

# ***Overview of TWI's High Pressure Hydrogen Testing Facility***

***2 day informational meeting  
Sandia National Laboratories  
9 & 10 April 2013***

**Richard Pargeter & Chris Miller**

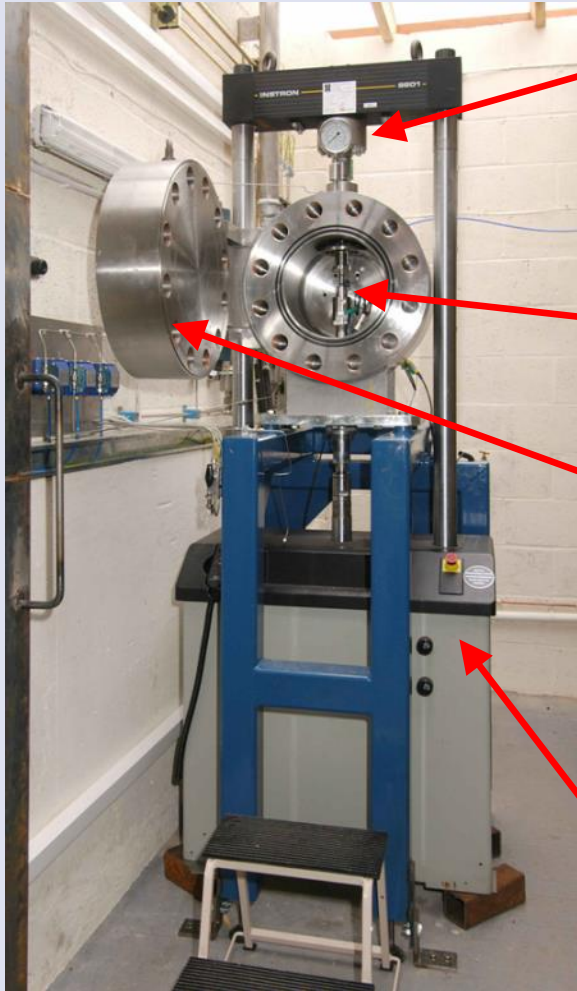
# *Summary*

- **2 dedicated vessels allow a variety of mechanical tests to be performed in high purity hydrogen gas at pressures up to 1000bar (14500psi)**
- **Testing can be conducted at elevated and sub-zero temperatures**
- **Facility for pre-charging specimens with hydrogen prior to testing**
- **Supporting, eg analytical, facilities.**

# ***450bar test vessel***

- **Atmospheric pressure to 450bar (6500psi)**
- **Ambient temperature to 100°C**
  - Heaters embedded in vessel wall
- **Maximum tensile load: 100kN**
- **Maximum compressive load: 50kN**
  - (no pressure balance)
- **Cyclic loading up to a maximum frequency of 5Hz.**

