Developments in Stress Relaxation and Lifetime estimation test methods and instruments

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Stress Relaxation

Standardised test methods

Relaxation in compression, ISO 3384

a) measurement at test temperature

b) measurement at room temperature

c) measurement in liquids (rings)

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Stress Relaxation

Standardised test methods

Relaxation in tension, ISO 6914

a) continuous elongation

b) intermittent elongation

this is not relaxation, but measurement of the change in modulus

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Stress Relaxation

What happens in the material

- Physical relaxation
- Thermal degradation
- Oxidative degradation
- Continued crosslinking

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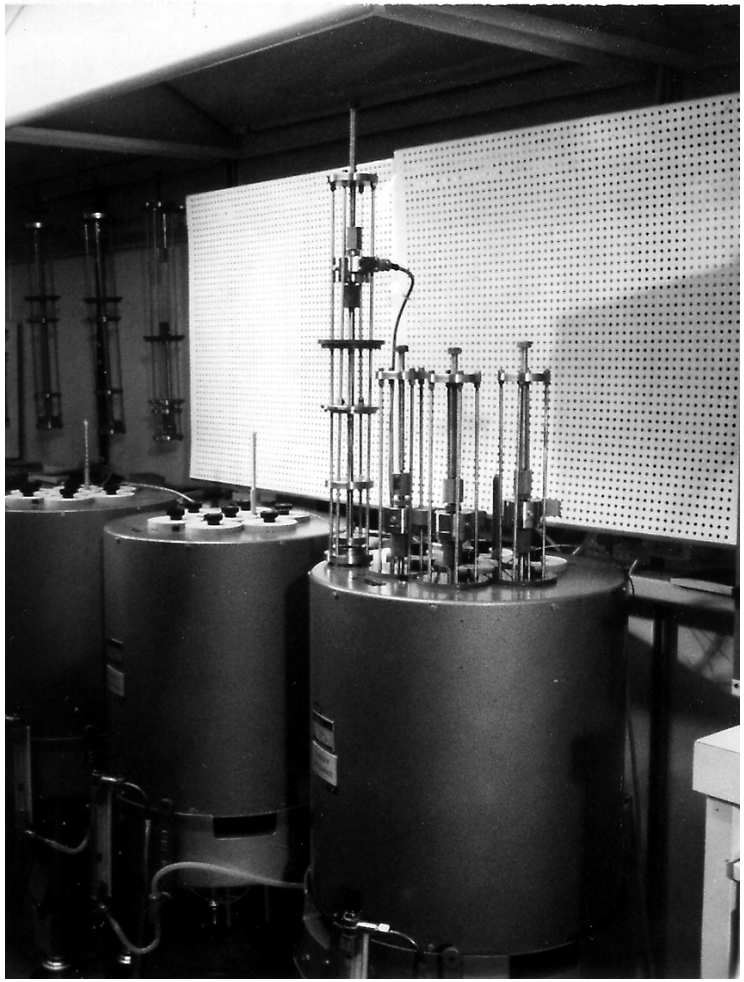
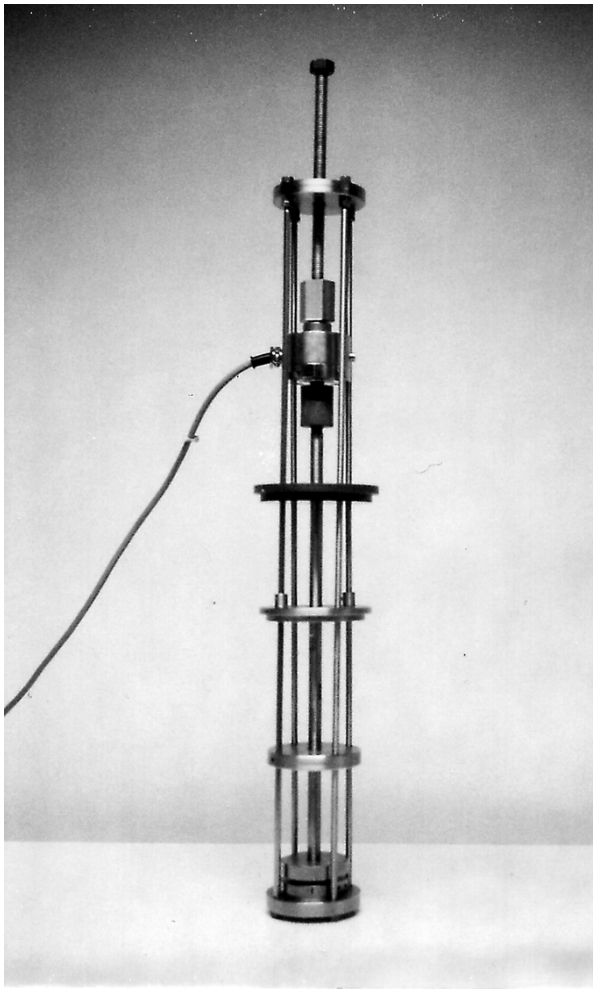
History

The first relaxation rig





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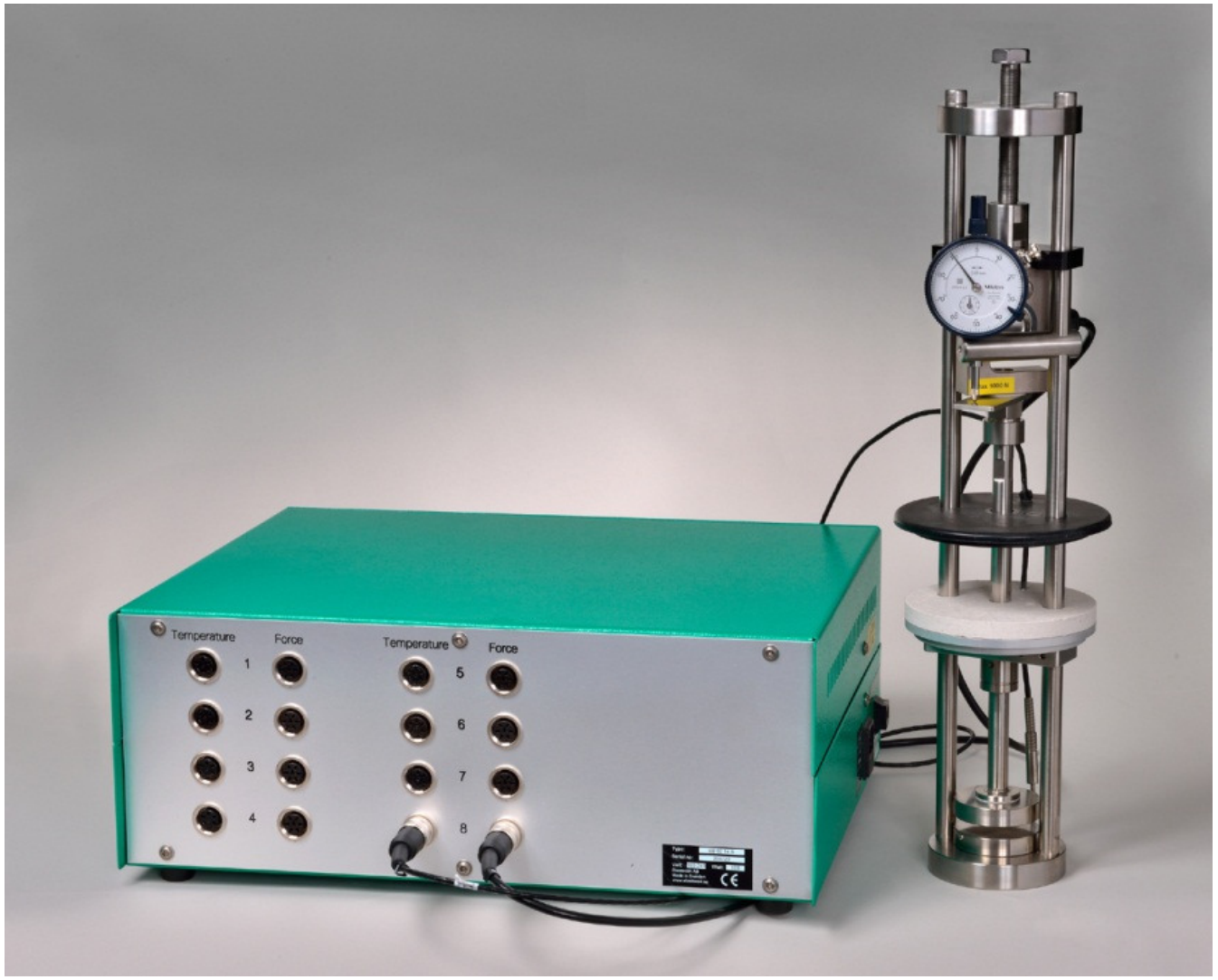
Relaxation rig and amplifier



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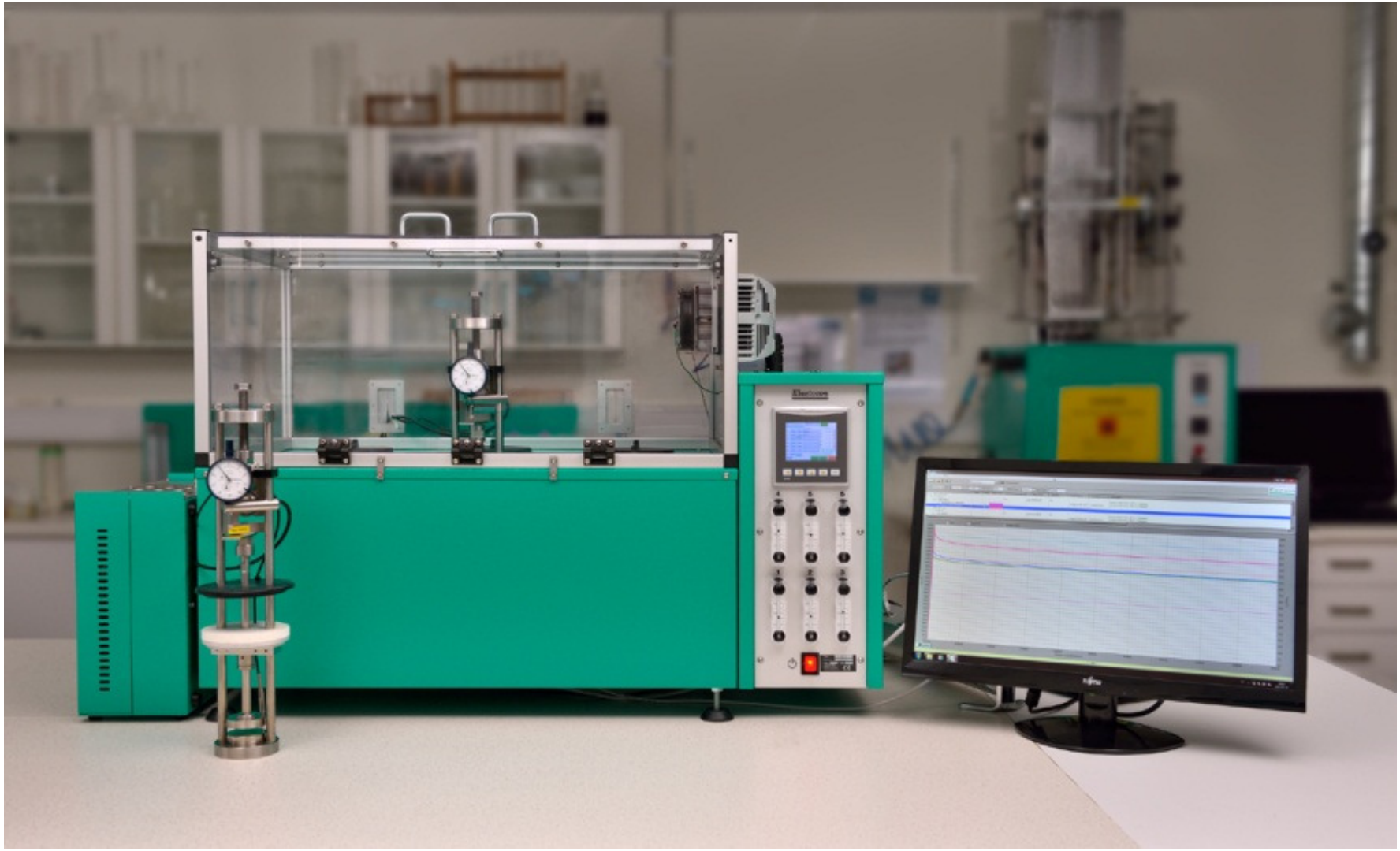
Relaxation system



