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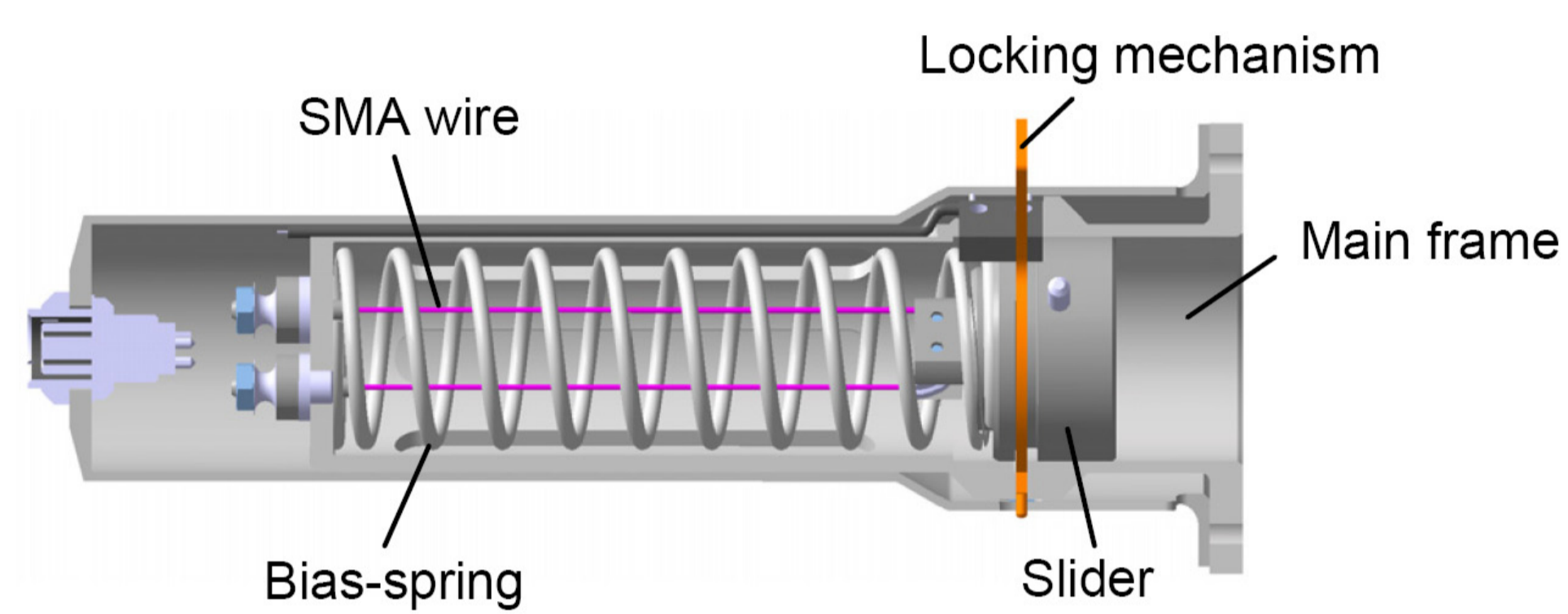
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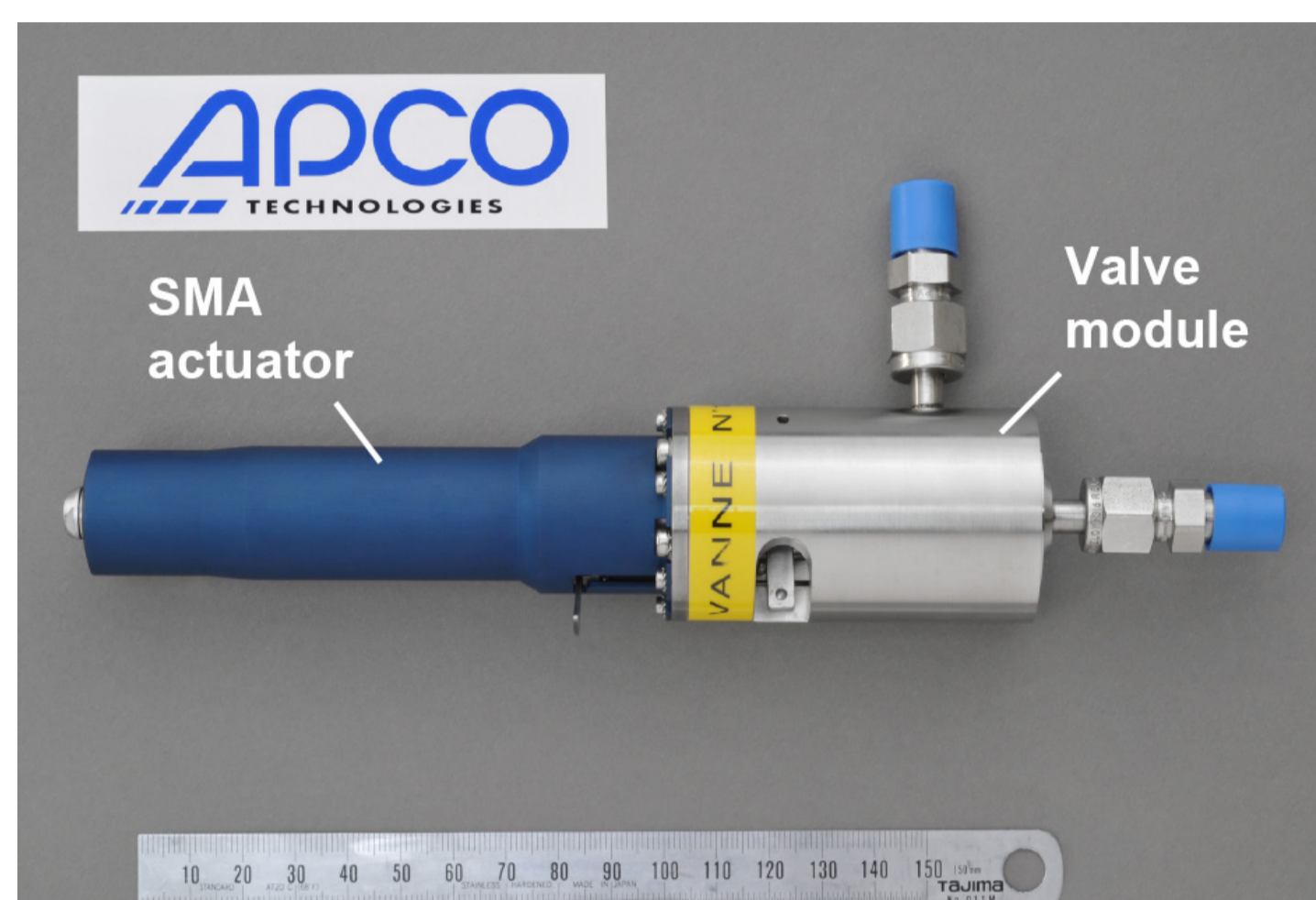
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**Abstract:** Pyrovalves are currently used for valve actuation in space propulsion systems because of their fast response, high reliability and low weight to actuation force ratio. However they are hazardous, single use items, their operation induces shocks and pressure waves that affect other components. Moreover, gases produced in the combustion chamber might contaminate the propellant flow passage. To solve these drawbacks shape-memory actuators appear promising. The paper reports on the development of a multiple-use, manually resettable shape-memory alloy actuated space valve used to open the flow of liquid or gas propellant in spacecrafts.