# 450bar Vessel



External  
load cell

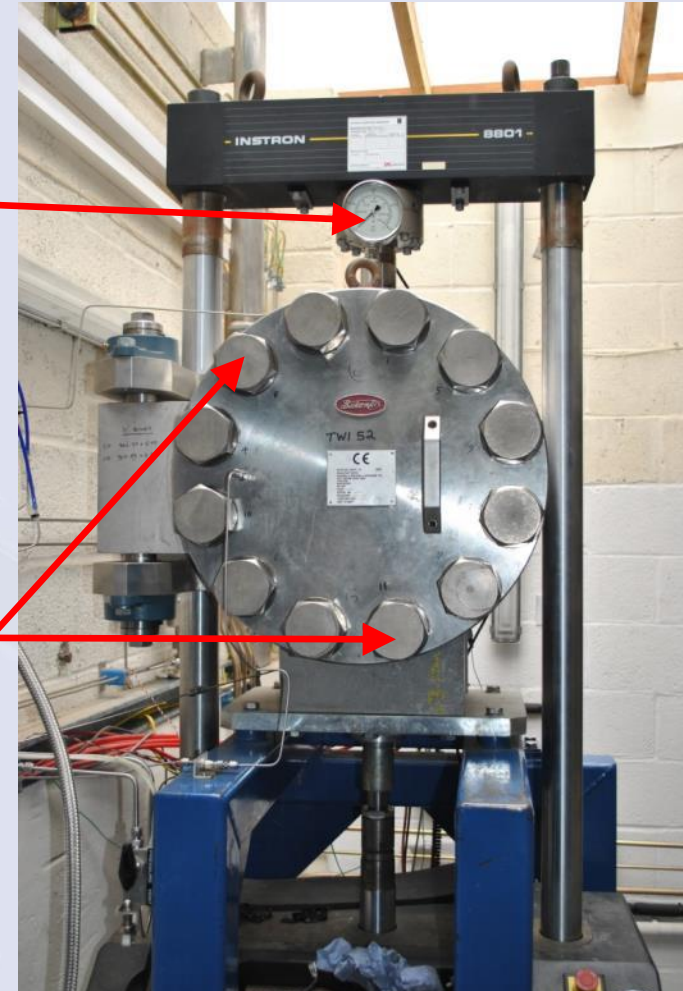
Pressure  
gauge

Test  
chamber

Vessel door

Locking  
bolts

Servo-hydraulic  
test machine



# 450bar Vessel

Internal load cell

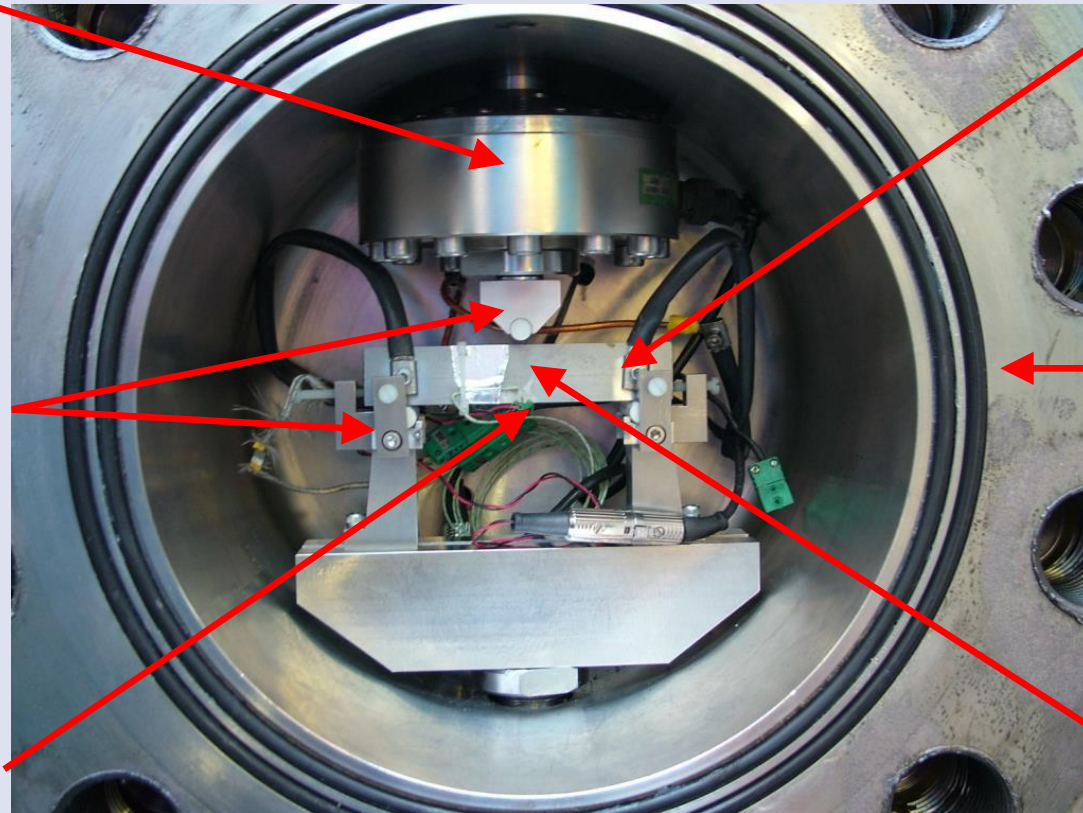
DC current supply

3-point bend loading jig

Gas seals

DCPD measurement

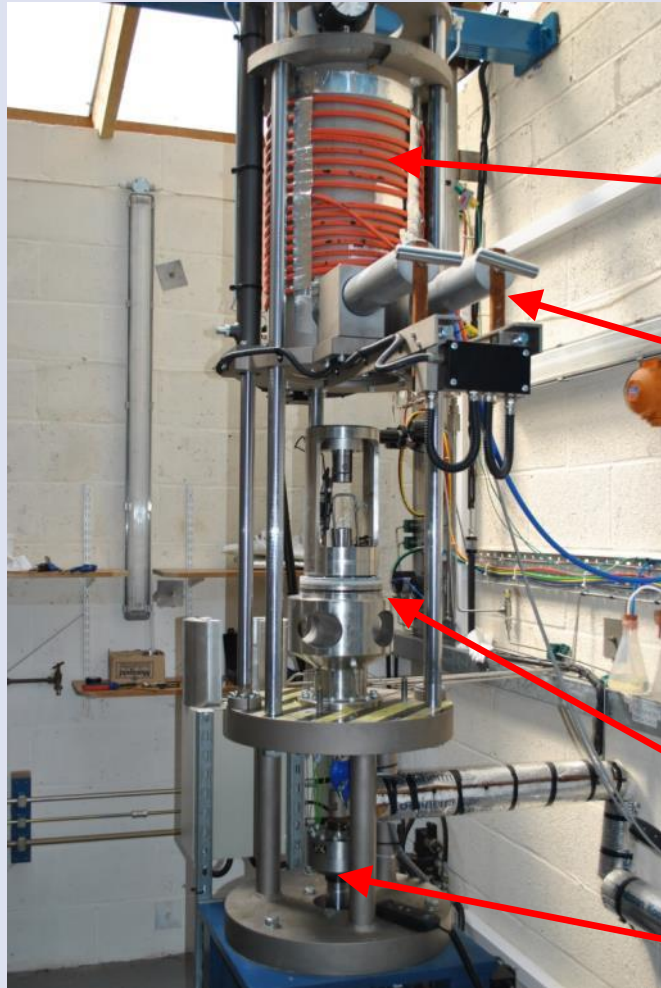
SENB specimen



# *1000bar vessel*

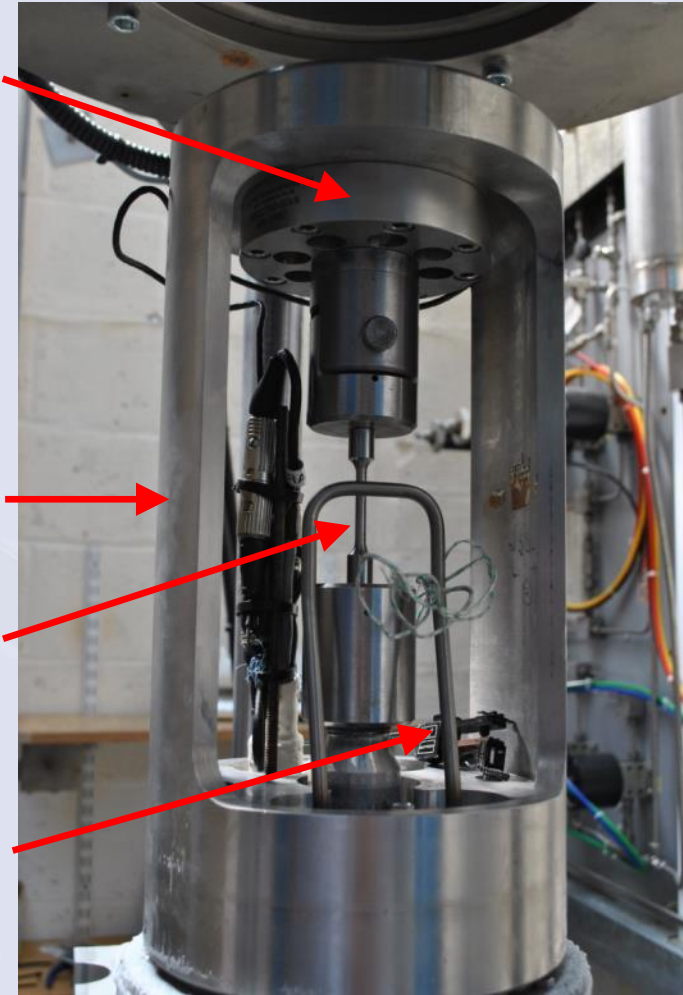
- **Atmospheric pressure to 1000bar (14500psi)**
  - (seals not so good at low pressure)
- **85°C to -50°C**
  - Local specimen heating/cooling
- **Maximum tensile and compressive load: 100kN (dynamically balanced)**
- **Cyclic loading up to a maximum frequency of 5Hz.**

