

Functional Characterization of SMA Wires in Actuation Conditions

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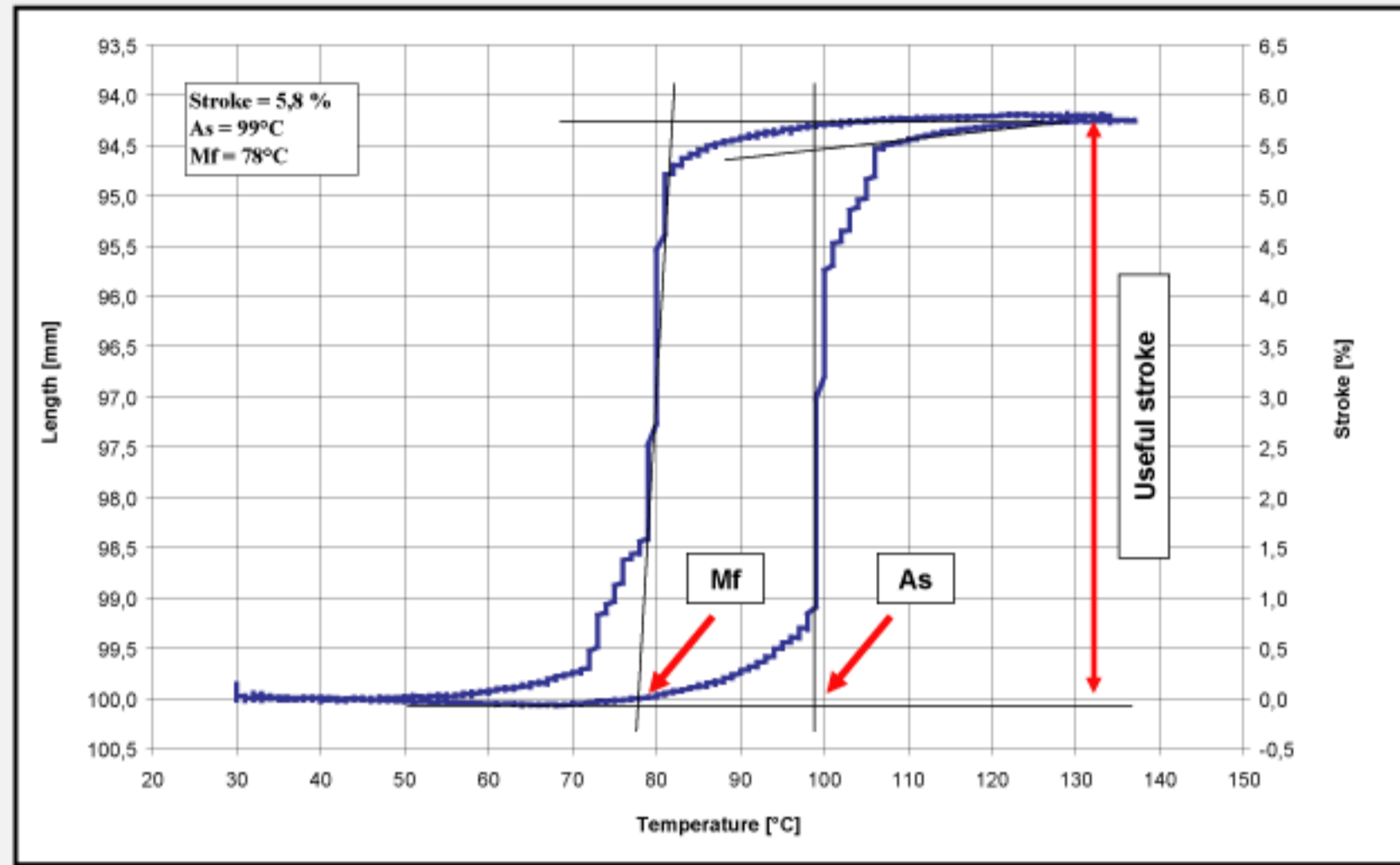
Actuation is one of the most promising fields for industrial application of Shape Memory Alloys (SMA). Since most of the present industrial applications are in the medical field, there is a lack of standardization in the characterization of SMA for actuators. SmartFlex is a wire specifically developed by SAES for actuation. Applications in automotive and domestic fields are often based on Joule effect actuation and require a number of cycles ranging from 10'000 to 60'000 cycles. A set of near-real condition tests on SmartFlex will be presented.