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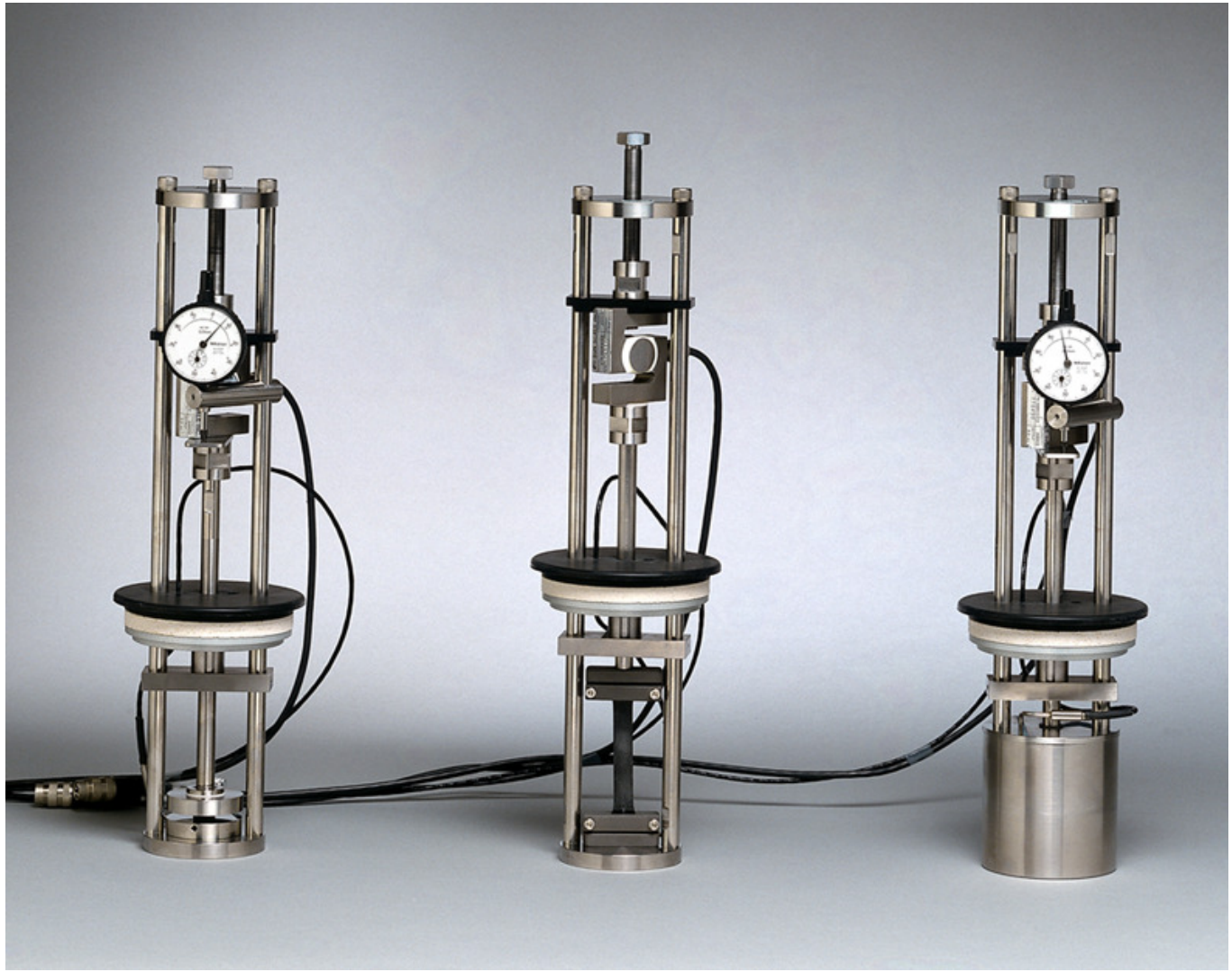
Relaxation rigs

Compression, Tension, in liquids



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Discontinuous relaxation

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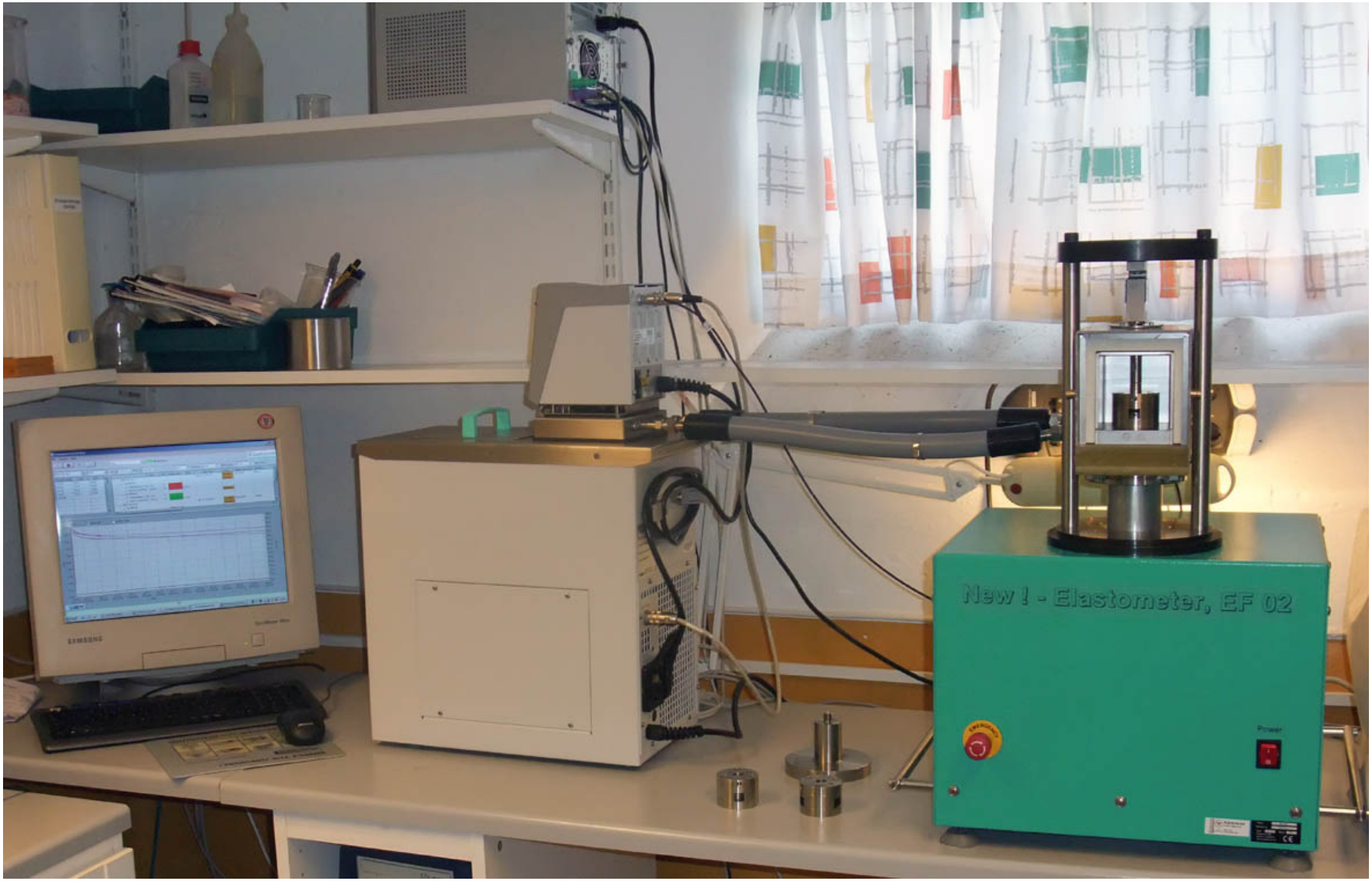
Discontinuous relaxation



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Compression Tester

Control and measurement of:

- Temperature 0,1 °C
- Force 0,1 N
- Displacement 0,001 mm

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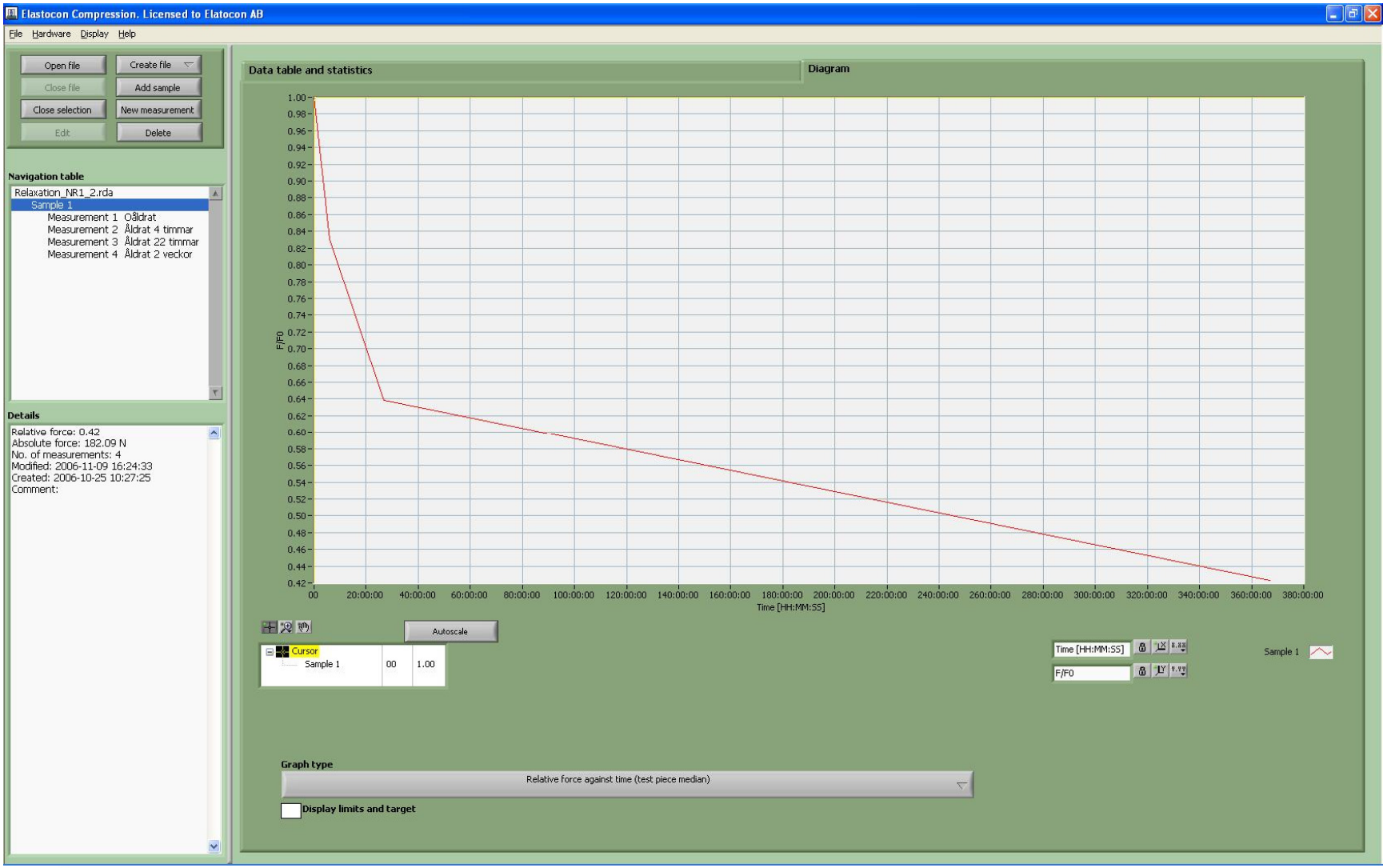
Discontinuous relaxation results



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ITP ISO 3384 Stress relaxation,1998