# 1000bar Vessel - open

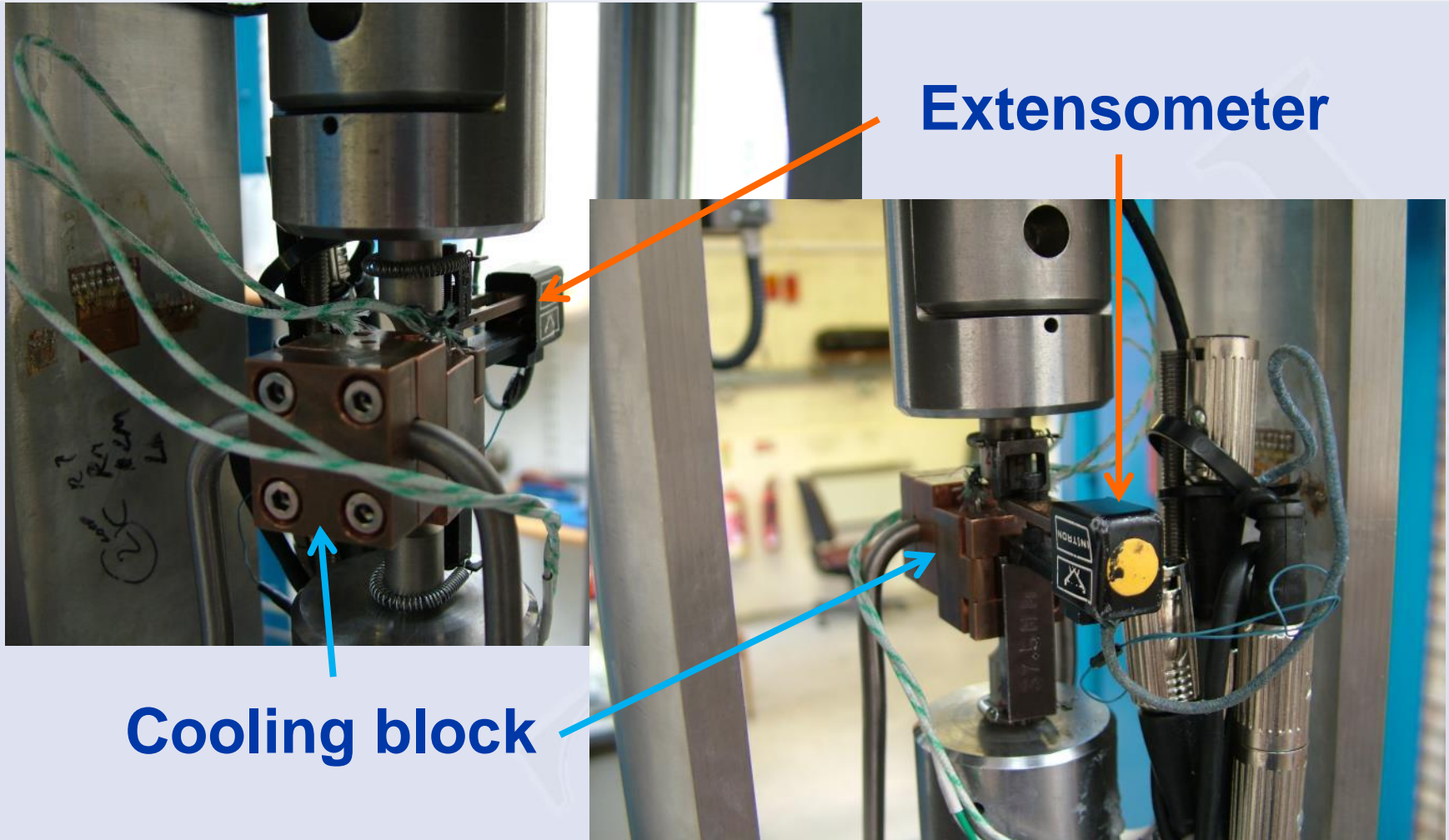


Internal load cell  
External vessel  
Locking rods

Lantern ring  
Tensile specimen  
Gas seal  
Cooling coil  
External load cell



# ***-50°C tensile arrangement***

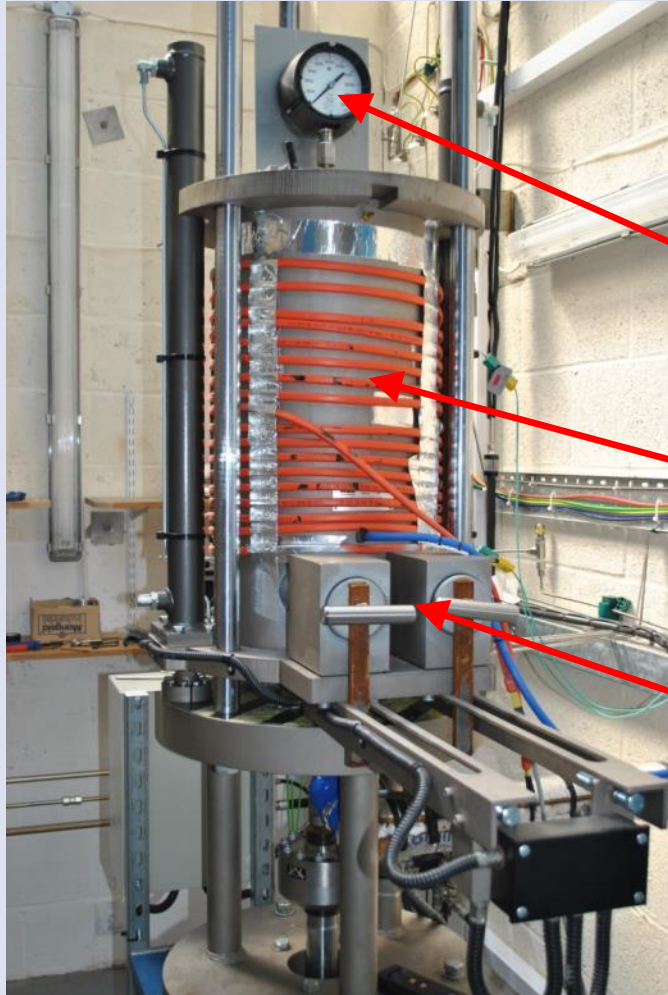


**Extensometer**

**Cooling block**



# 1000bar Vessel - closed



Blast door interlocks

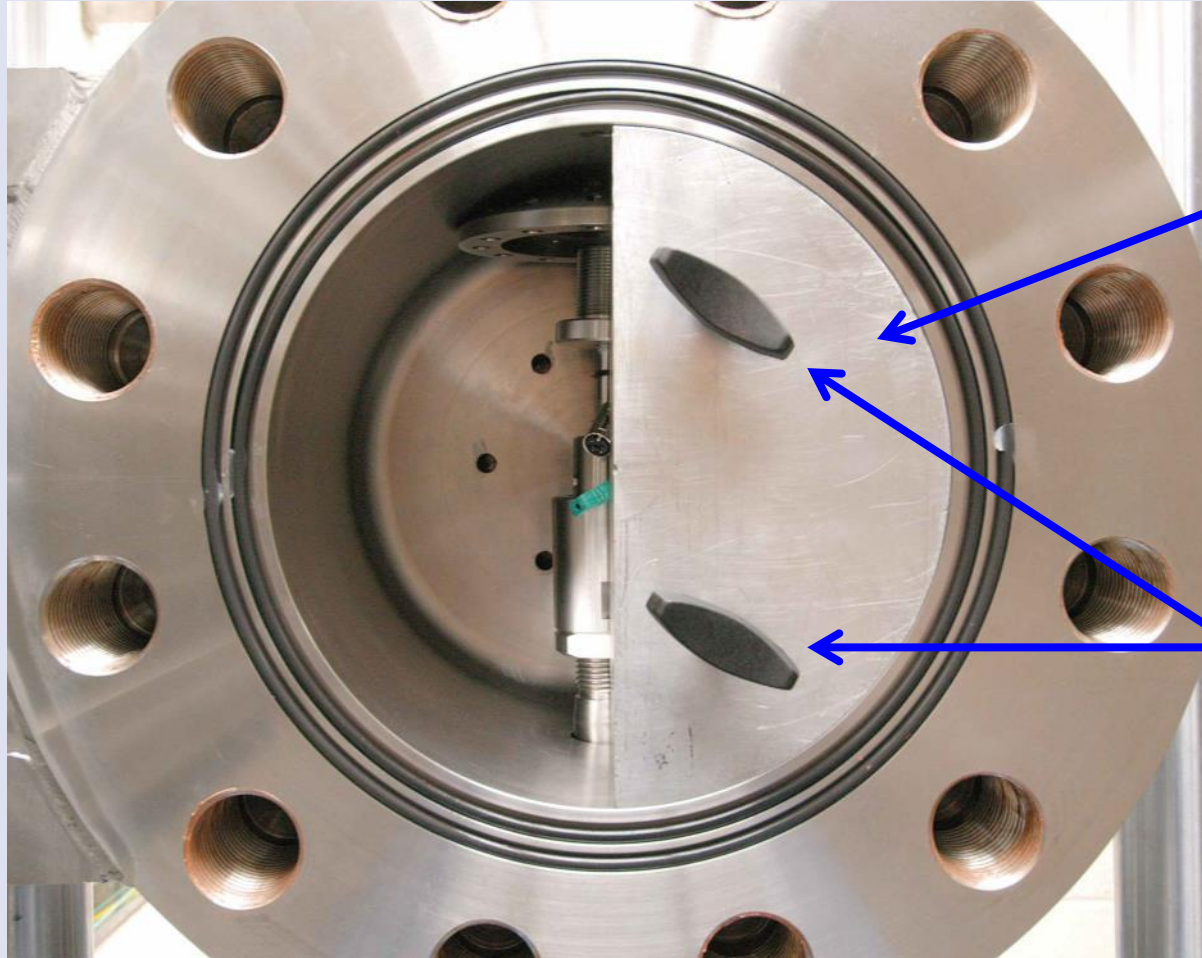
Pressure gauge

External heat tracing

Locking rods



# *Space fillers, 450bar*



**Half block**

**Removable handles**

# *Space fillers, 1000bar*



From back

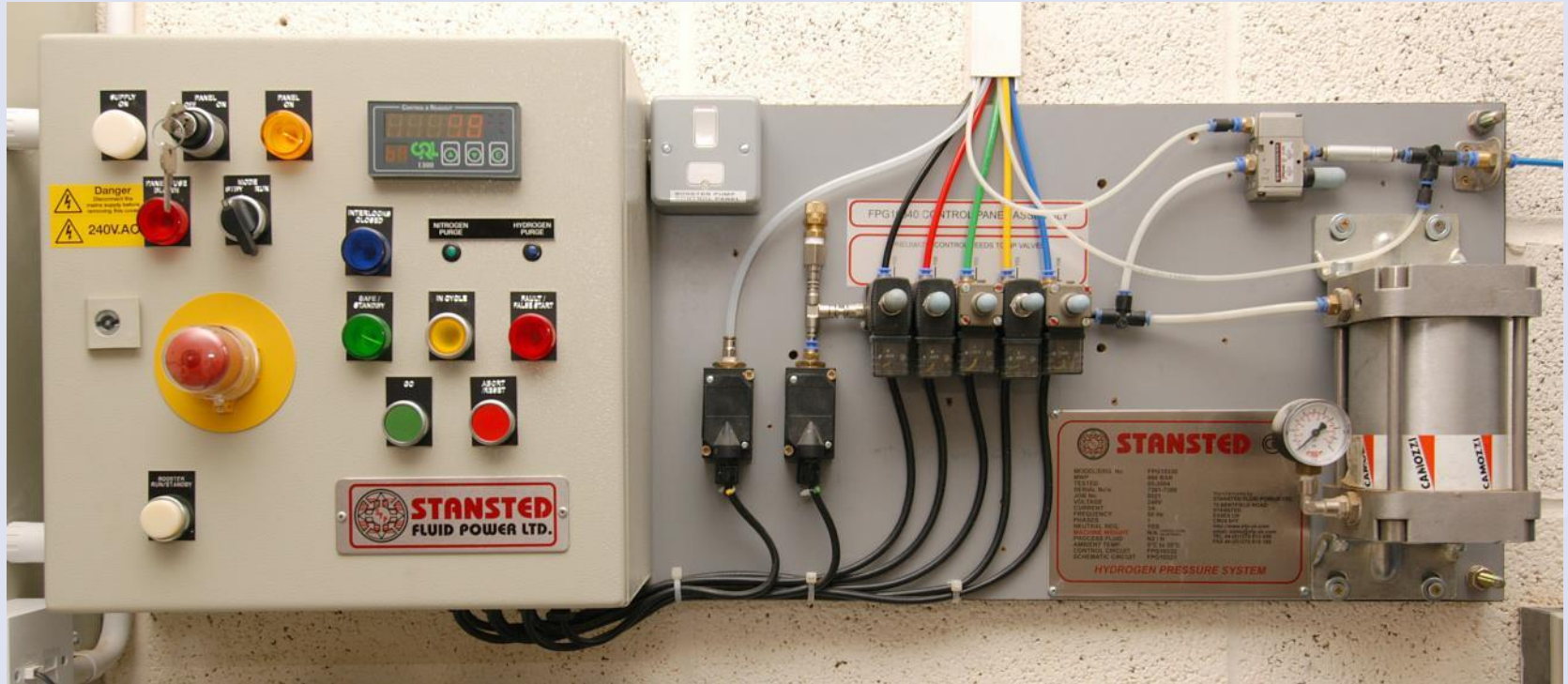
Front half shell



Both half shells



# Control



- PID control – one button initiates full purge sequence
- Pneumatic valves.

# *Pre-test sequence*

- Specimen loaded into vessel
- Vessel & test cell closed and locked
- Nitrogen purges (3): 10 bar
- Hydrogen purges (8): 10 bar
- Quick fill to bottle pressure
- Booster on, pressurising the vessel to test pressure
- Heating/cooling equilibration
- Test initiated.

PID  
controlled

# Gas Supply

- 99.9999% purity Hydrogen supplied in banks of 12
- Solenoid valves
- (Other gasses possible - 99.9999% purity He has been used)
- Oxygen-free Nitrogen used for purging
- Liquid nitrogen for cooling
- Air compressor for pneumatic valves.



# Gas Booster

- Boosts bottle pressure (typically 200bar when full) to a maximum of 1000bar
- Minimum bottle pressure of 40bar required for effective operation.