Hysteresis Measurement

Thermal cycling of a SMA wire under a constant applied load.

Information gathered:

- Maximum stroke at a given load
- Thermal profile at a given load (transition temperatures)



Strengths:

- Gives a very detailed picture of the wire behavior
- Possibility of changing loads and thermal profiles (also temperatures below 0 °C are possible using environmental cells)

Weakness:

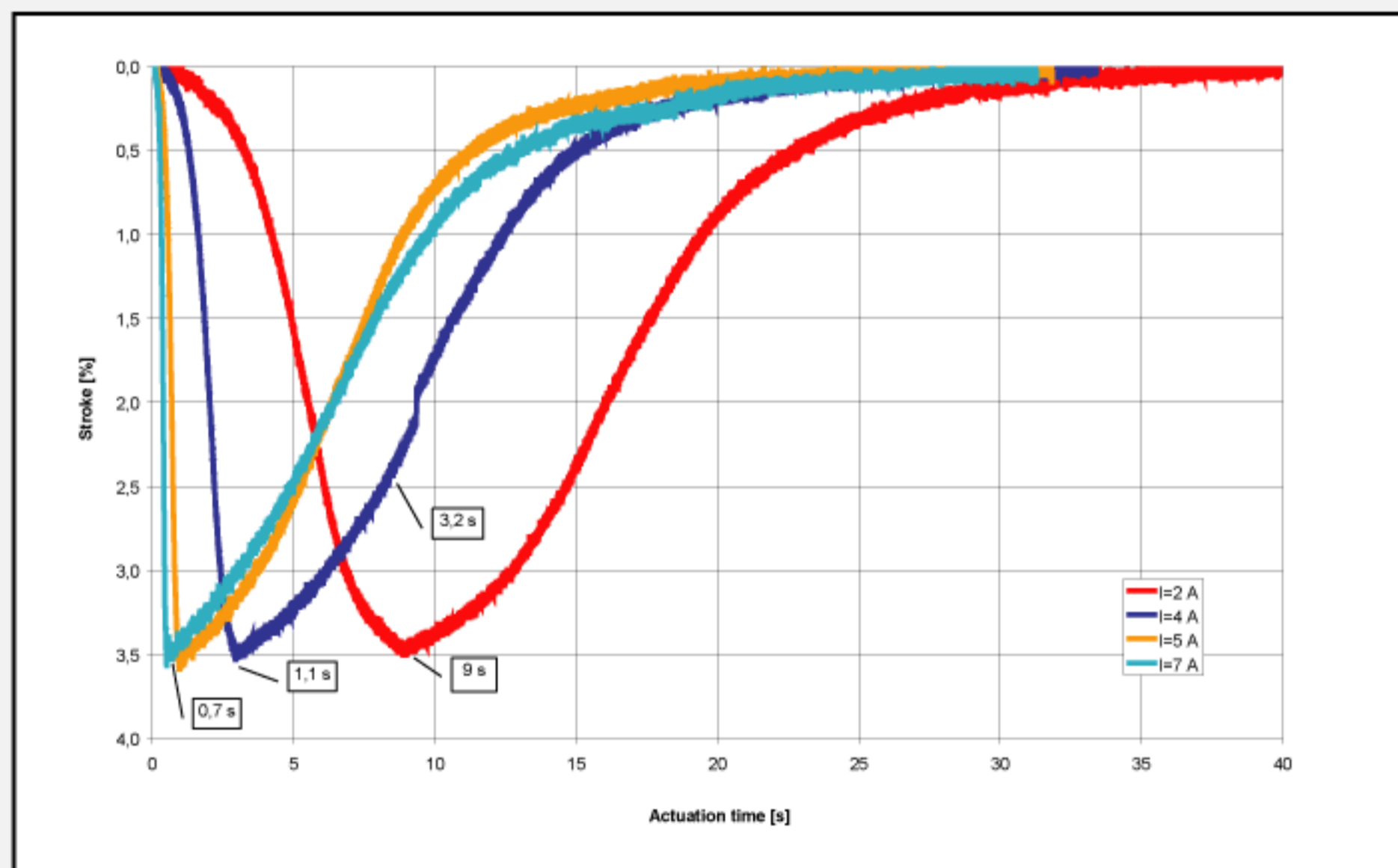
- Long (at least 2 hours per cycle)
- Characterization on a single piece (100mm)

Single Actuation Cycle Study

Study of the profile of a single Joule effect actuation cycle, varying the feeding conditions.