Table 1 Precision

Method A 168 h at 23 ℃; % relaxation

Material	Mean	Sr	r	SR	R	(R)
A	10,9	0.80	2.22	1.21	3.40	31

Method A 168 h at 100 ℃; % relaxation

Material	Mean	Sr	r	SR	R	(R)
A	50.5	0.85	2.37	2.15	6.03	11,9

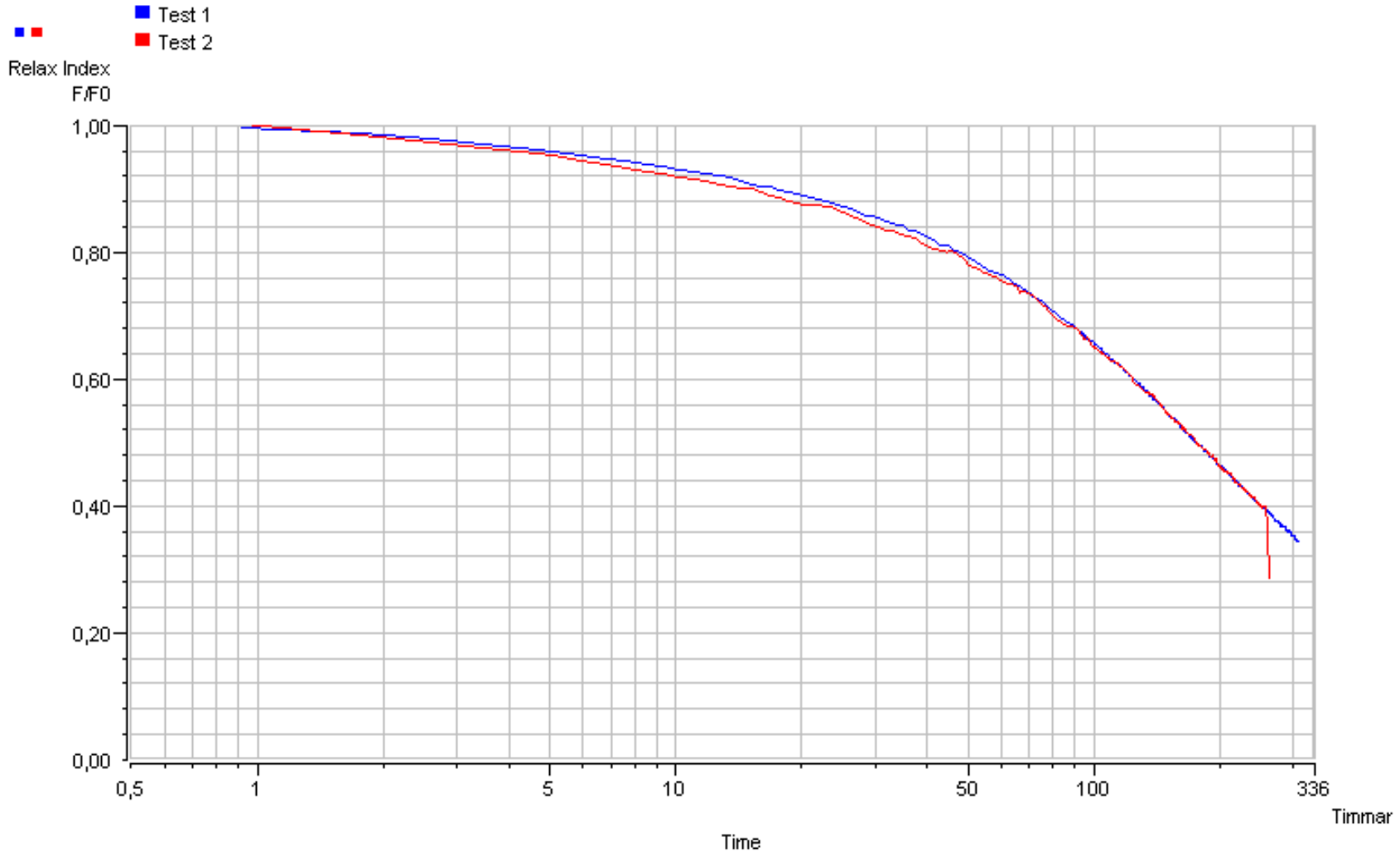
Method B 168 h at 100 ℃; % relaxation

Material	Mean	Sr	r	SR	R	(R)
A	67.5	2.07	5.80	8.66	24.3	36

Sr = repeatability standard deviation, measured units
r = repeatability, in measured units (i.e..%relaxation)
SR = reproducibility standard deviation, measured units
R = reproducibility in measured units (i.e..%relaxation)
(R) = reproducibility in %

Repeatability

One rig different test periods



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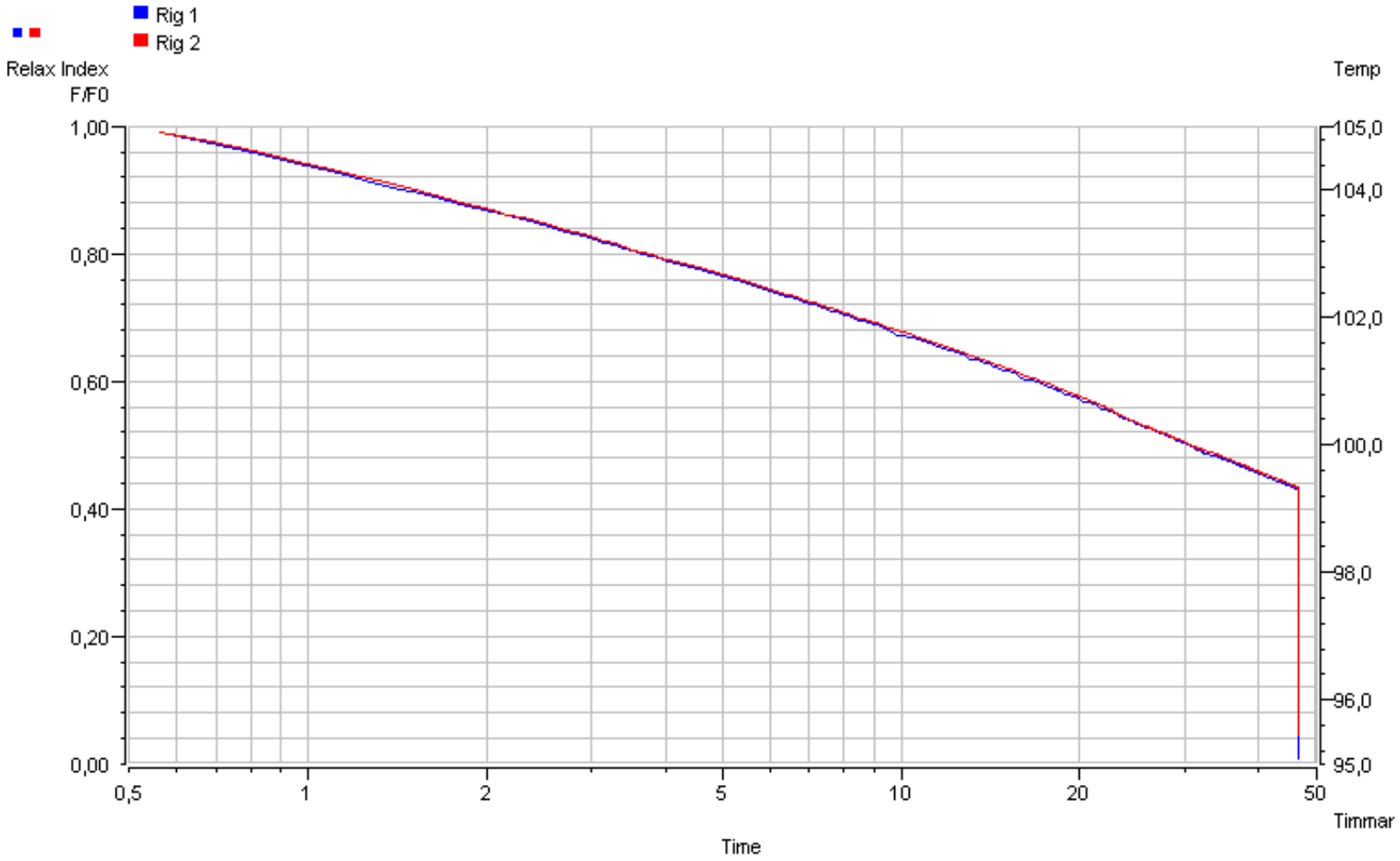
Repeatability

Two rigs the same test period



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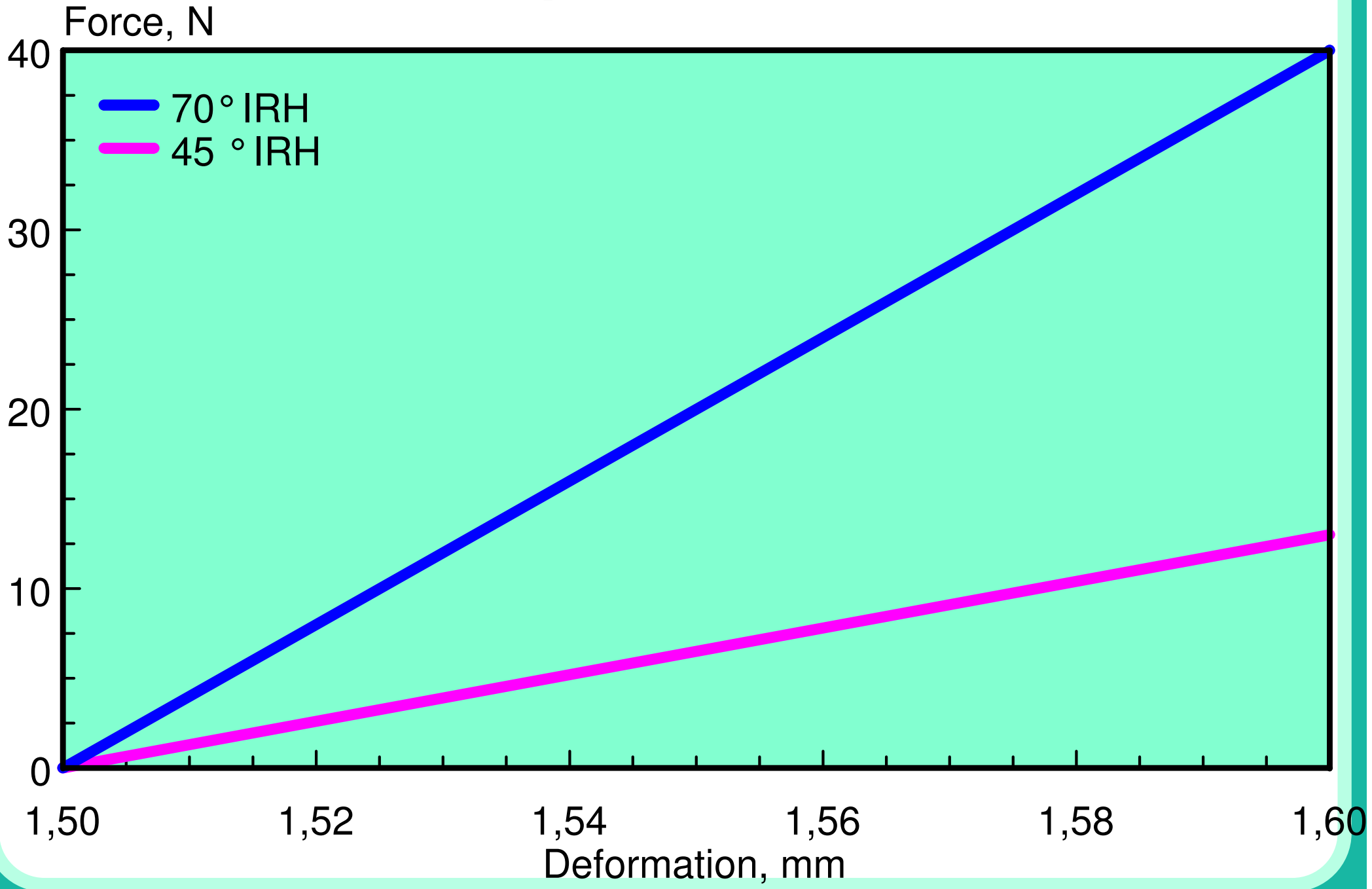
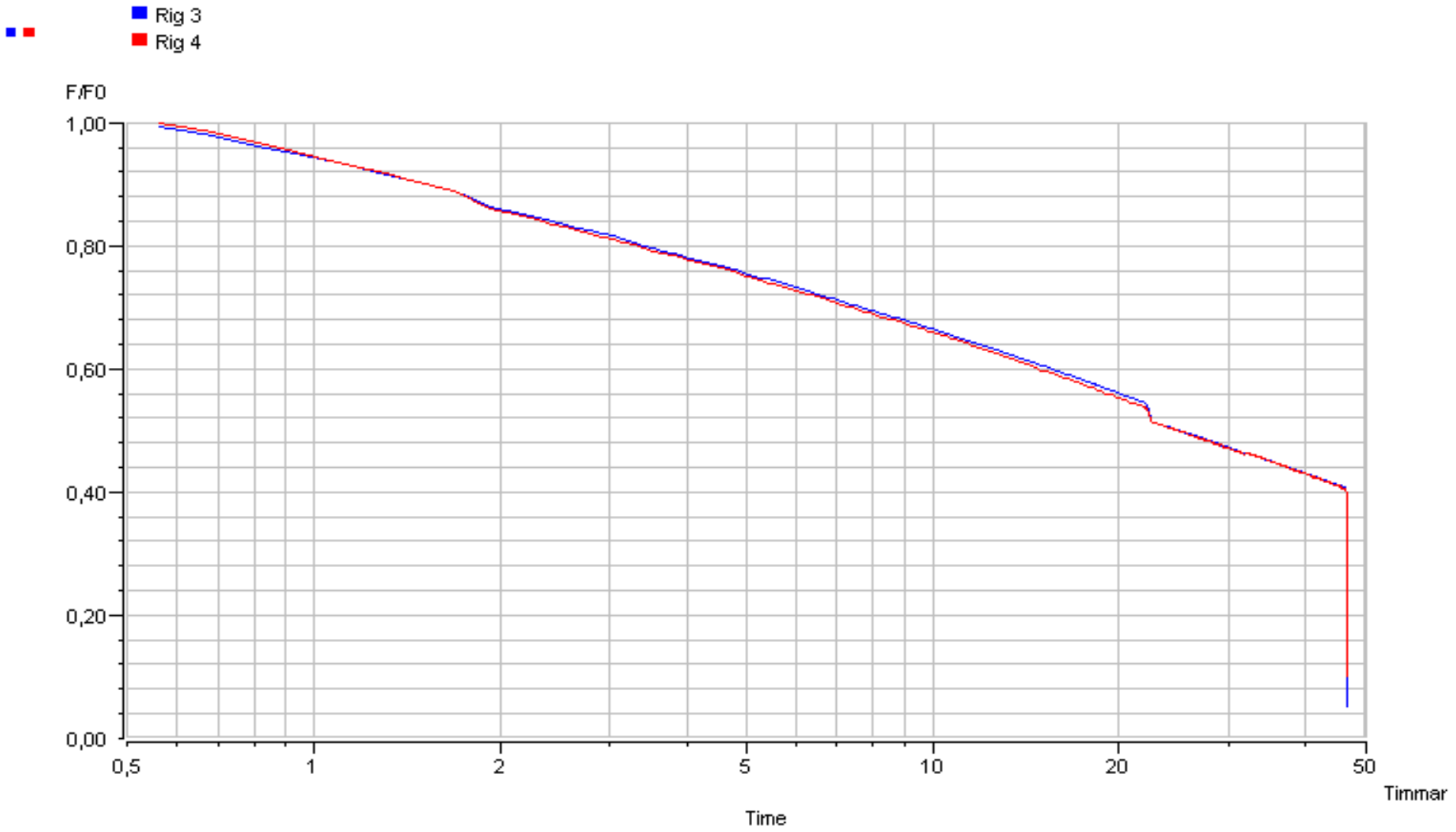
Important factors