# ***Under great pressure***

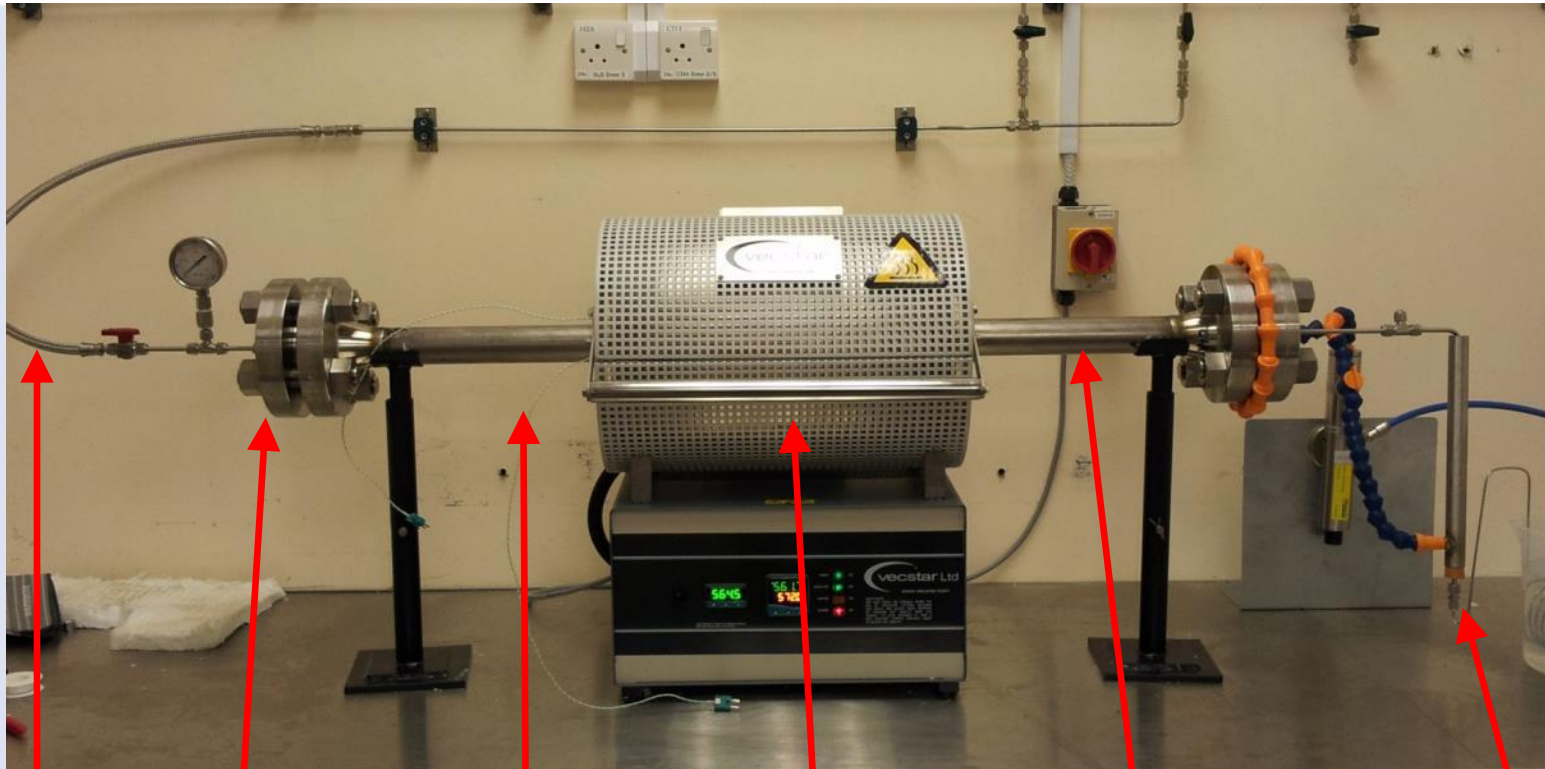
[Under great pressure - TWI's Hydrogen test facility - YouTube](#)



# *Hydrogen Pre-charging*

- **Specimens exposed to high purity hydrogen at up to 100bar (1450psi) pressure and up to 500°C**
- **Used for Hastelloy 230, Alloy 783, Alloy 718, A286...**