Gathered data:

- Actuation/de-action time at given wire diameter and electrical feeding conditions
- Current-Voltage evolution

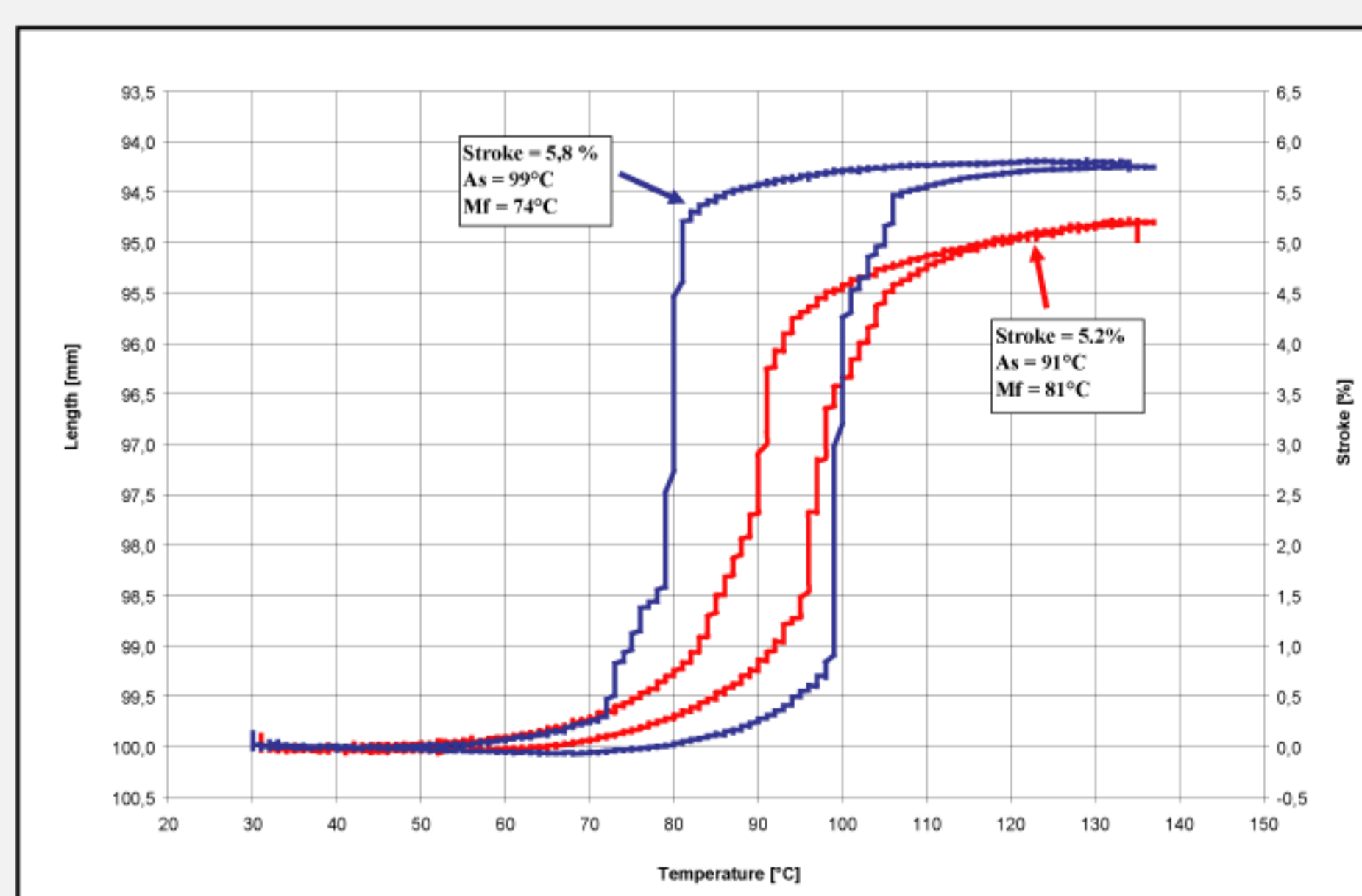


Wire Performance Evolution During Life

Actuation is basically a thermal cycling between two fixed wire positions. This cycling can affect the wire microstructural features, and eventually its actuation related performance.

