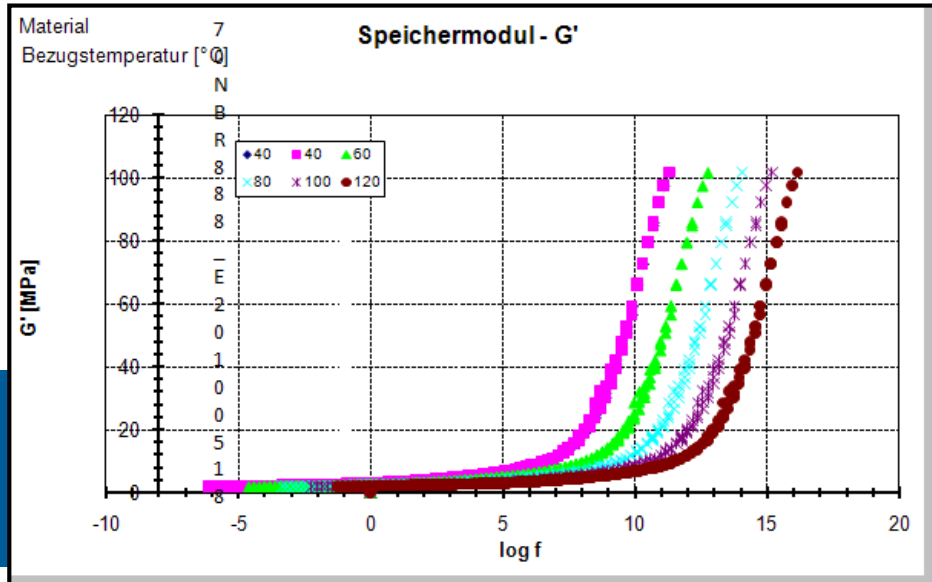


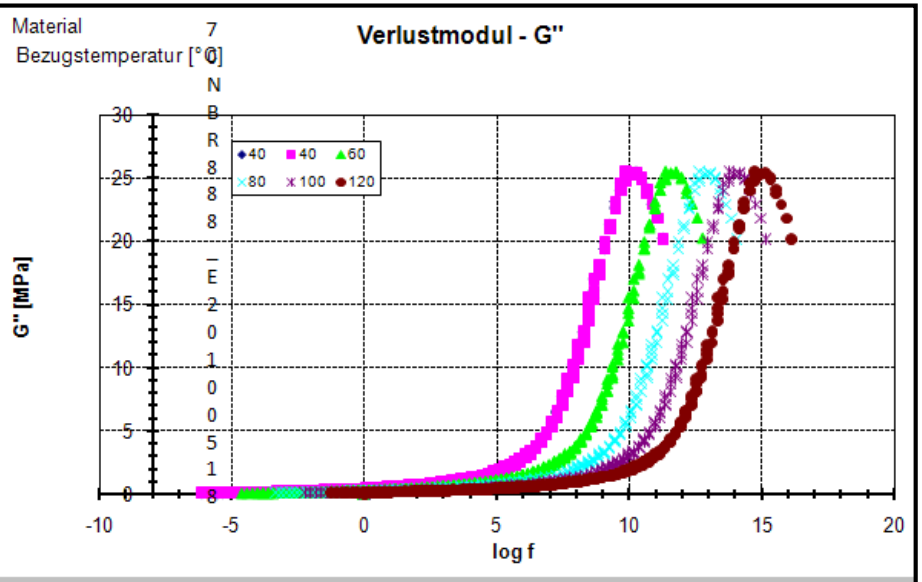
„WLF shifting“:

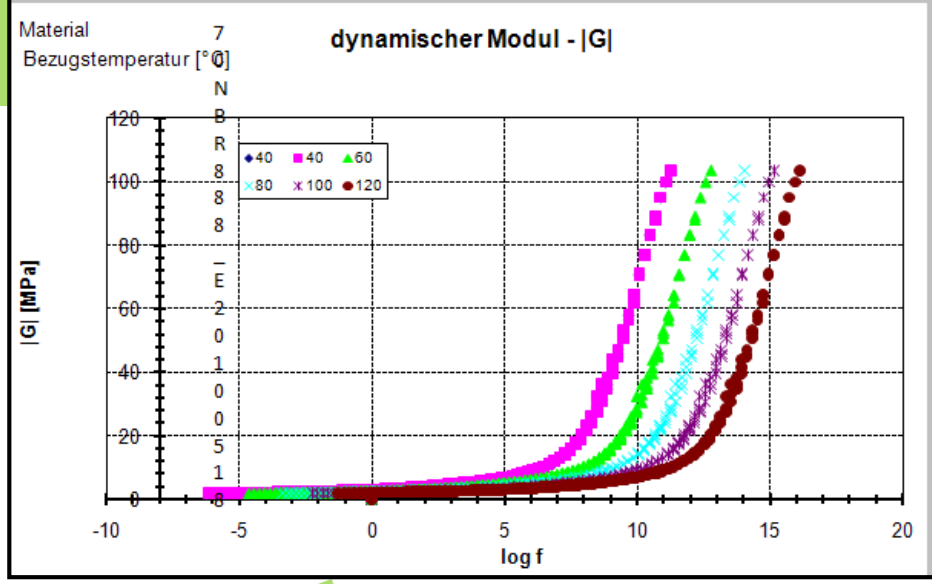
„*reference temperature*“

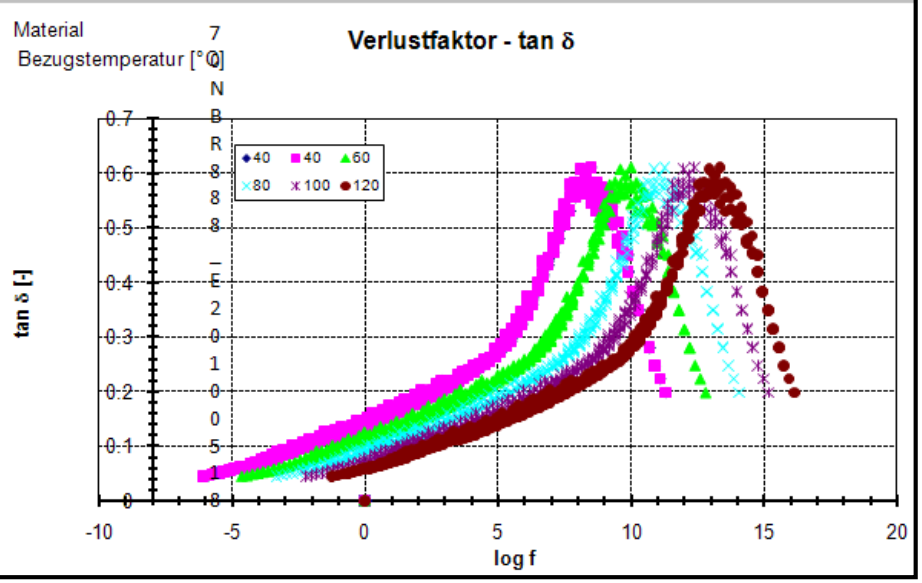
$$\log(a_T) = -\frac{c_1 (T - T_s)}{c_2 + T - T_s}$$