## Actuator design and operation



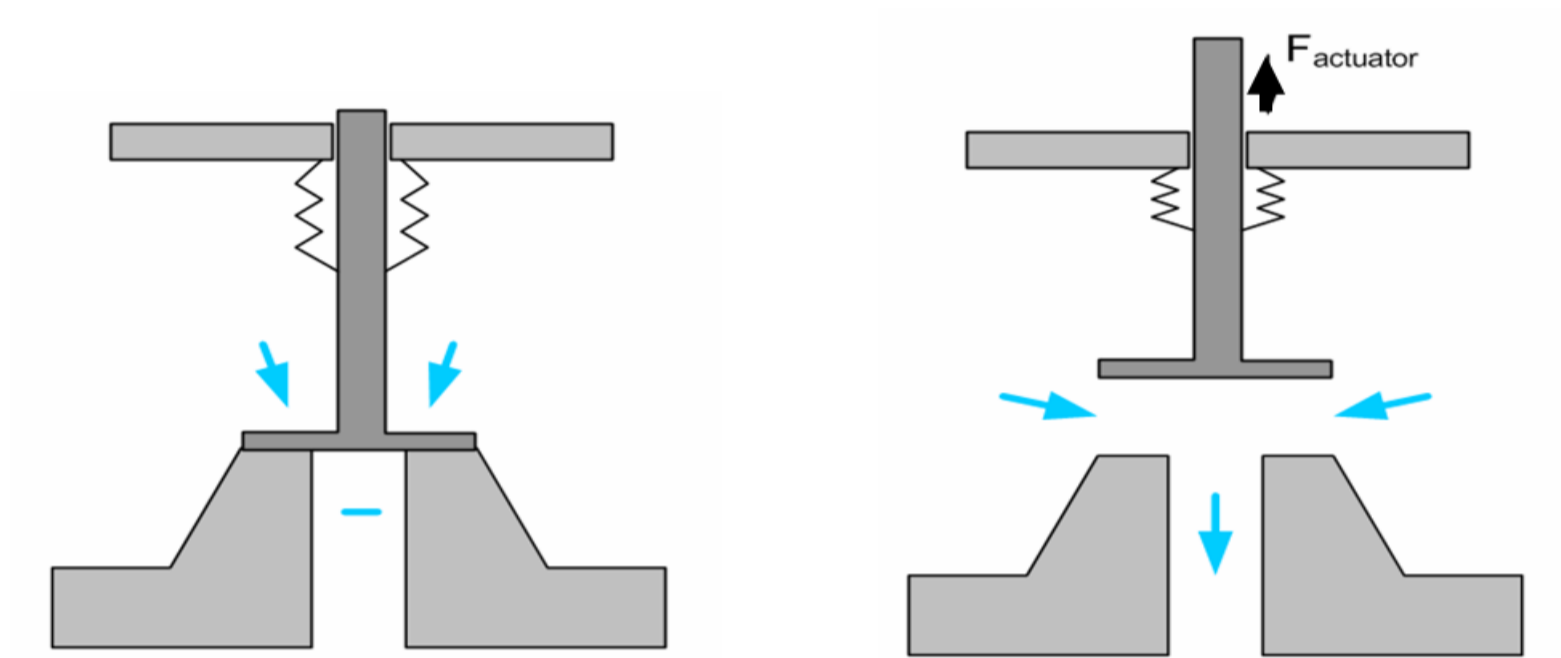
CAD cut view of the actuator



SMA actuated valve

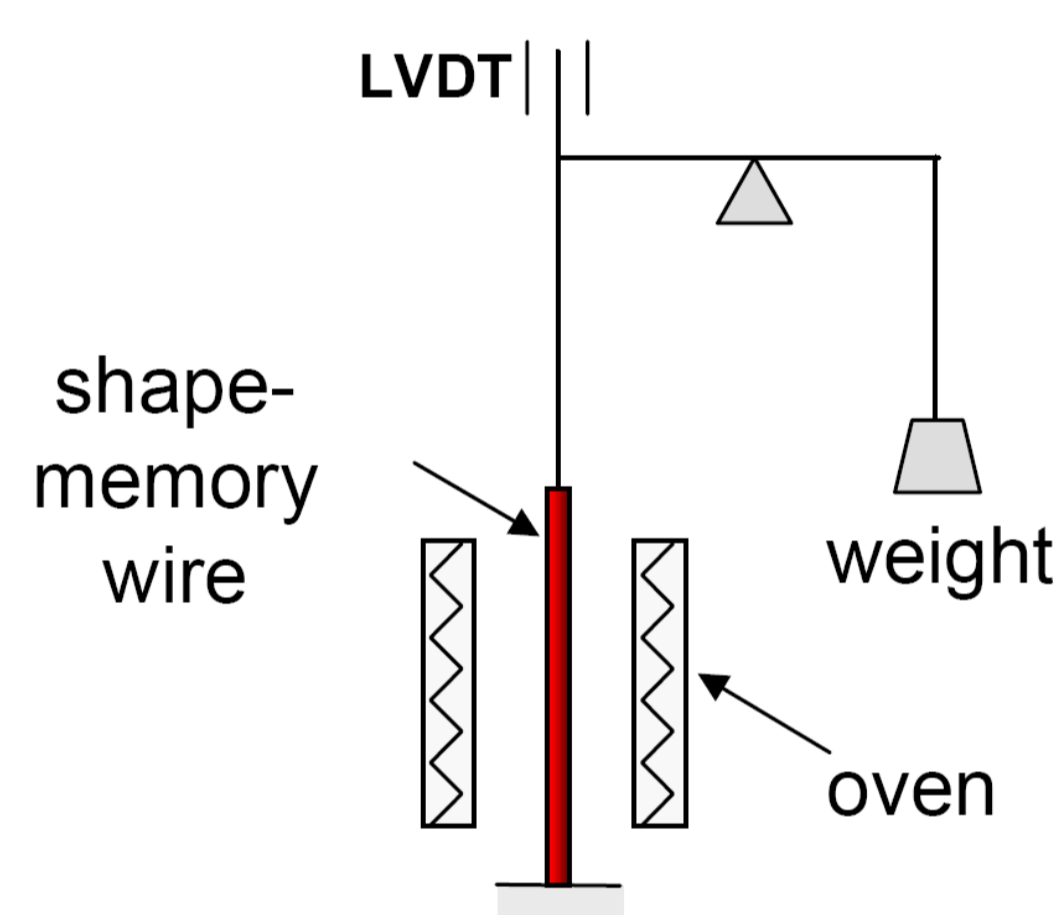
Valve module characteristics:

- 40 N opening force
- 1 mm stroke

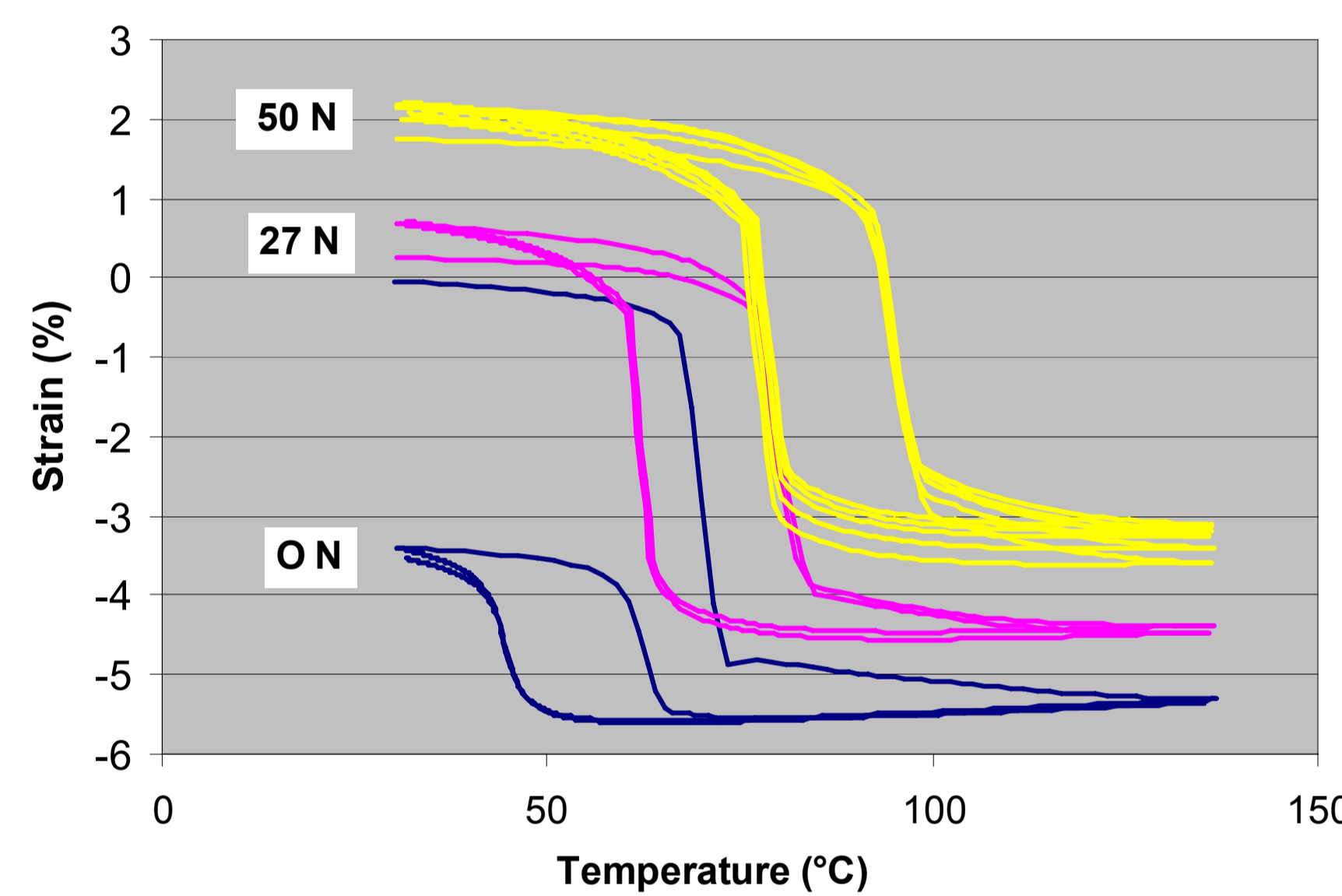


Valve module working principle (poppet valve)