# Hydrogen Pre-charging



Gas supply

Thermocouple wire

Alloy 625 vessel body

Sealing flange

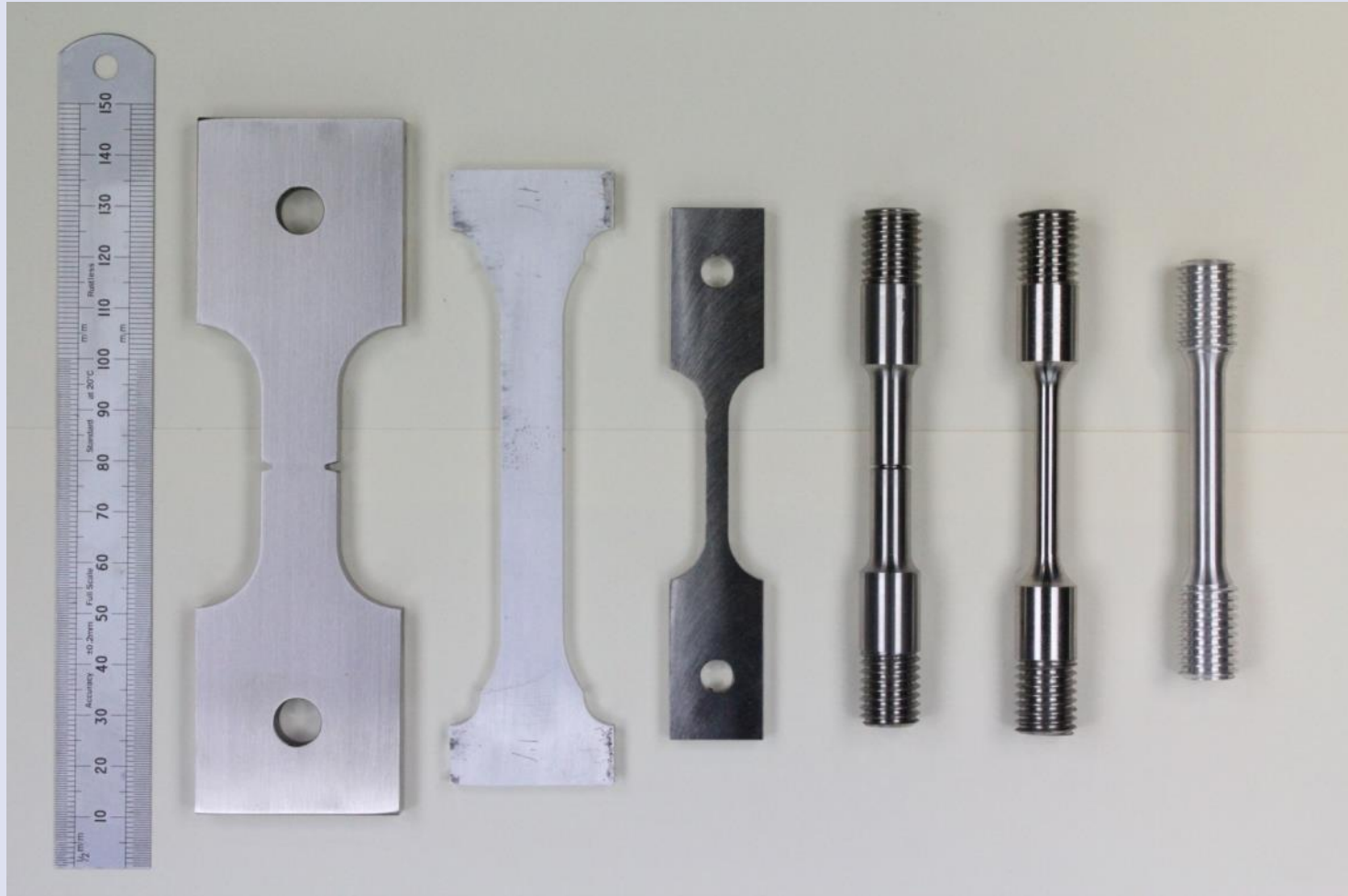
Split-tube furnace

Cooled gas vent

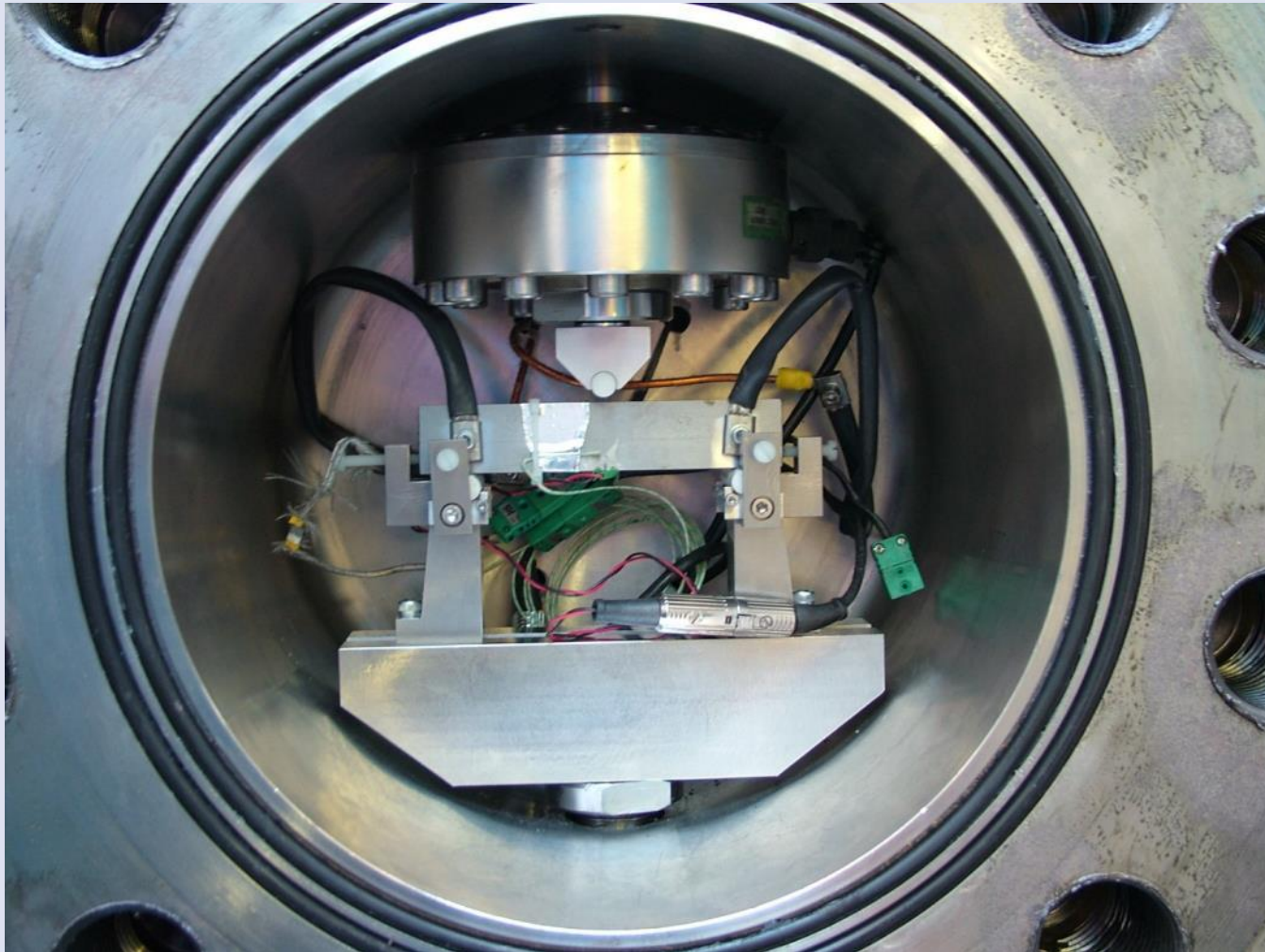
# *Testing Conducted To-Date*

- **Tensile testing of round specimens**
- **Tensile testing of flat specimens**
- **Tensile testing of notched round specimens**
- **Fatigue endurance testing of notched round and flat tensile specimens**
- **Fracture toughness and fatigue crack growth rate (FCGR) testing of single edge notch bend (SENB) and surface notch tension specimens.**