DMA @ „NBR888“

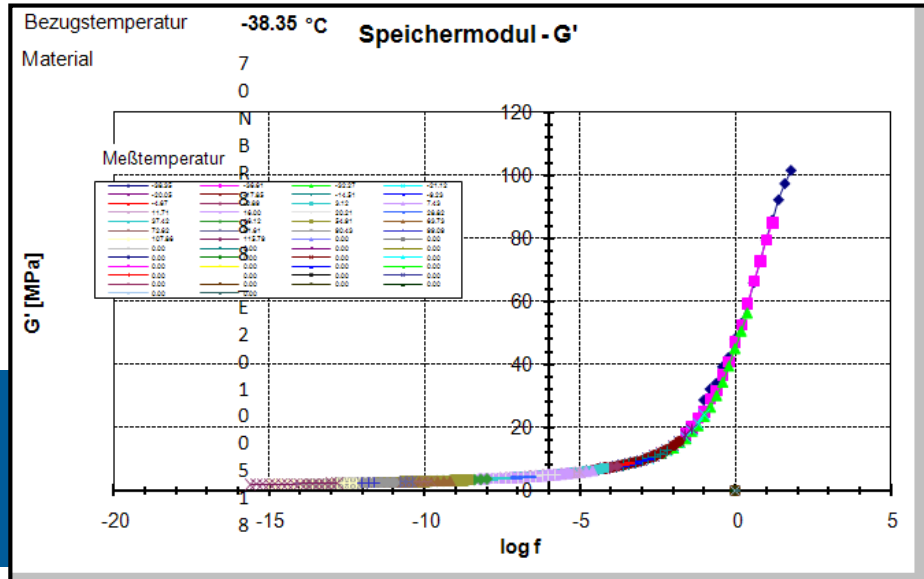

Material
Bezugstemperatur [°C]
7
NBR888_E20100518
Speichermodul - G'
40 40 60
80 100 120
G' [MPa]
log f

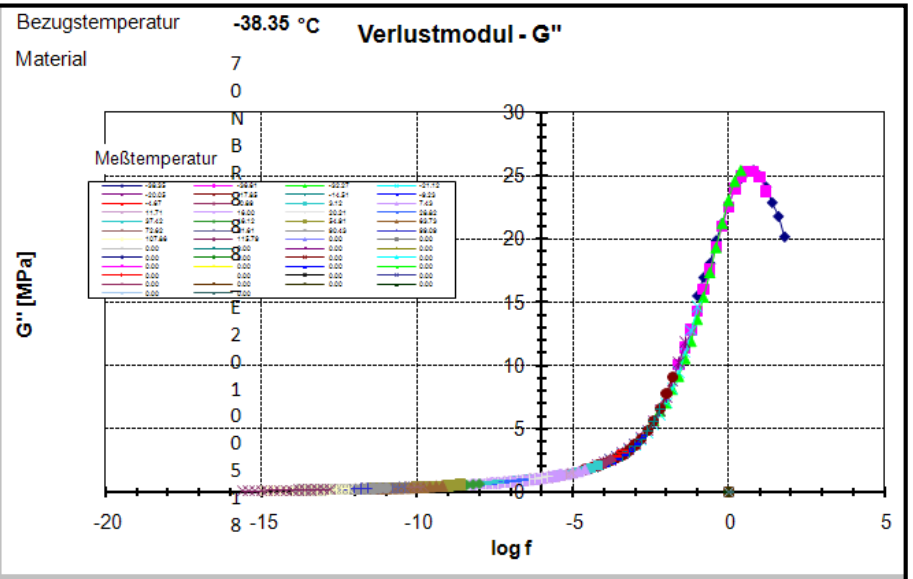

Material
Bezugstemperatur [°C]
7
NBR888_E20100518
Verlustmodul - G''
40 40 60
80 100 120
G'' [MPa]
log f