- Keeping a constant deformation
- Keeping a constant temperature

Compression curve



Manual compensation



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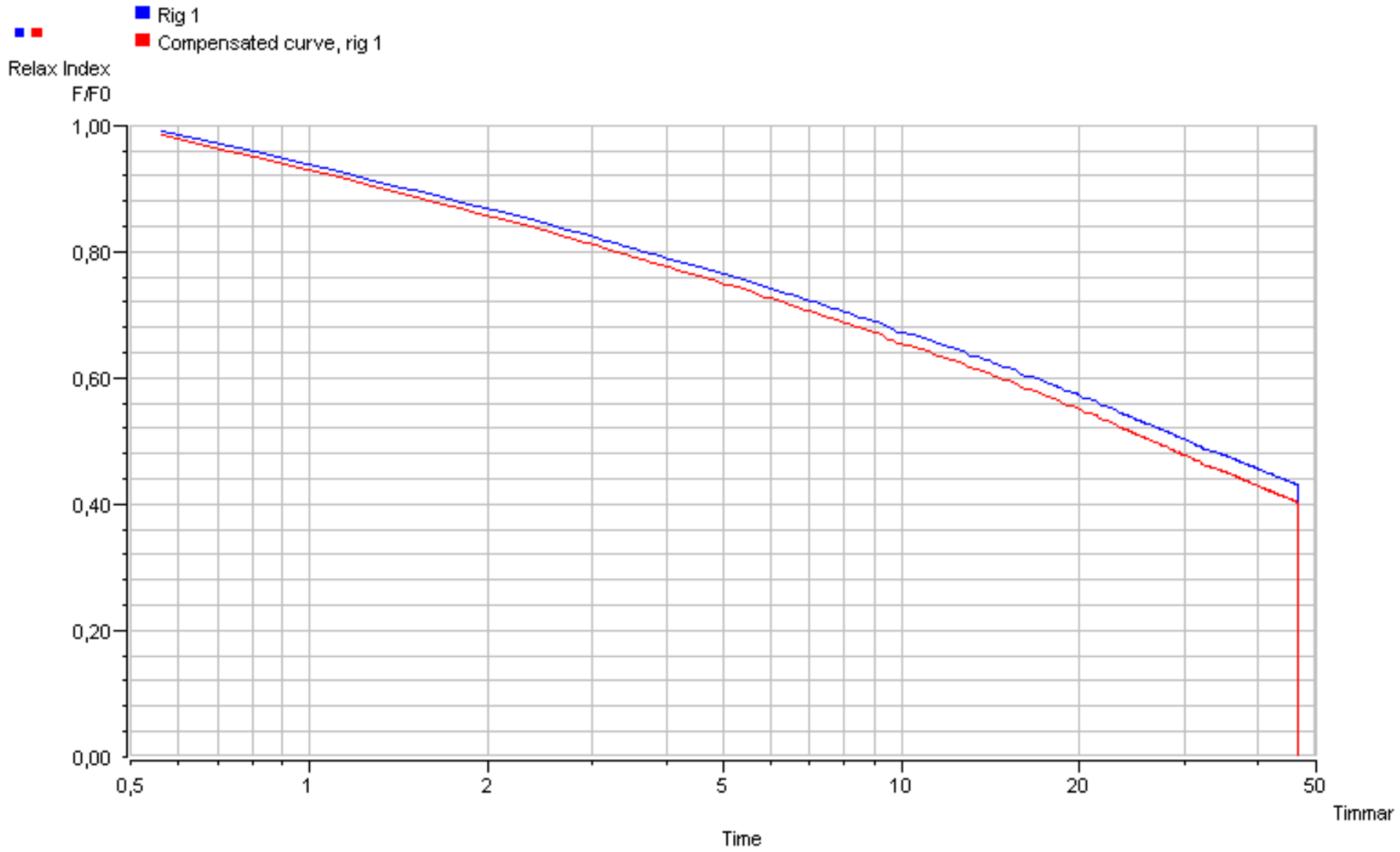
Calculated compensation



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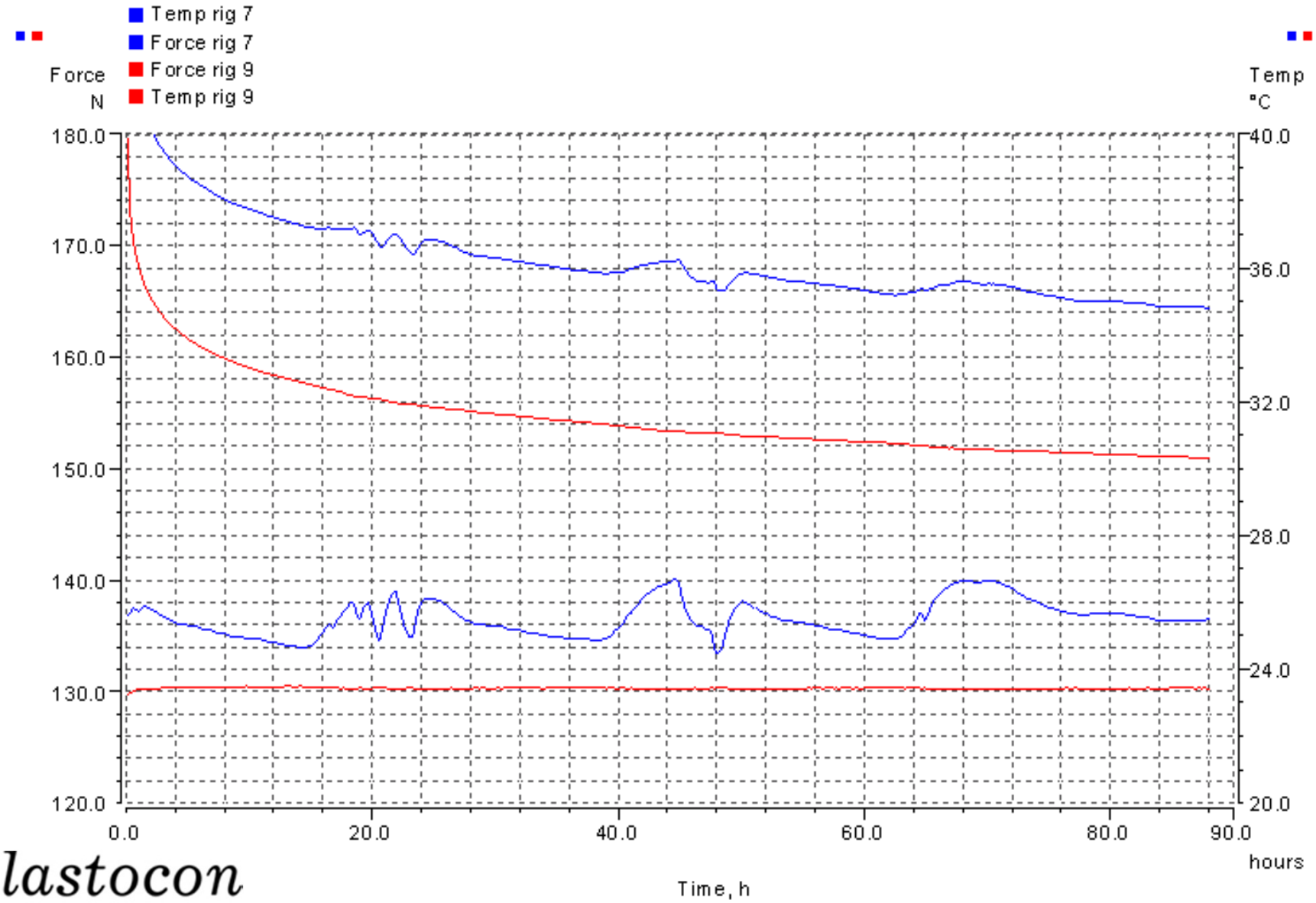
Relaxation test in room temperature