A series of tests have been carried out characterizing (DSC + hysteresis) some fresh wires and then repeating the test after 5'000 cycles at full stroke.

Comments: fatigue cycling tends to reduce the stroke and the hysteresis, and to increase the martensitic transformation temperatures, while the austenitic transformation temperatures are not strongly affected by the fatigue.



Summary

In order to have a complete characterization of SmartFlex, a dedicated set of equipment and procedures have been set up:

- Hysteresis
- Fatigue life test
- 100% hysteresis

The data we obtained on 0.5mm SmartFlex are:

- Stroke: >5.5%
- Total cycles: > 100'000
- Permanent elongation at 50'000 cycles: 0.2%
- As = 90 °C
- Mf = 75 °C

Important Parameters to Be Monitored

Features affecting the SMA actuator behavior are:

- Stroke
- Transition temperatures under load (As and Mf)
- Fatigue behavior
 - Permanent elongation at a given cycle number
 - Number of cycling before fracture

Fatigue Life Test

Electrical actuation on wire with constant load (weight) applied, monitoring wire elongation.

Gathered data:

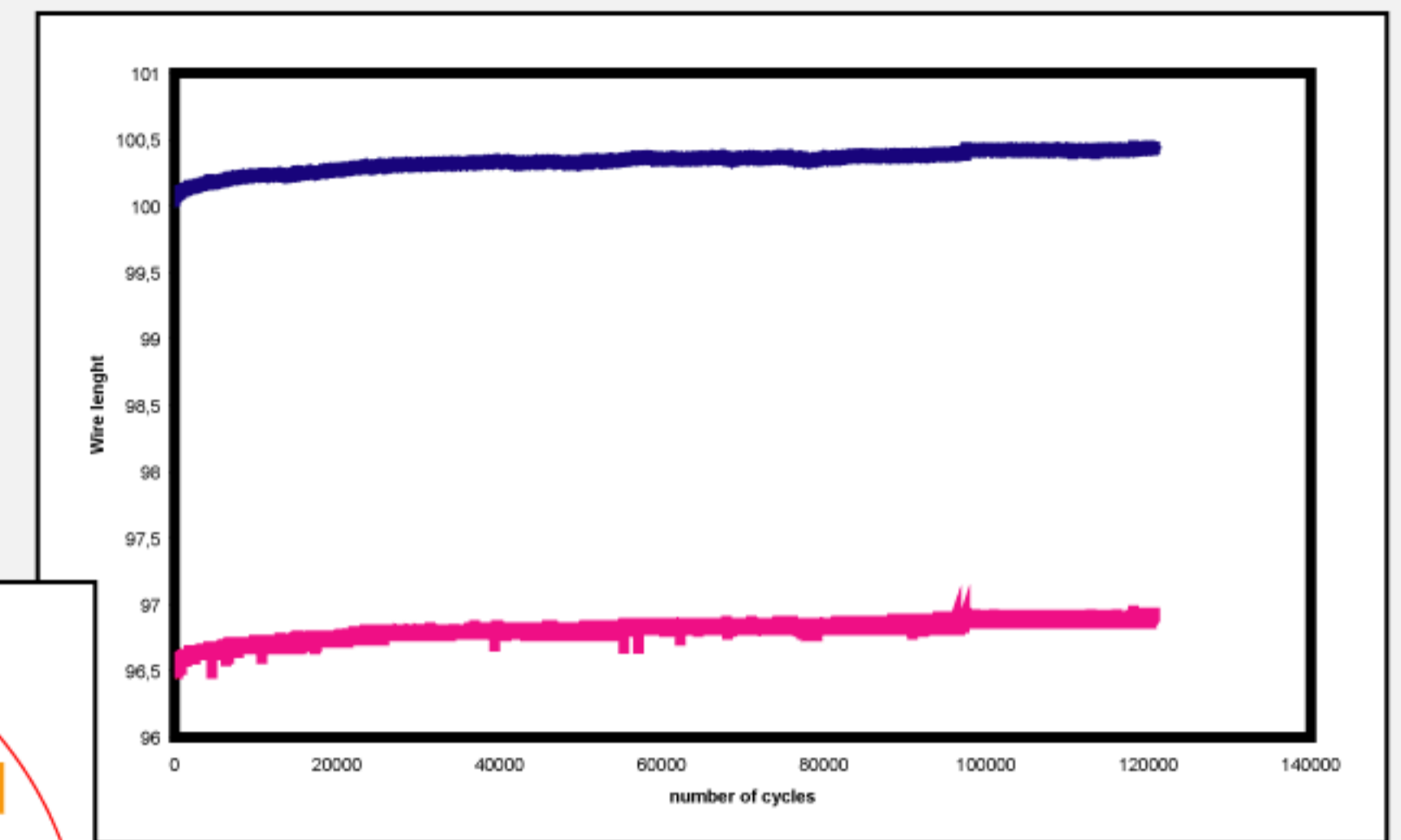
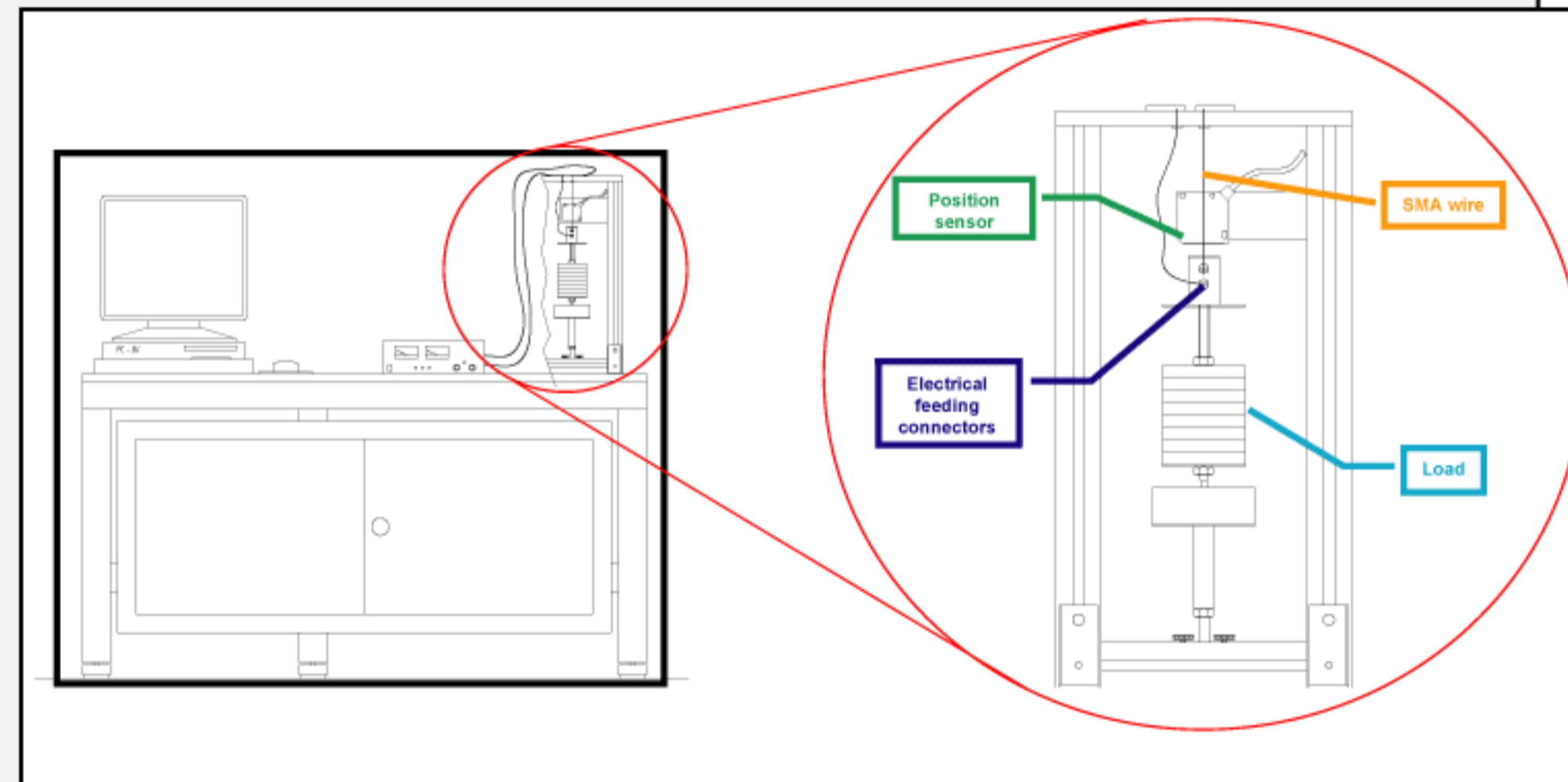
- Elongation and stroke vs cycle number
- Cycles at fracture