## Shape-memory wire testing



Thermal cycling under load test



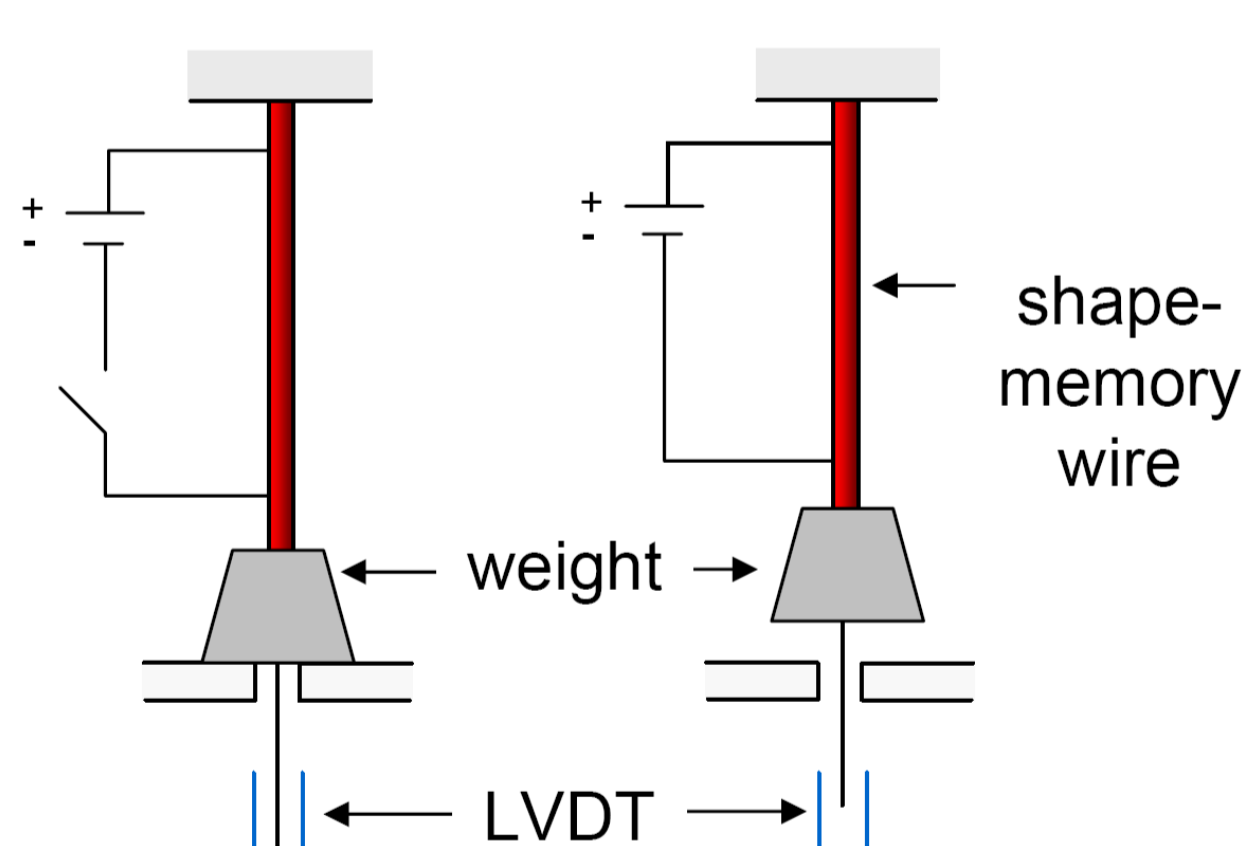
Thermal cycling under load test results