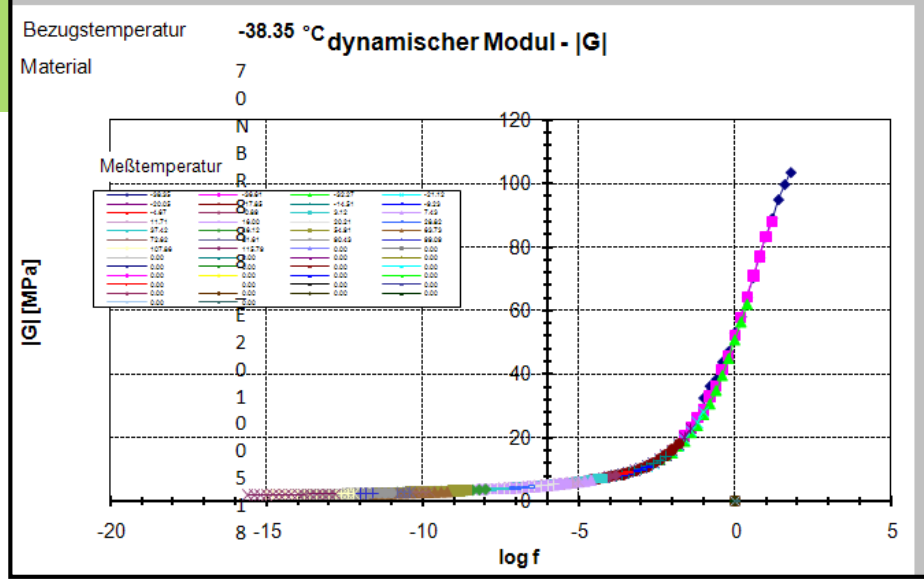

Material
Bezugstemperatur [°C]
7
NBR888_E20100518
dynamischer Modul - |G|
40 40 60
80 100 120
|G| [MPa]
log f

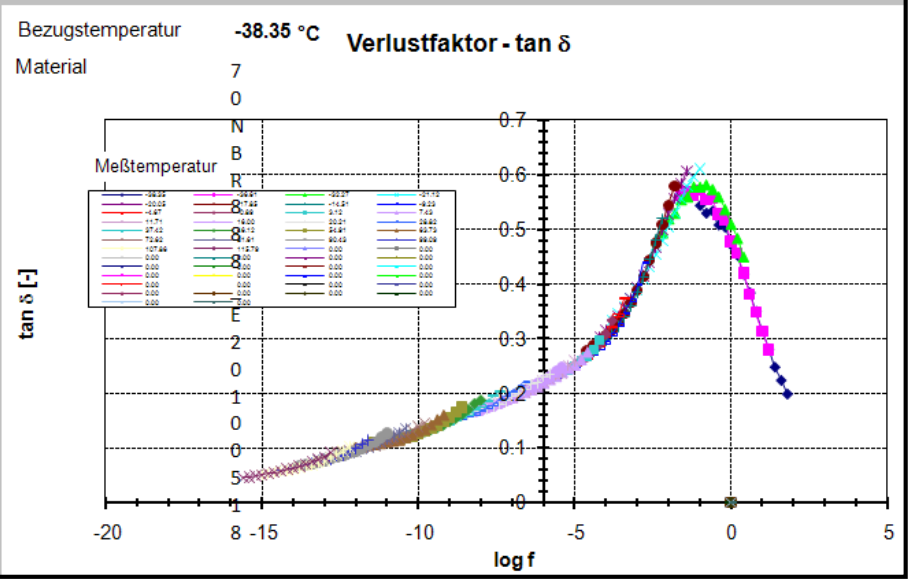

Material
Bezugstemperatur [°C]
7
NBR888_E20100518
Verlustfaktor - tan δ
40 40 60
80 100 120
tan δ [-]
log f