Possible testing configuration:

- Straight
- U shaped

Possible testing conditions:

- Constant run
- Constant actuation time
- Constant I or V



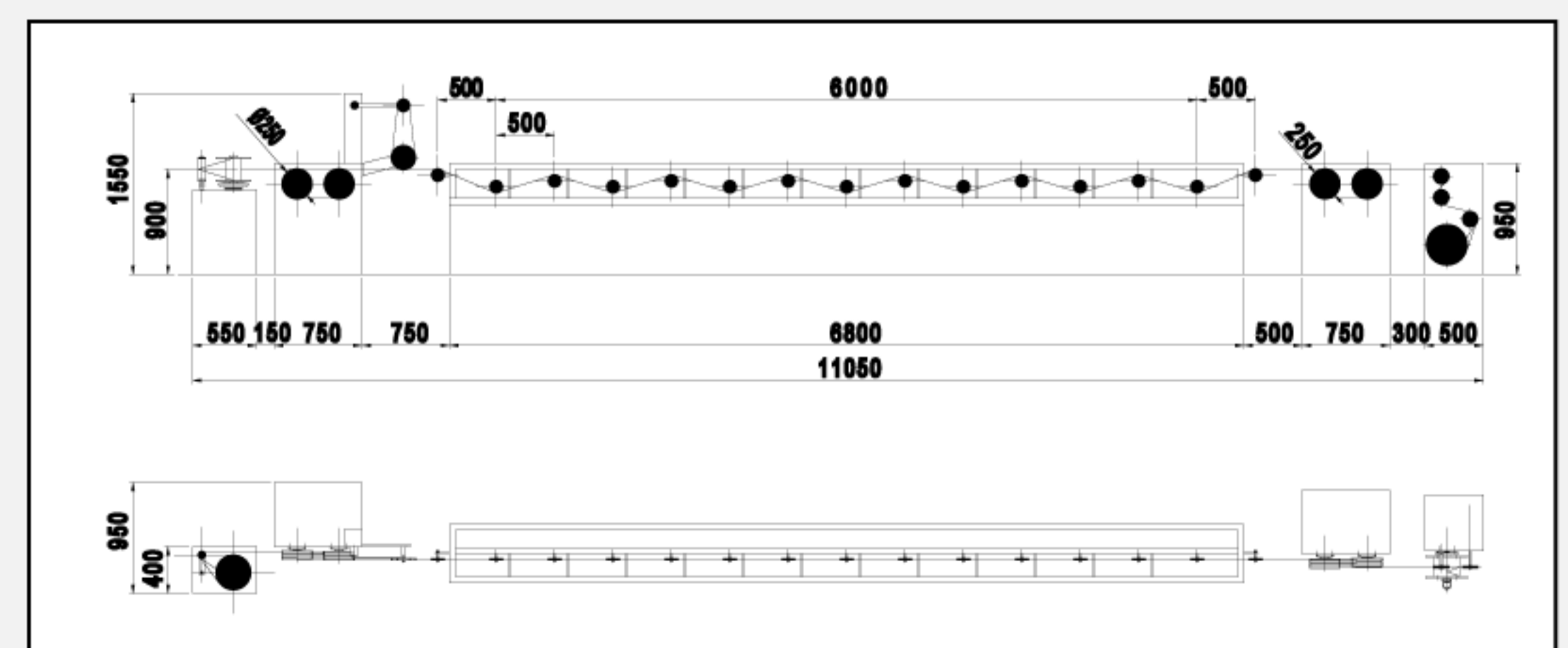
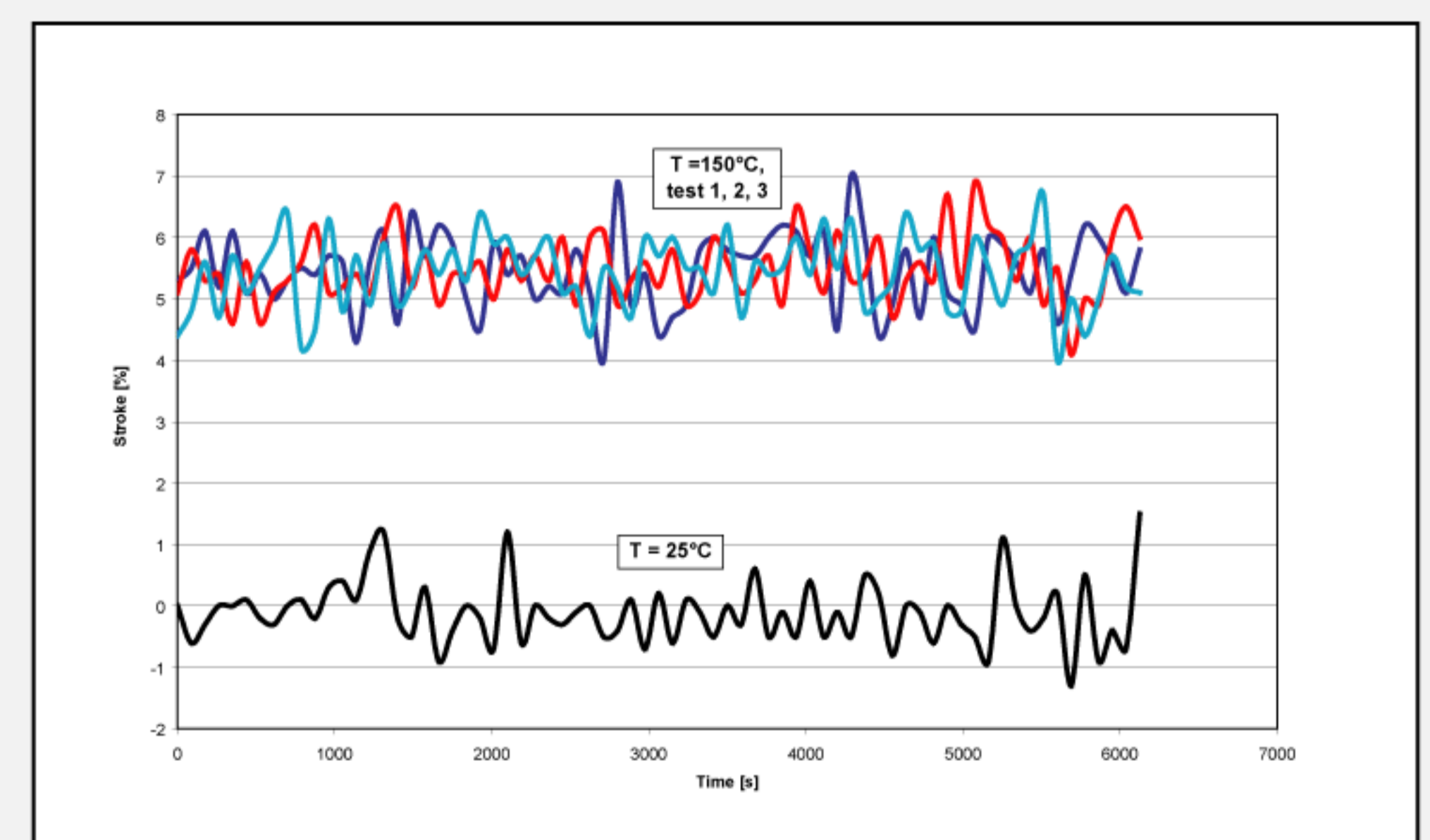
100% Hysteresis Measurement

New concept (patented by SAES Getters S.p.A.) of characterization: the same data of hysteresis measurement, but on 100% of the wire.

The wire is passed through a series of furnaces at different temperatures (raising from 25 to 150 °C, and then back to 25 °C), with a constant load applied. The wire is wound around cabstains, whose rotational speed is proportional to the wire length. Therefore, a shortening of the wire will result in the lowering of the cabstains rotational speed.

Information gathered (on 100% of the wire):

- Maximum stroke at a given load
- Thermal profile at a given load (transition temperatures)



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