# Tensile Specimens



# *SENB Specimen in 3-point Bend*

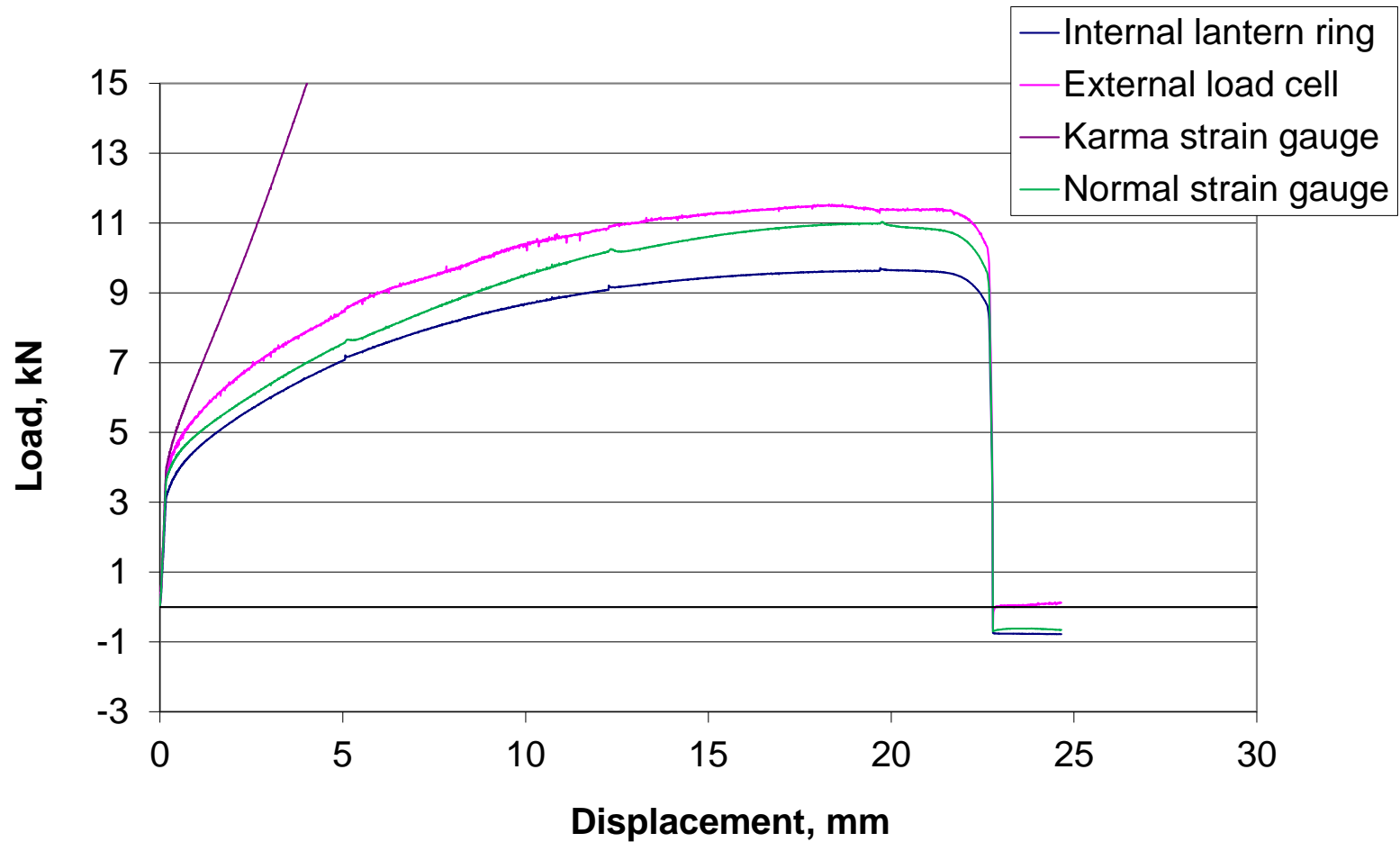


# *Future Development*

- **Development of tooling to accept a wider range of specimen geometries; e.g. compact tension specimens**
- **Development of technique for post-test sampling and compositional analysis of test gas.**