Shape-memory wire:

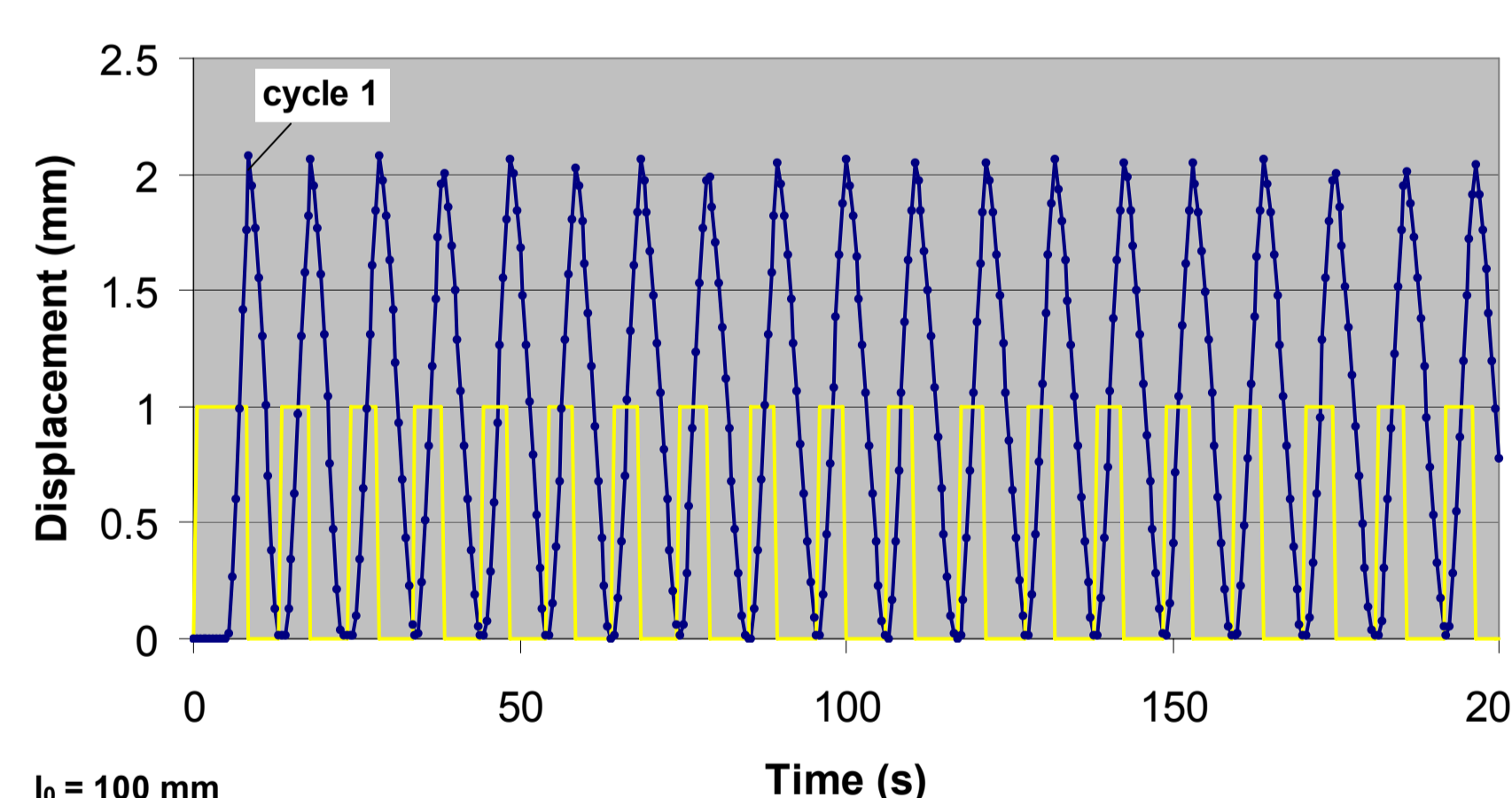
- NT-H7-TTR NiTiCu from Furukawa
- Diameter 0.5 mm