master curves for „NBR888“

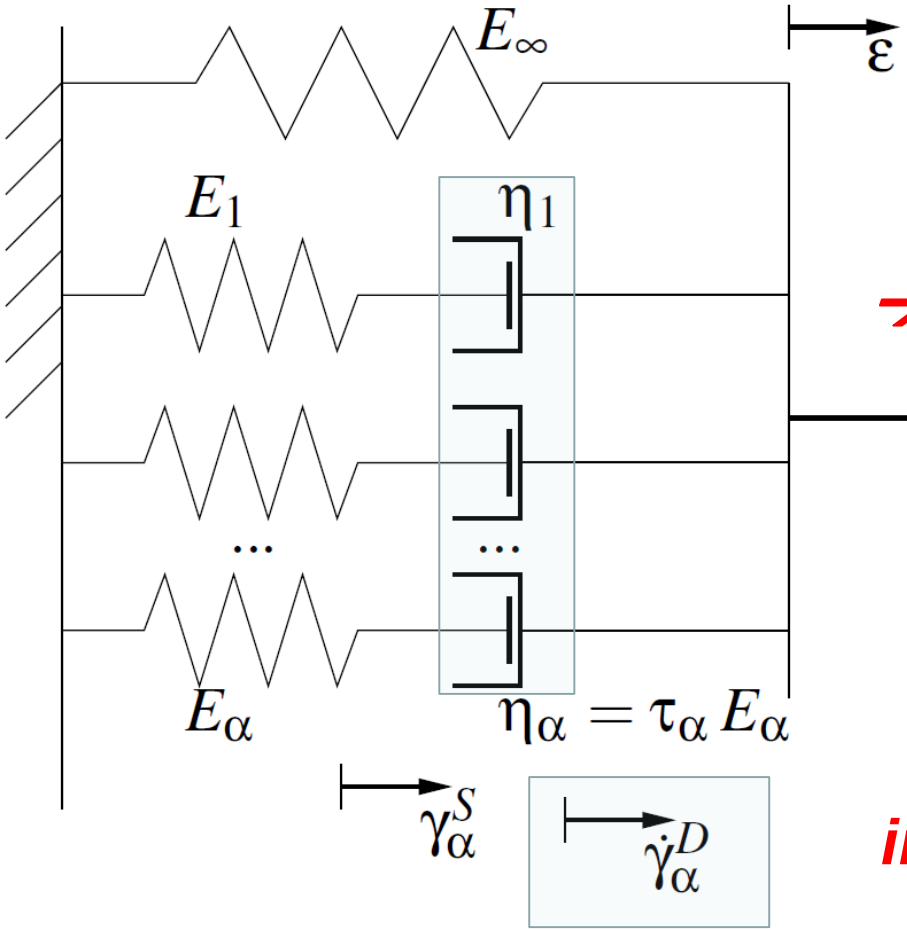








Generalized MAXWELL-Model

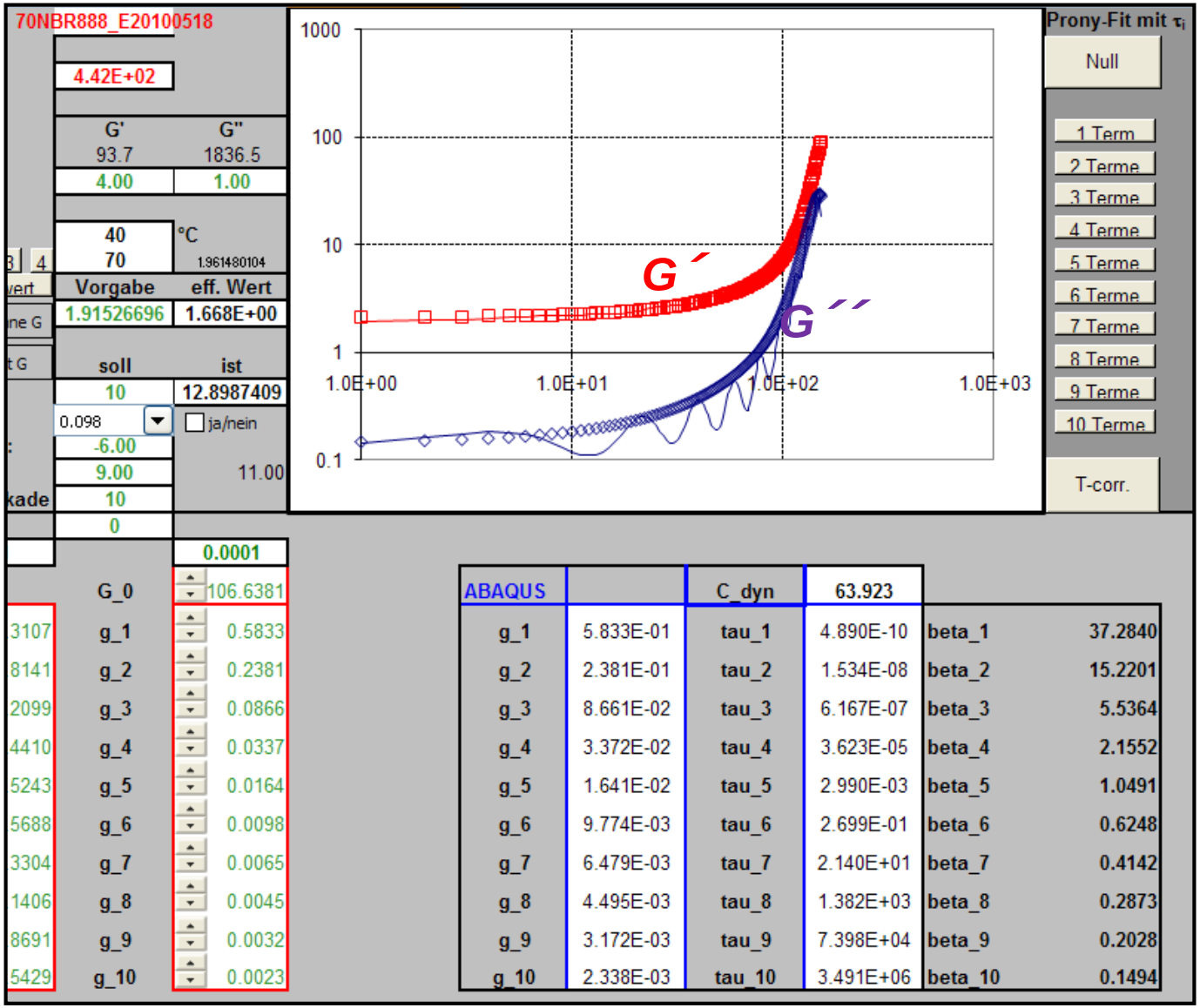


honey pots
→ dissipation

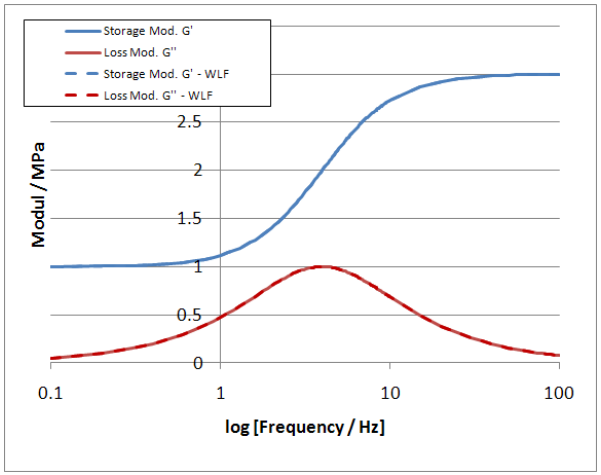
$$\sigma = \sigma_\infty + \sum_\alpha q_\alpha$$