Influence of temperature variations



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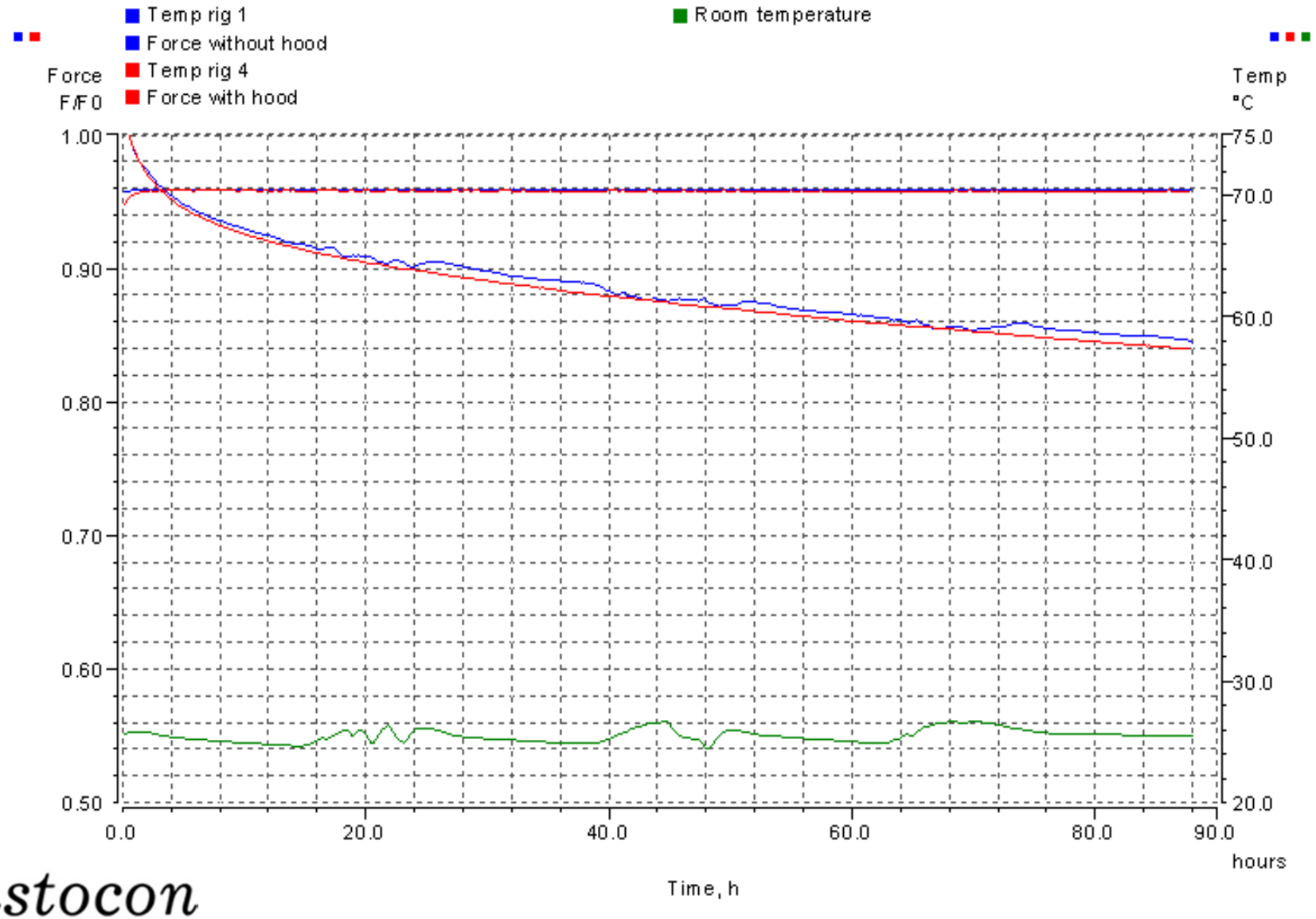
Relaxation test at elevated temperature

Influence of room temperature variations



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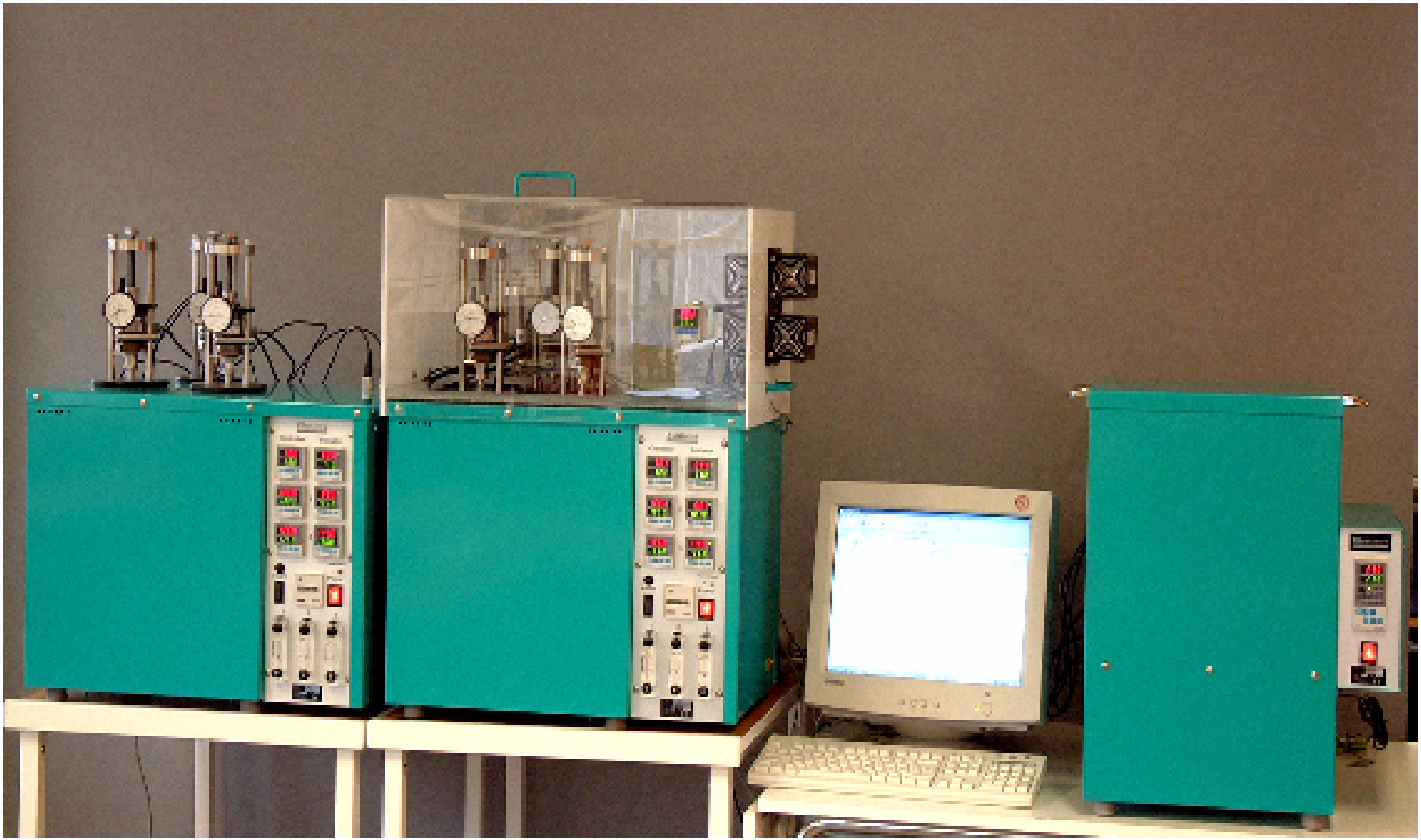
Stress Relaxation system

with draught hood and room temperature box



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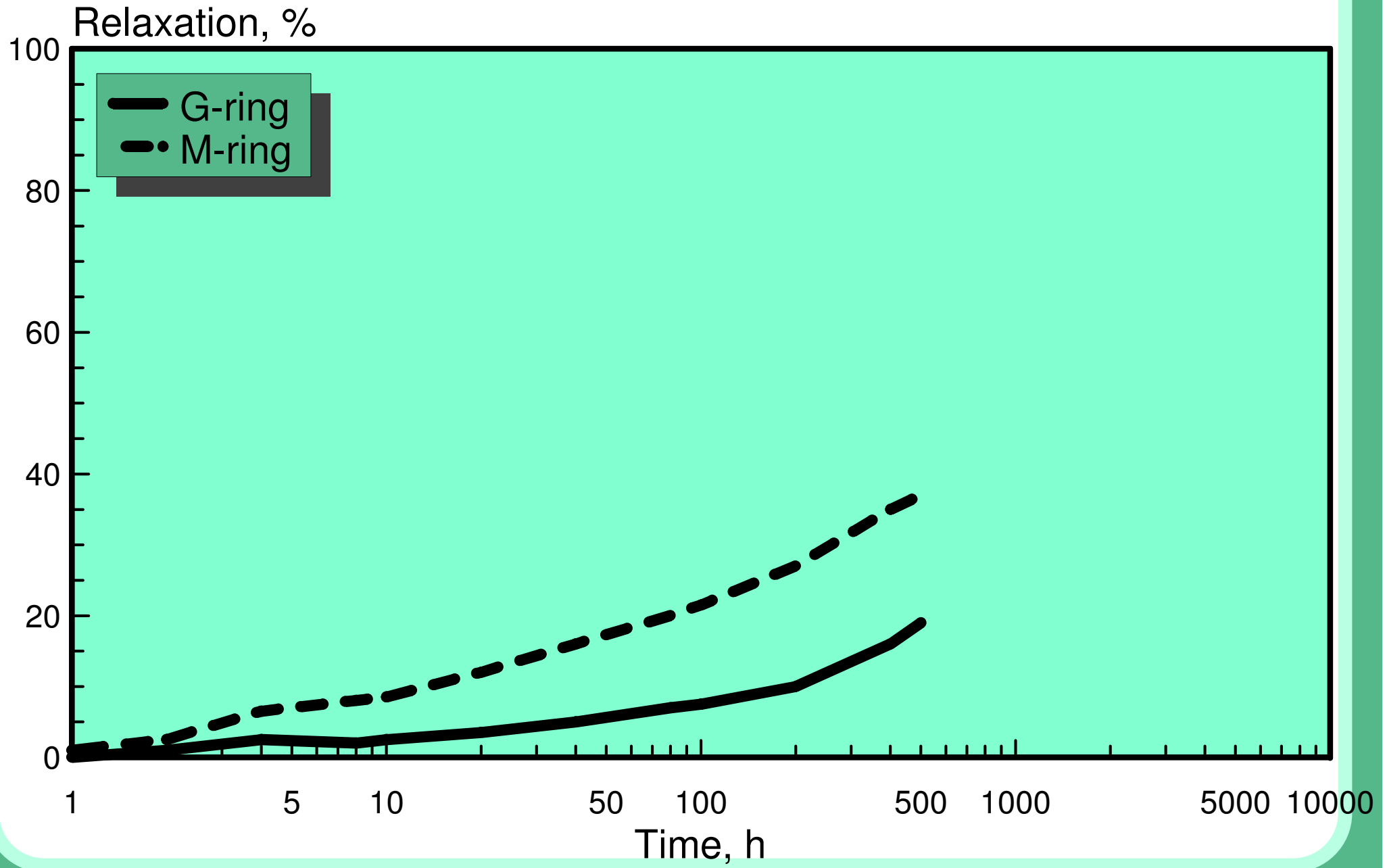
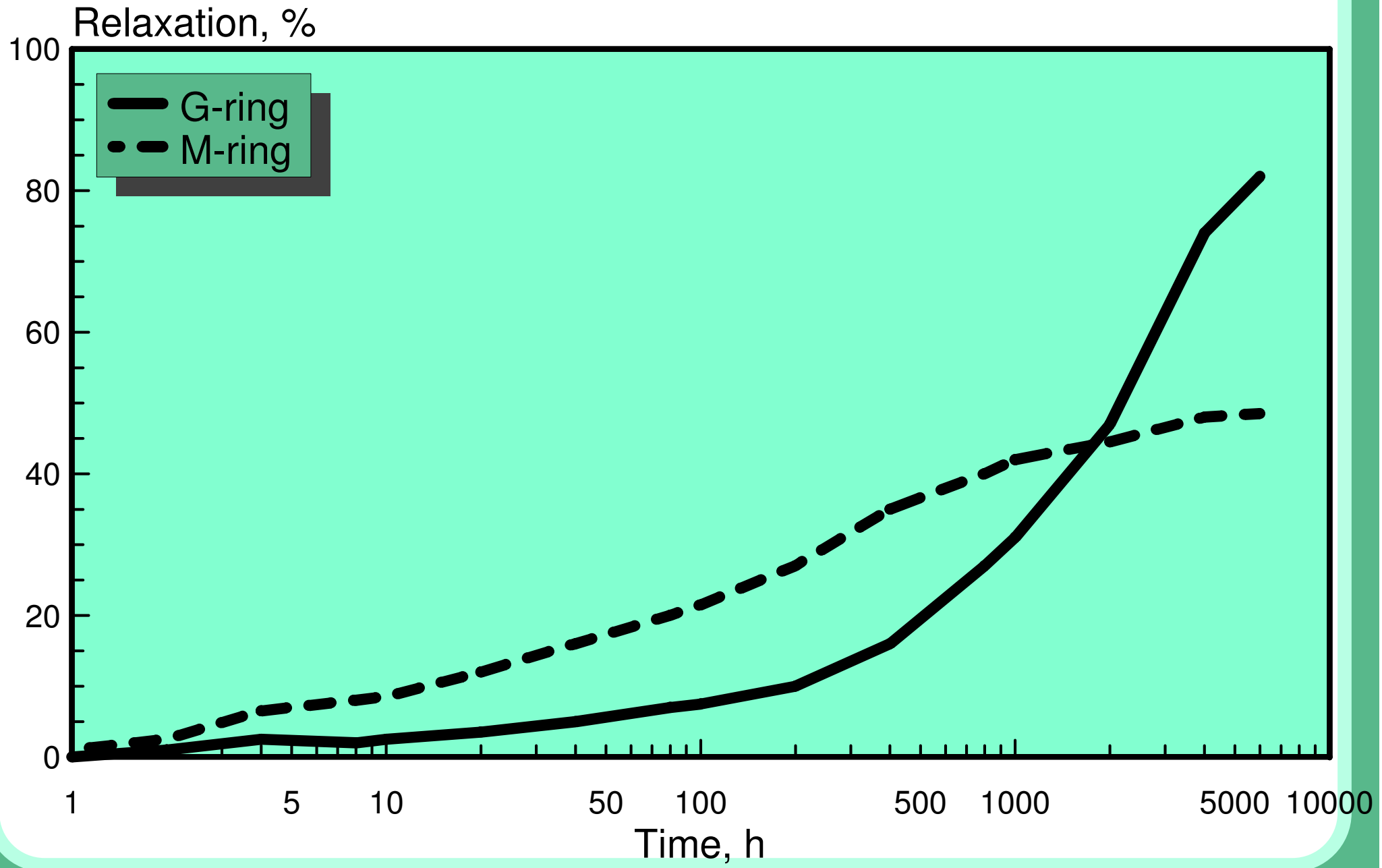
Relaxation Test