Stress (MPa)	M <sub>s</sub> (°C)	M <sub>f</sub> (°C)	A <sub>s</sub> (°C)	A <sub>f</sub> (°C)
15	47	42	59	65
138	64	59	76	83
254	80	74	91	99

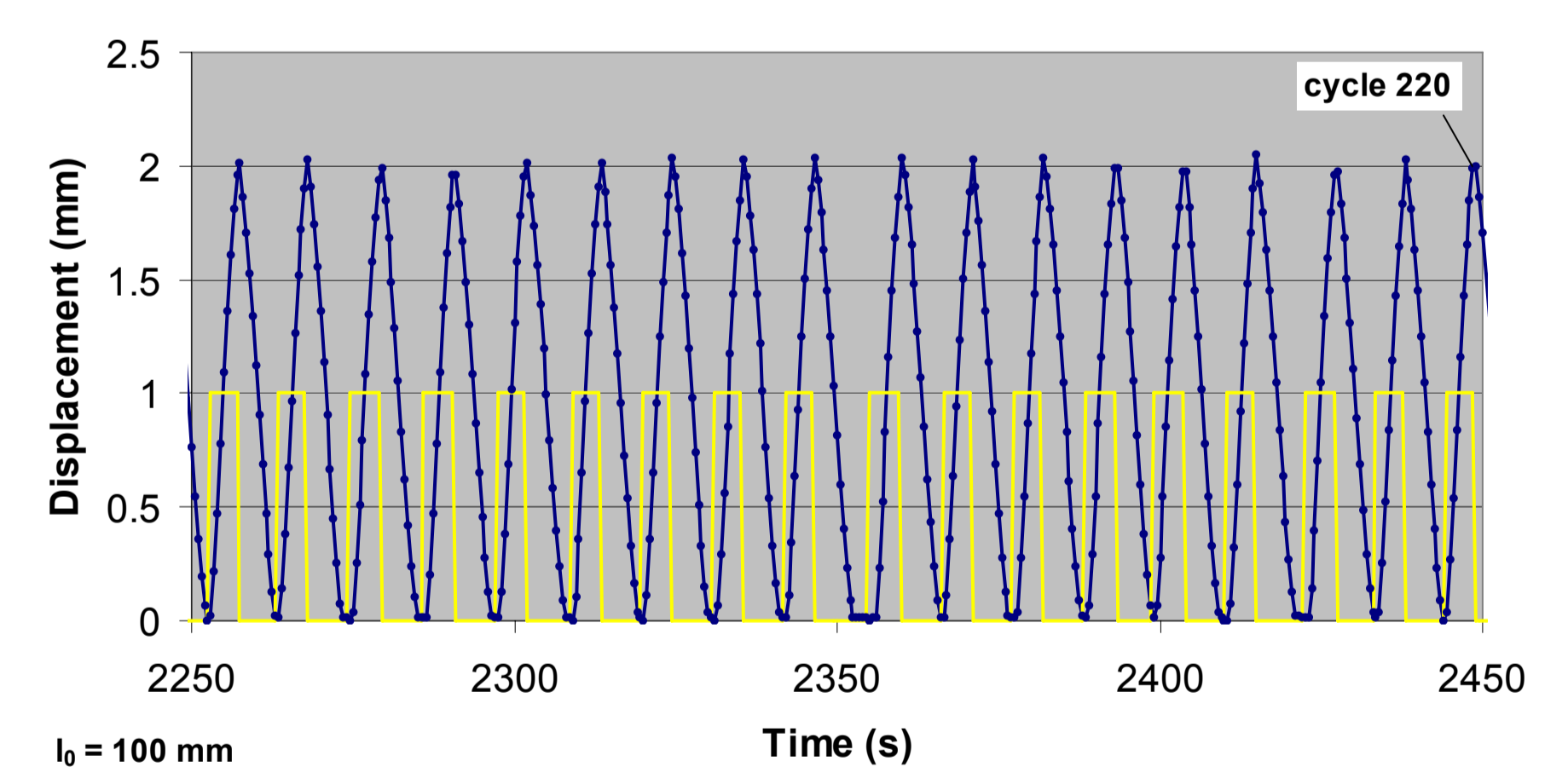
Transformation temperatures as derived from thermal cycling under load tests