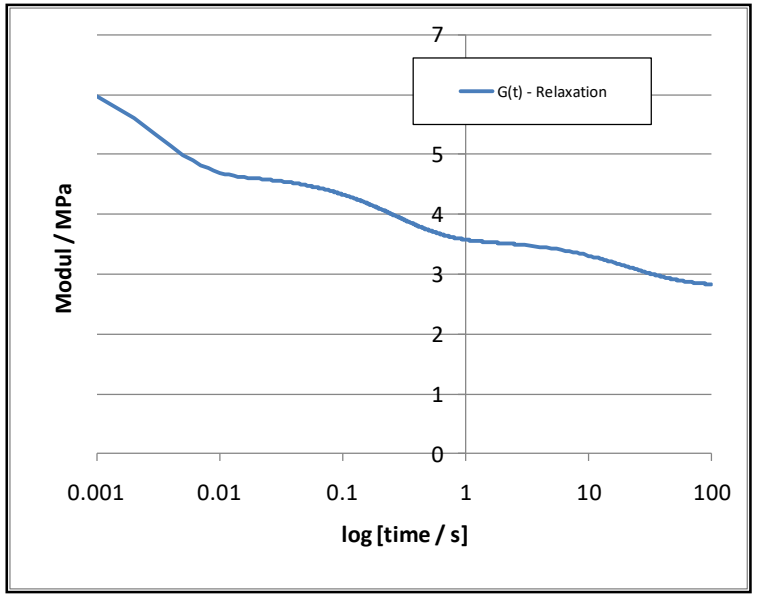
internal variables

PRONY series for „NBR888“



Relaxation





$$G(t) = G_0 \left[1 - \sum_i g_i \left(1 - \mathrm{e}^{-t/\tau_i}\right)\right]$$

Normalization:

$$g_i = \frac{G_i}{G_0}$$

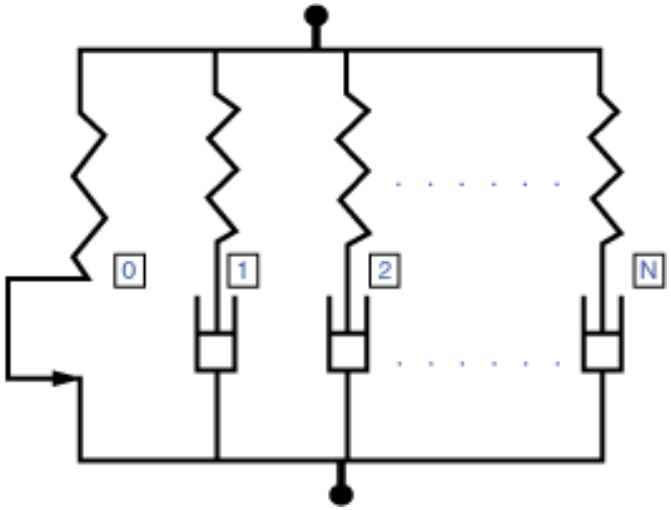
Ratio of *Infinitely (long term)*- to *Instant.-Modulus:*

$$\frac{G_\infty}{G_0} = 1 - \sum_i g_i$$

„parallel rheological framework“

Abaqus 6.13

SIMULIA



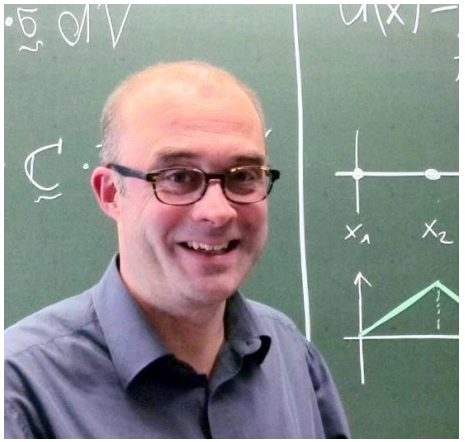
→ Manual #6.2

Prof. Dr.-Ing. habil. **Herbert Baaser**
"*Technische Mechanik & Finite Elemente Methoden*"

Fachbereich 2 - Maschinenbau
Berlinstr. 109
55411 Bingen am Rhein, Germany

TU Darmstadt
FB13 - Festkörpermechanik
64287 Darmstadt

Fon + 49 6721 409 132
H.Baaser@TH-Bingen.de



precision **i**n **num**erics
pinum.de