Sealing rings 70 °C

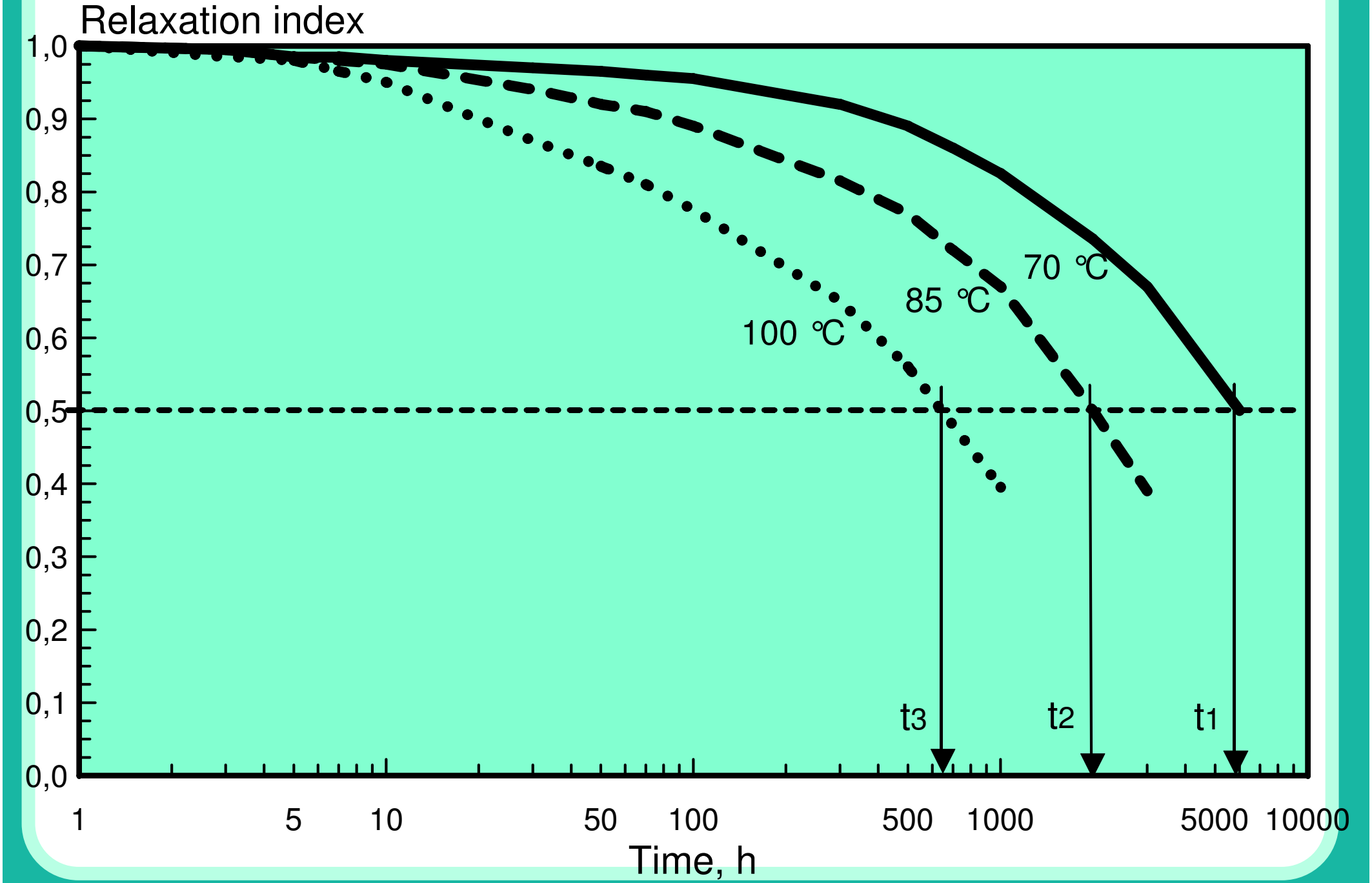


Relaxation Test

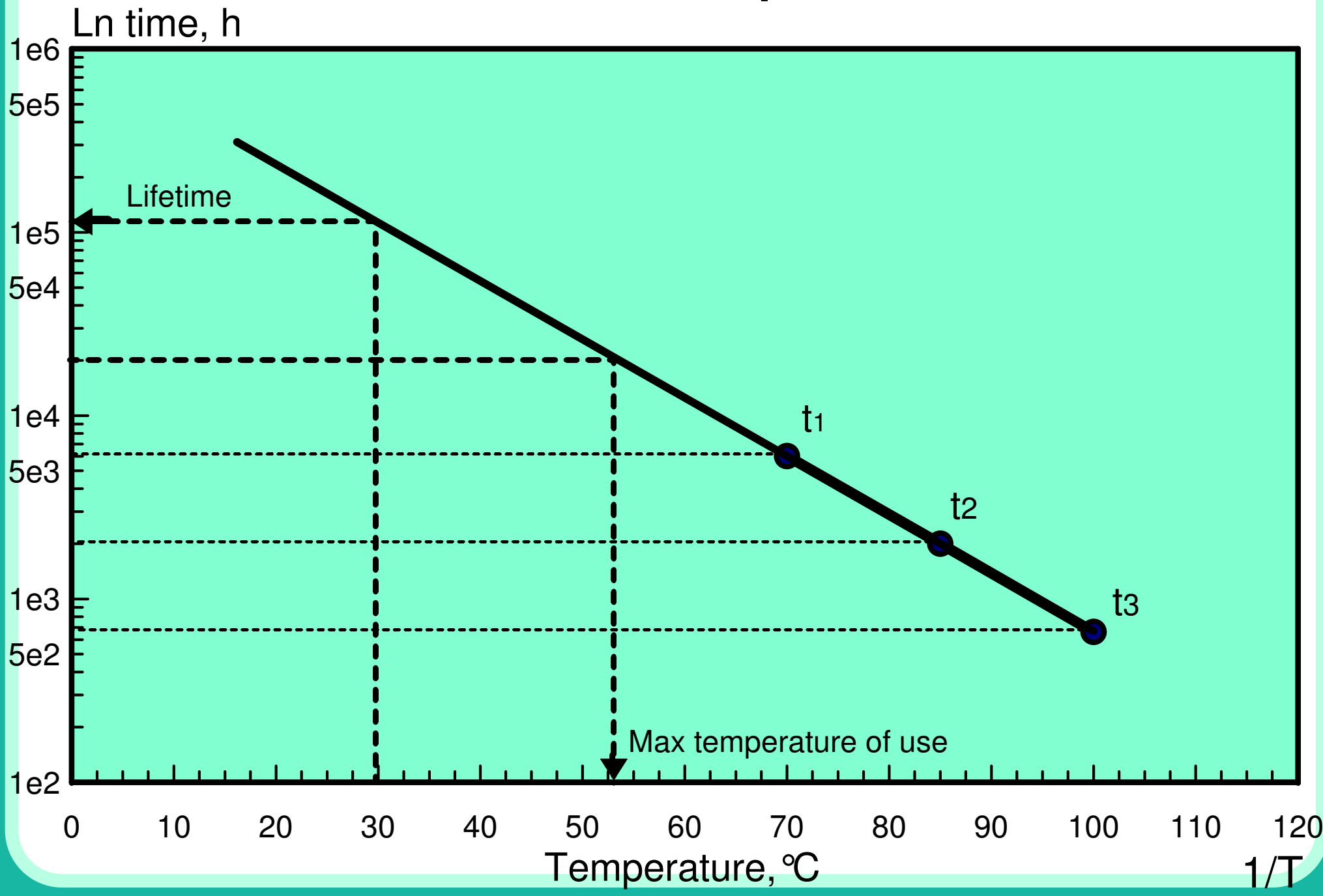
Sealing rings 70 ℃



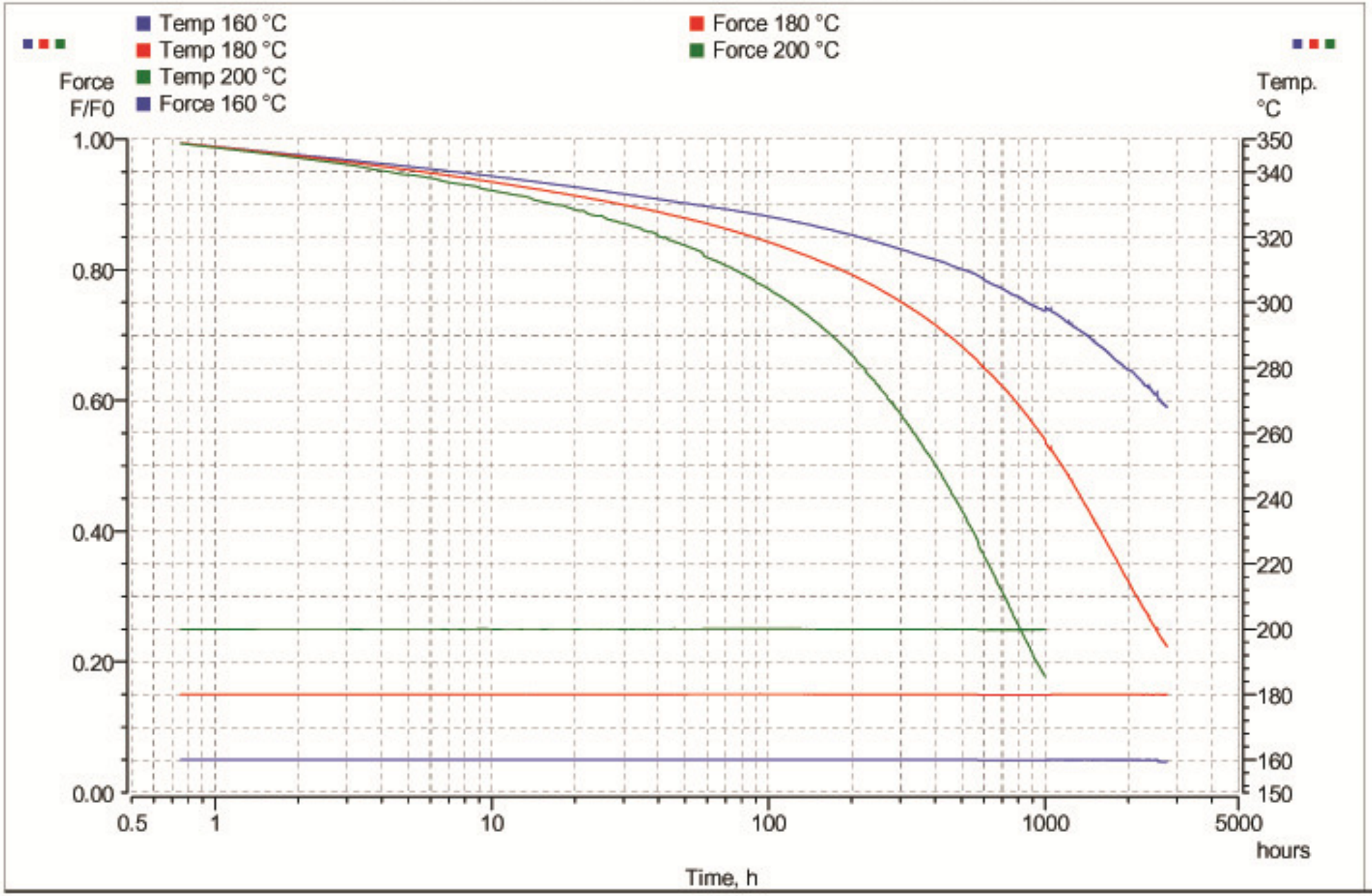
Relaxation - sealing rings



Arrhenius plot



Relaxation in compression - Greene Tweed FFKM 545



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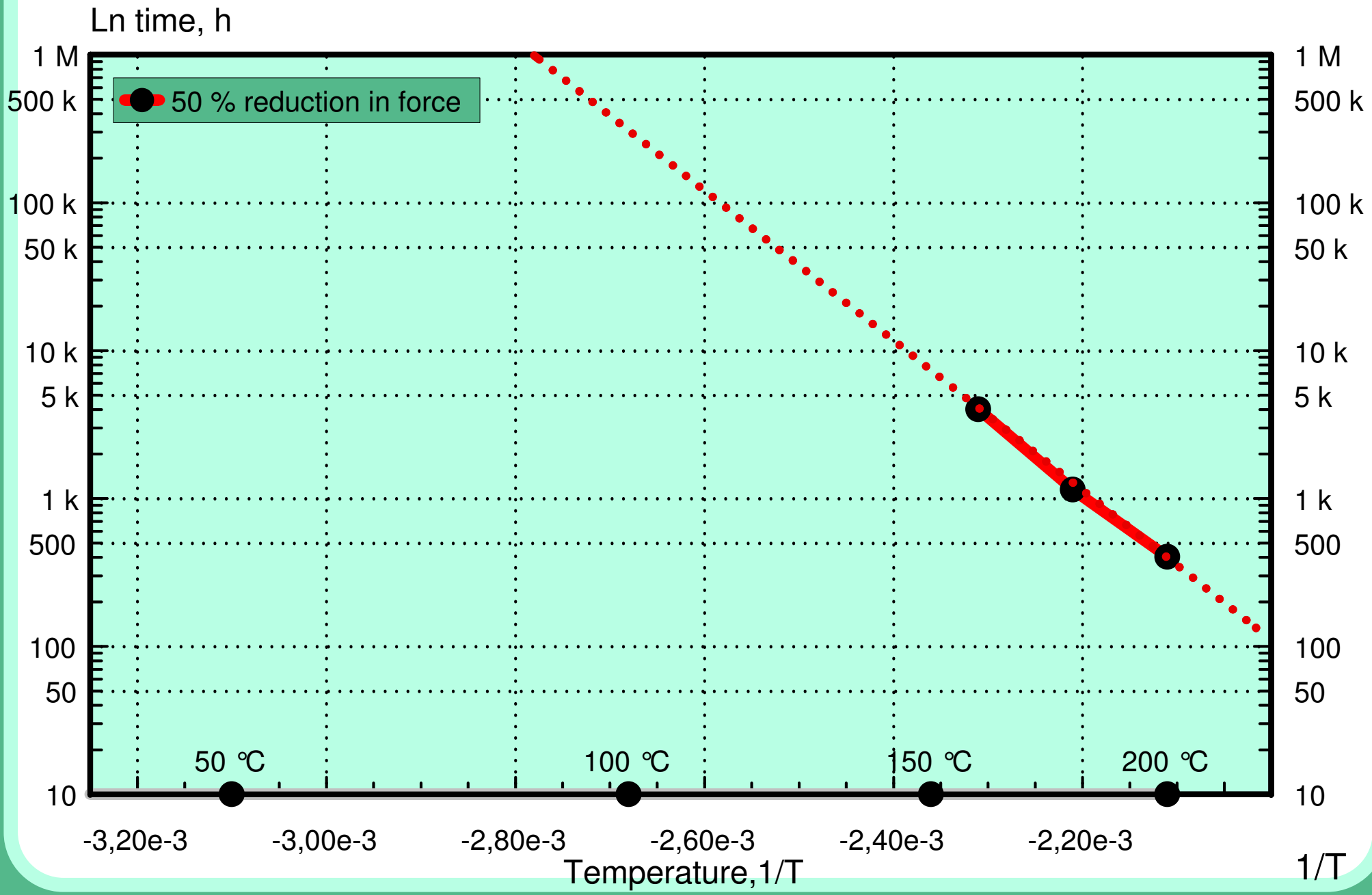
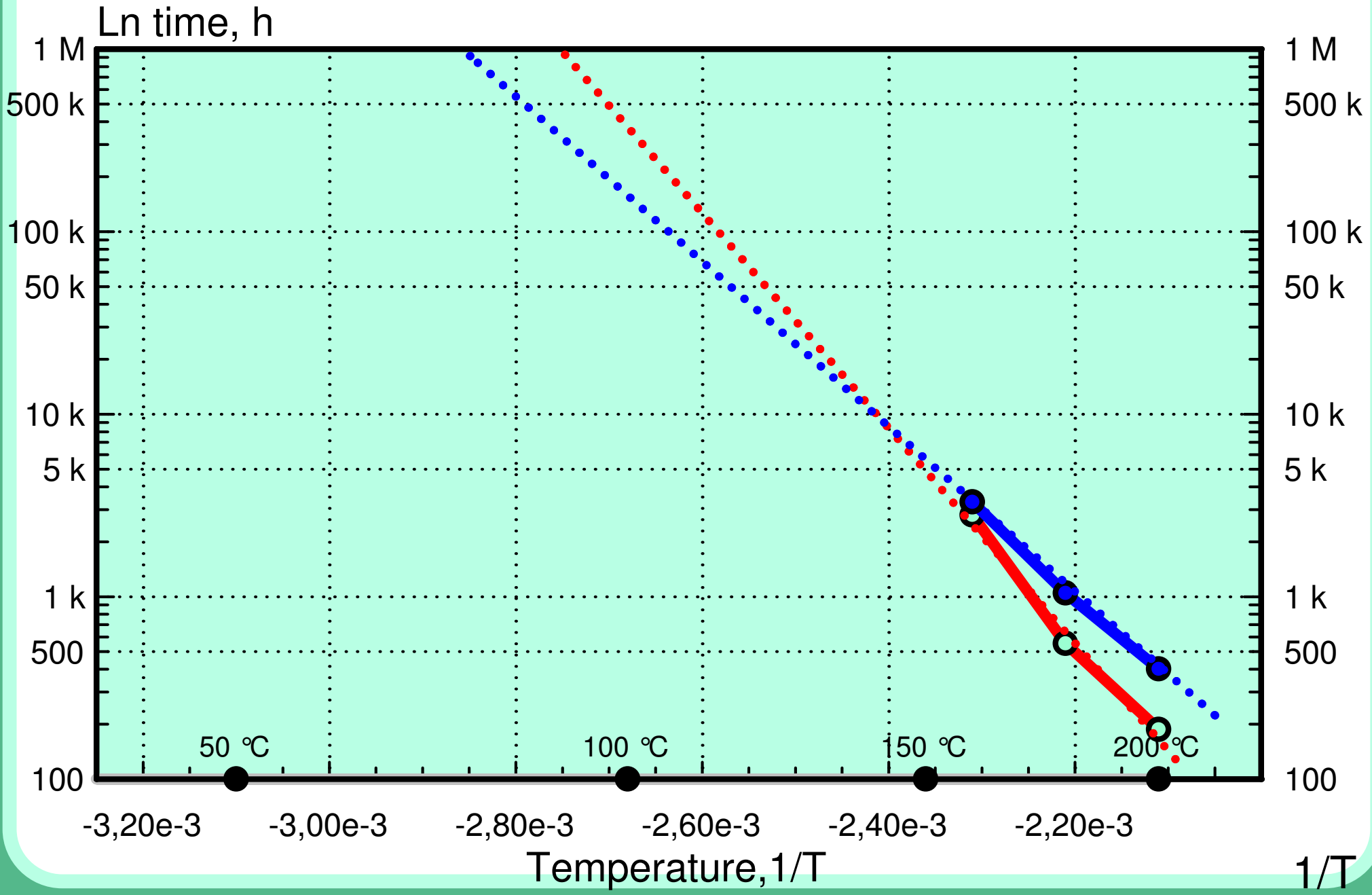
Arrhenius plot

FFKM 545



Arrhenius plot for FKM