Cycling stability test

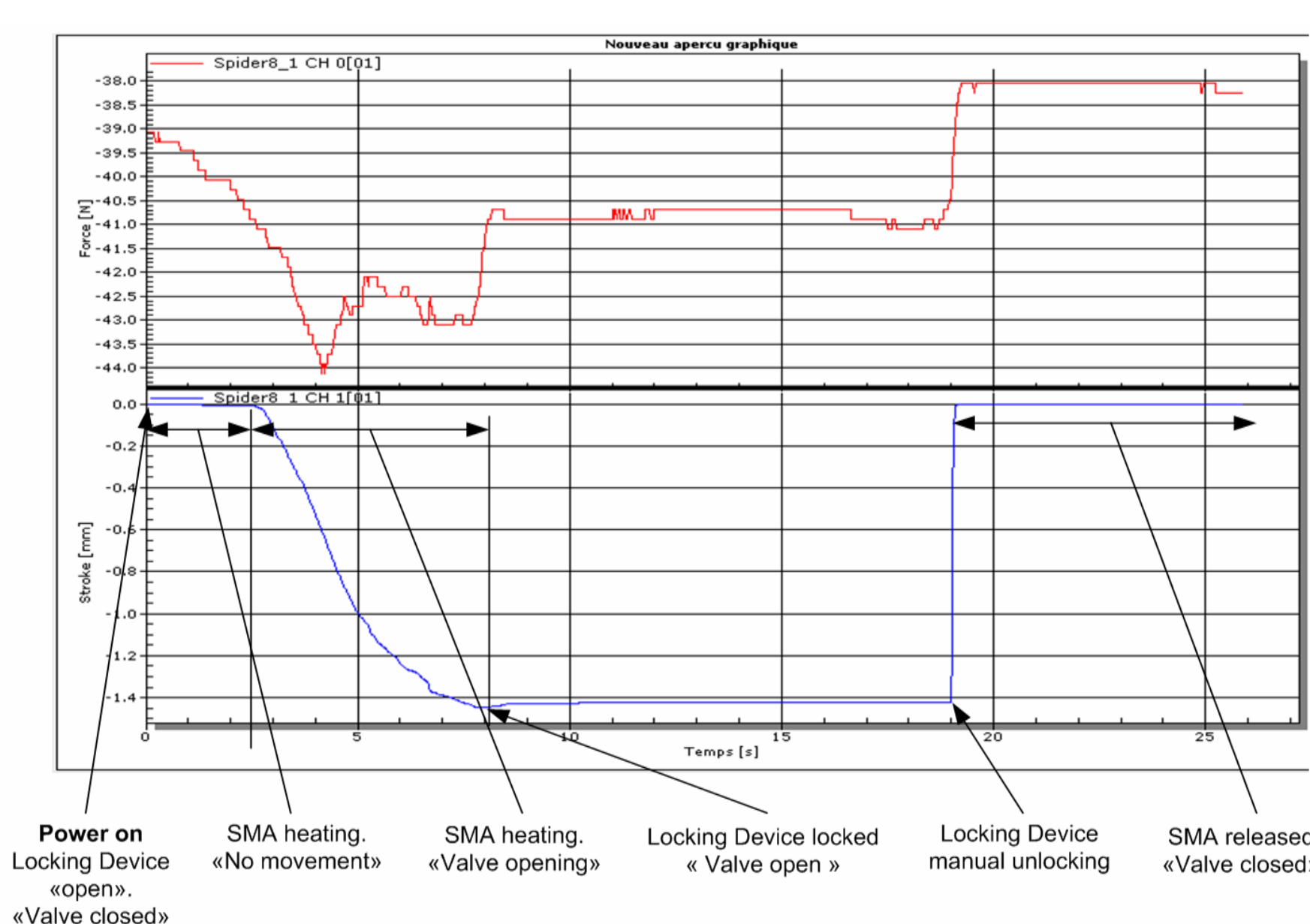


Cycling stability : first 200 s

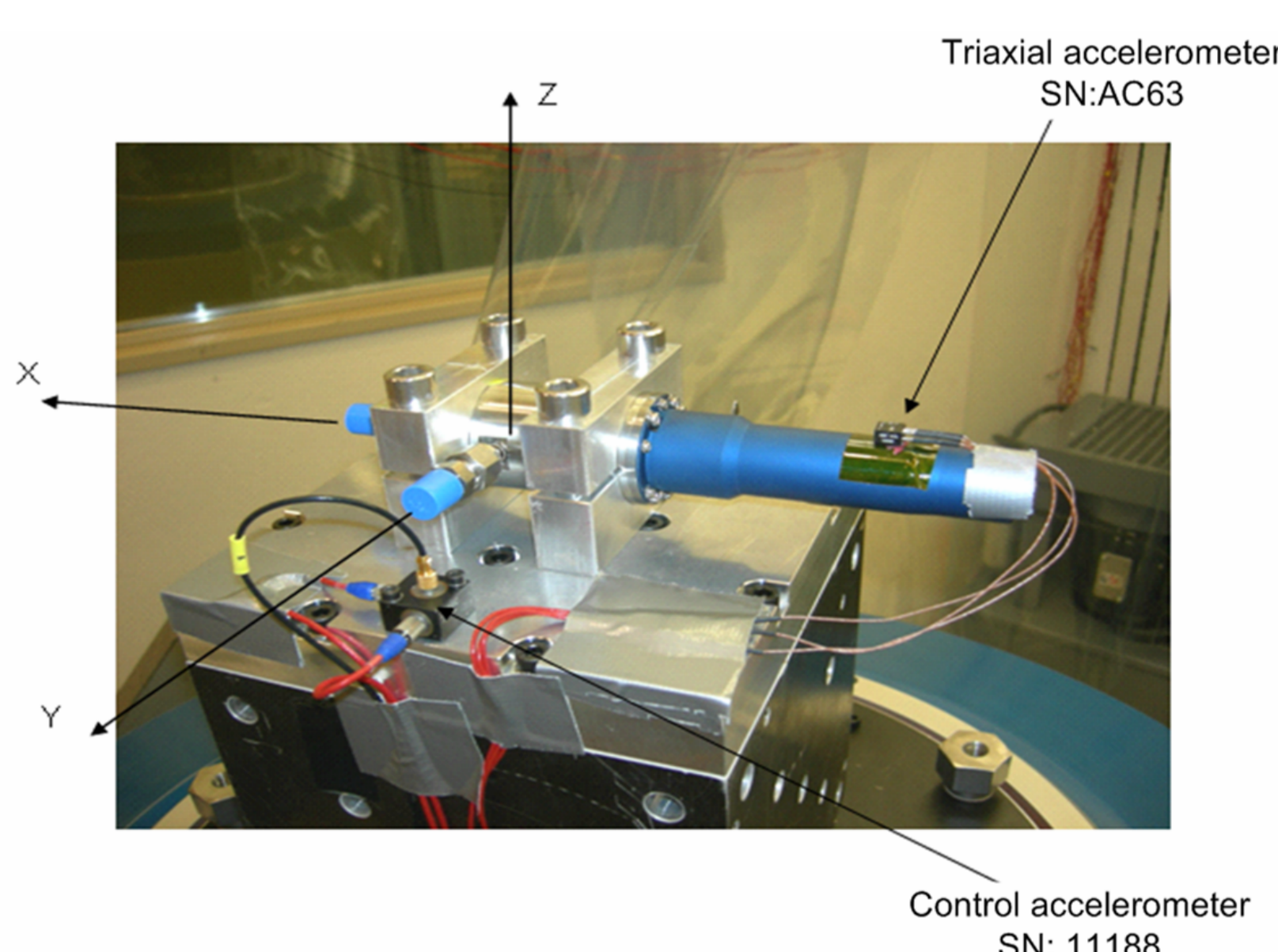


last 200 s

## Actuator and valve testing



Actuator behavior during one cycle of operation



Vibration testing

Measured characteristics:

- Opening time 6 s
- Closing possible after 11 s
- Number of cycles: 55 certif. with a factor of fatigue of 4 acc. to ECSS-E-30 part A
- Self actuation temperature 74°C
- Leak tightness  $8.3 \cdot 10^{-7}$  mbar l/s
- Flow rate 0.9 l/min

## Conclusions

- A multiple-use manually resettable shape-memory valve has been successfully developed and tested
- The valve shows excellent reliability in particular regarding cycling stability, vibration and leak tightness
- Further development towards a flight model is foreseen