Relaxation 50 % reduction in force



ISO 3384-1 changes

- Divided into two parts
  Part 1 at constant temperature
  Part 2 at cycling temperatures
- Technical revisions
- Addition of a calibration schedule

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ISO 3384-2
Testing with temperature cycling

- Method A, Once a week at low temperature
- Method B, Continuous cycling

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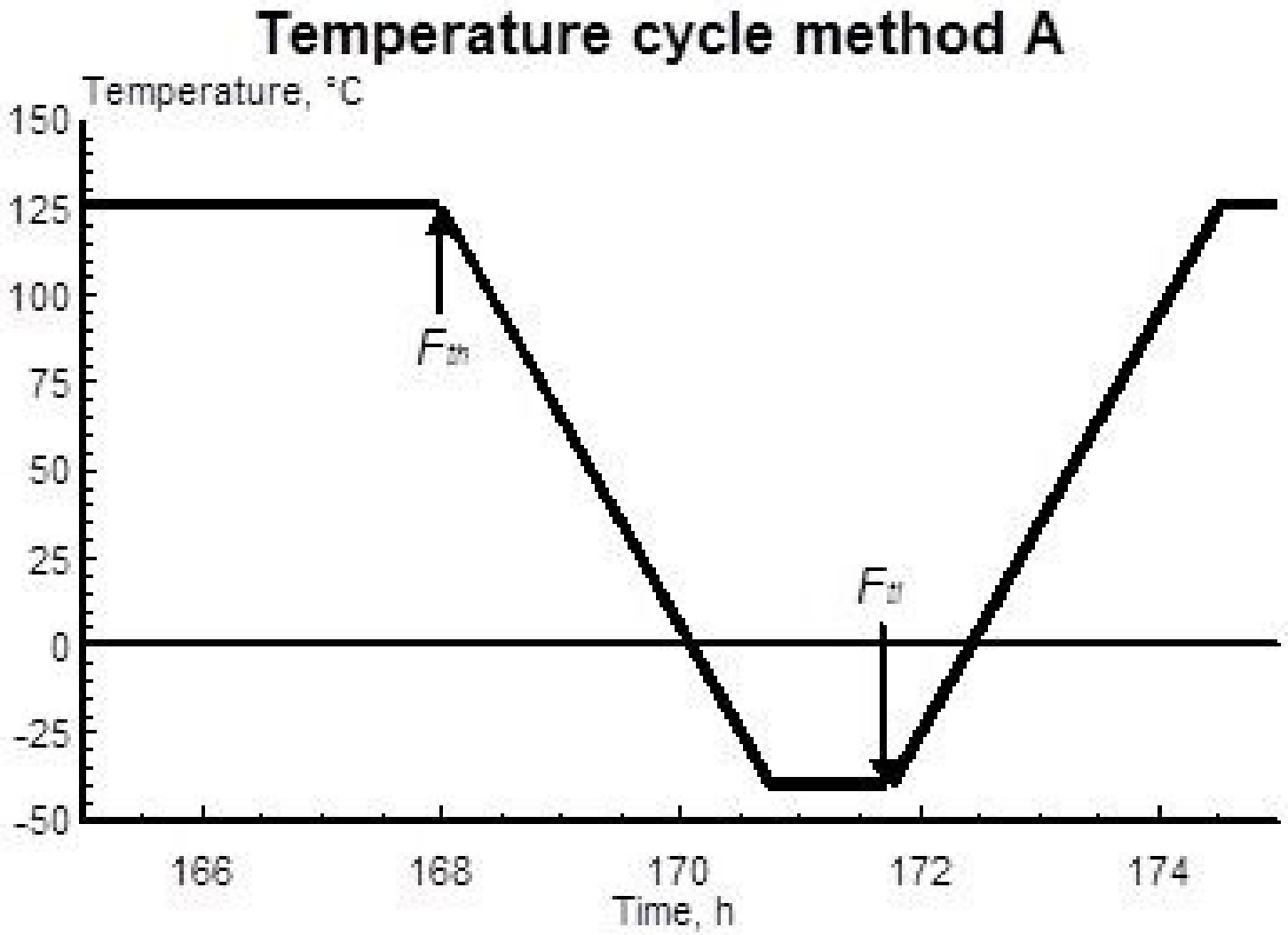
Temperature cycle for method A



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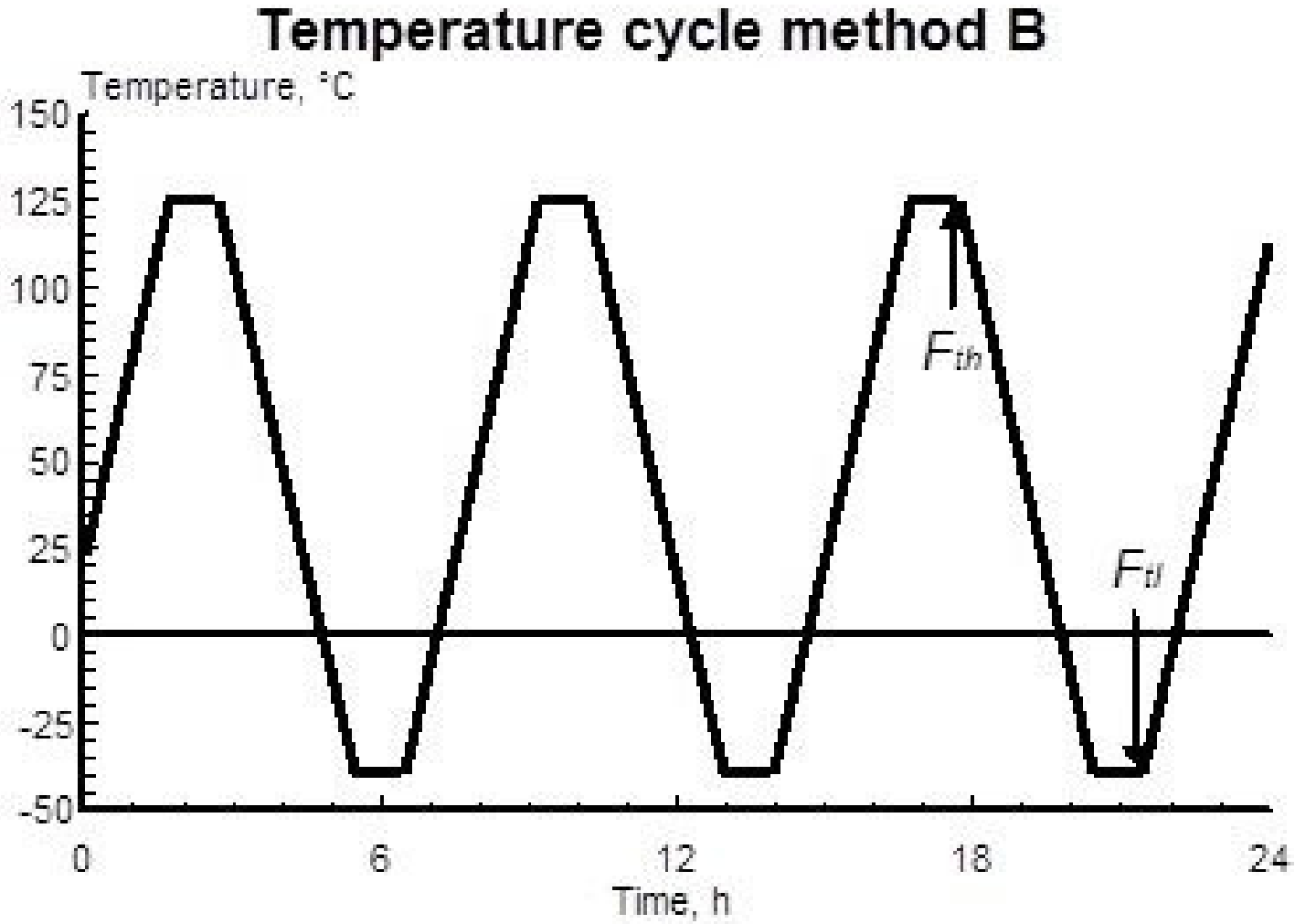
Temperature cycle for method B



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Example of a cycling test

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Oven for cycling tests

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Automatic Relaxation and Creep Tester

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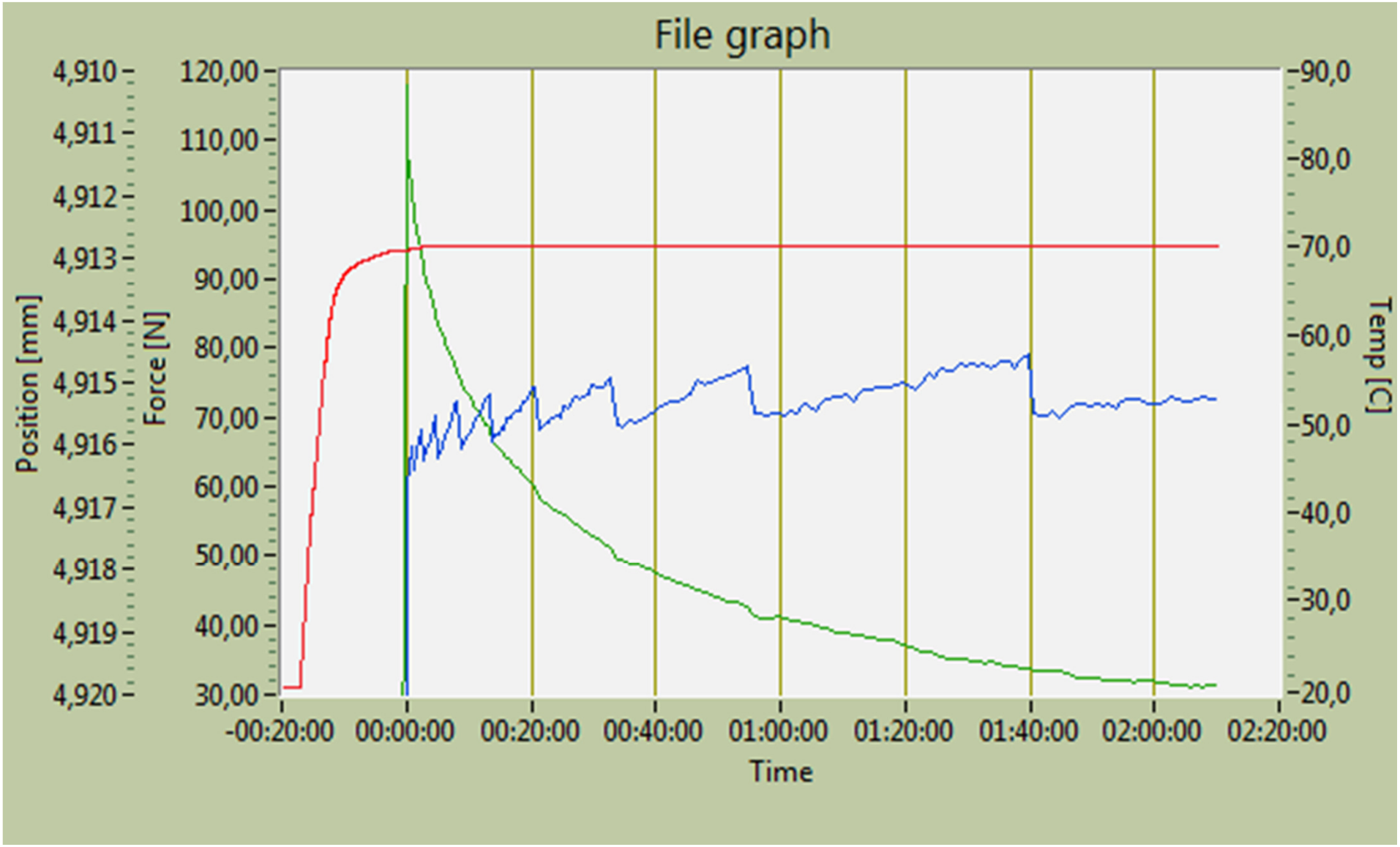
Automatic instrument

Control and measurement of:

- Temperature 0,1 °C
- Force 0,1 N
- Displacement 0,001 mm
- Servo motor driven movement of the test rig

Relaxation test



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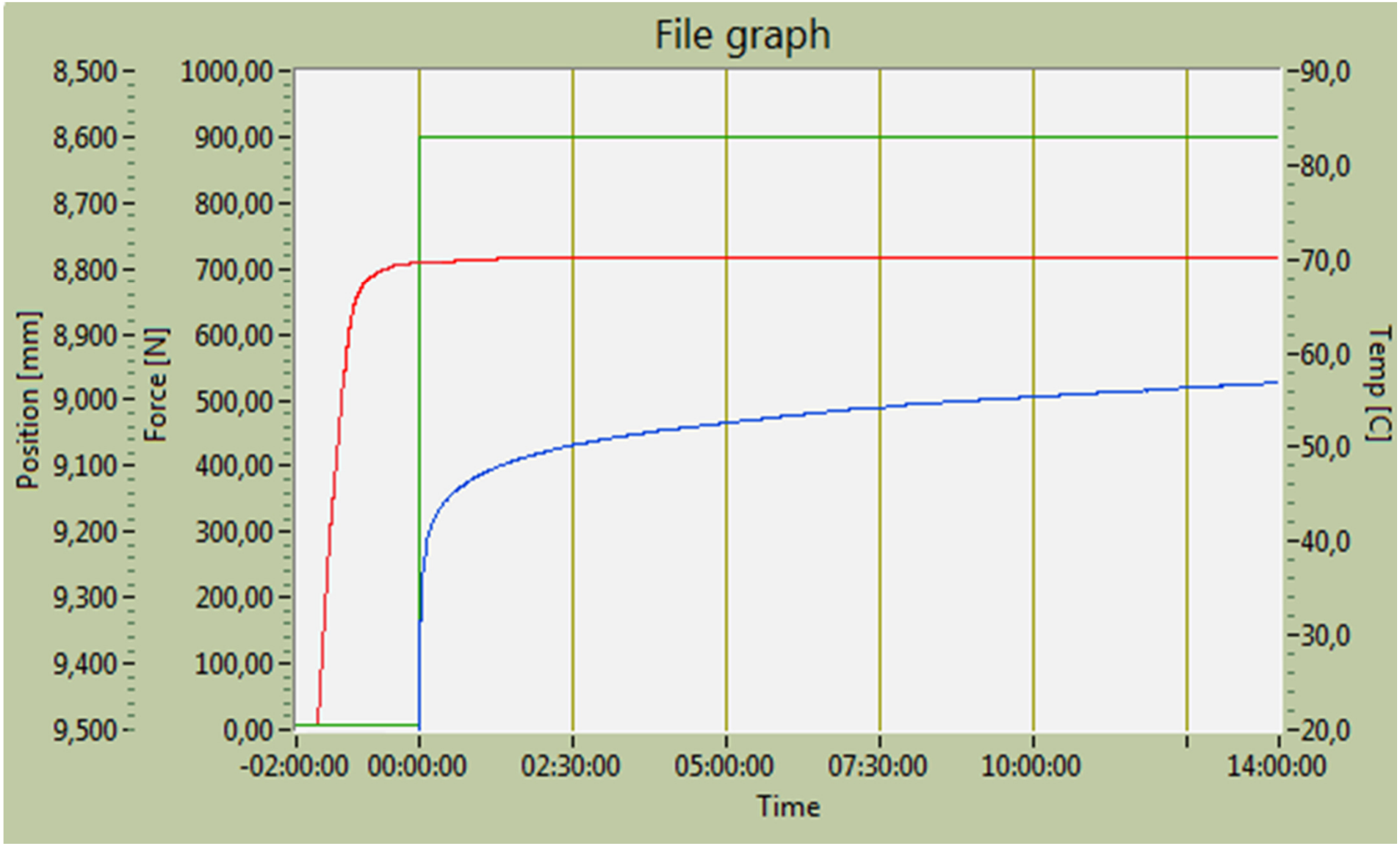
Creep test



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Stress Relaxation Tests

Stress relaxation tests are very effective for conducting ageing tests, as substantial amounts of information result with little effort, especially when using the continuous measurements system