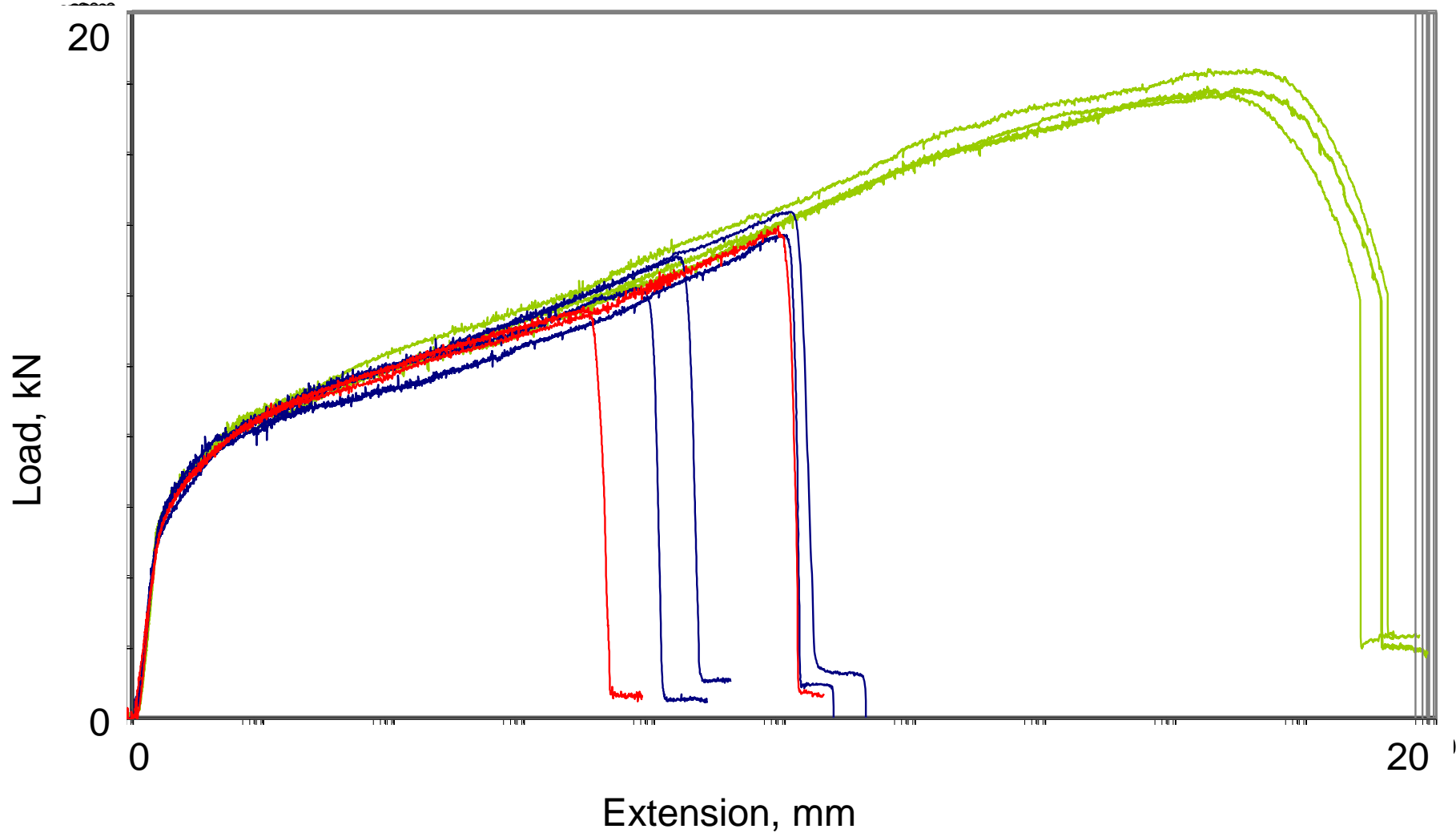
# *Some issues*

# 1000bar Initial lantern ring load cell trials

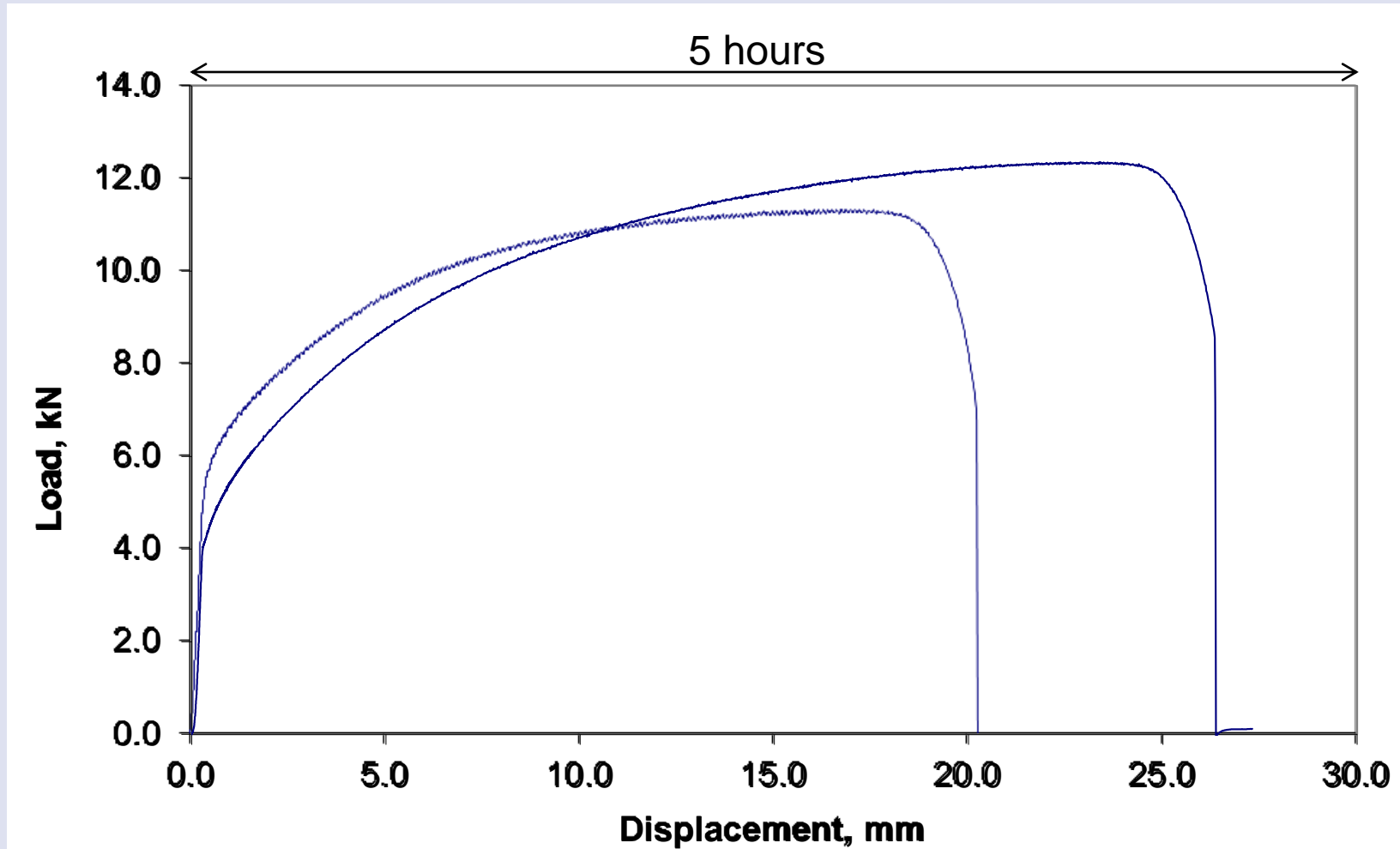




# He (green) and H<sub>2</sub>, 400bar, -50°C



# Current internal load cell

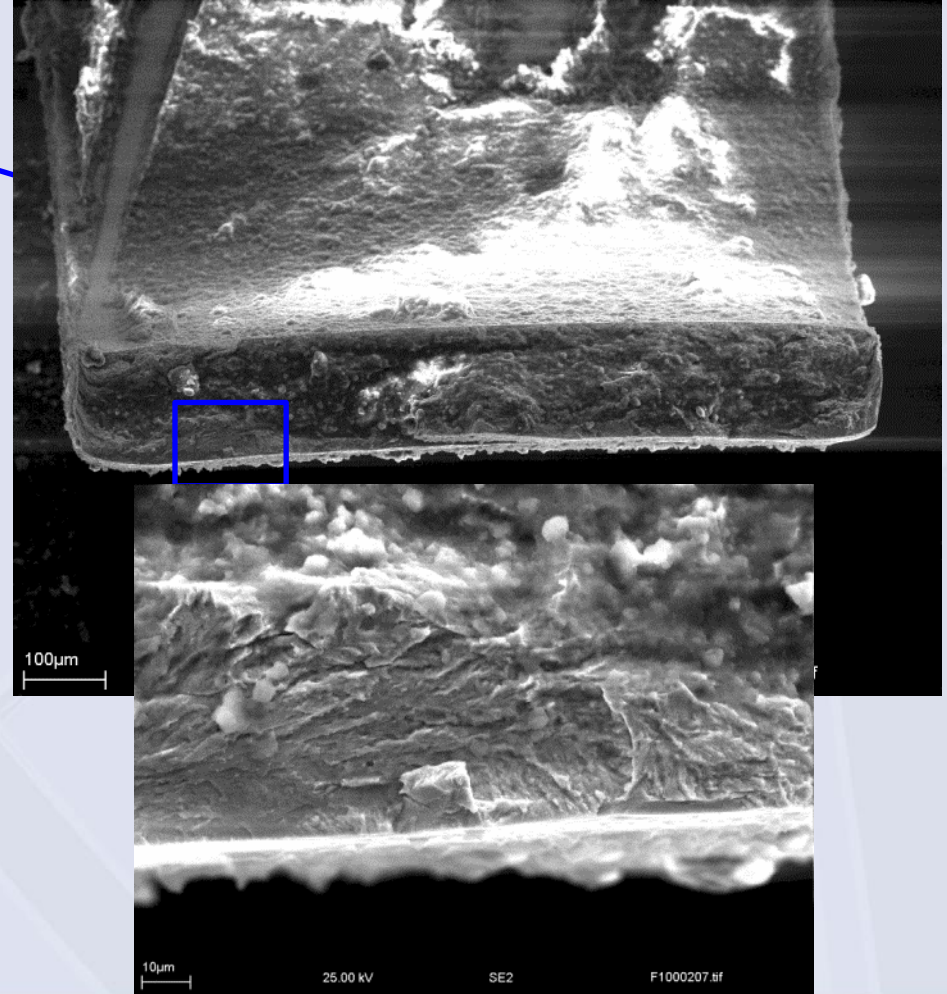
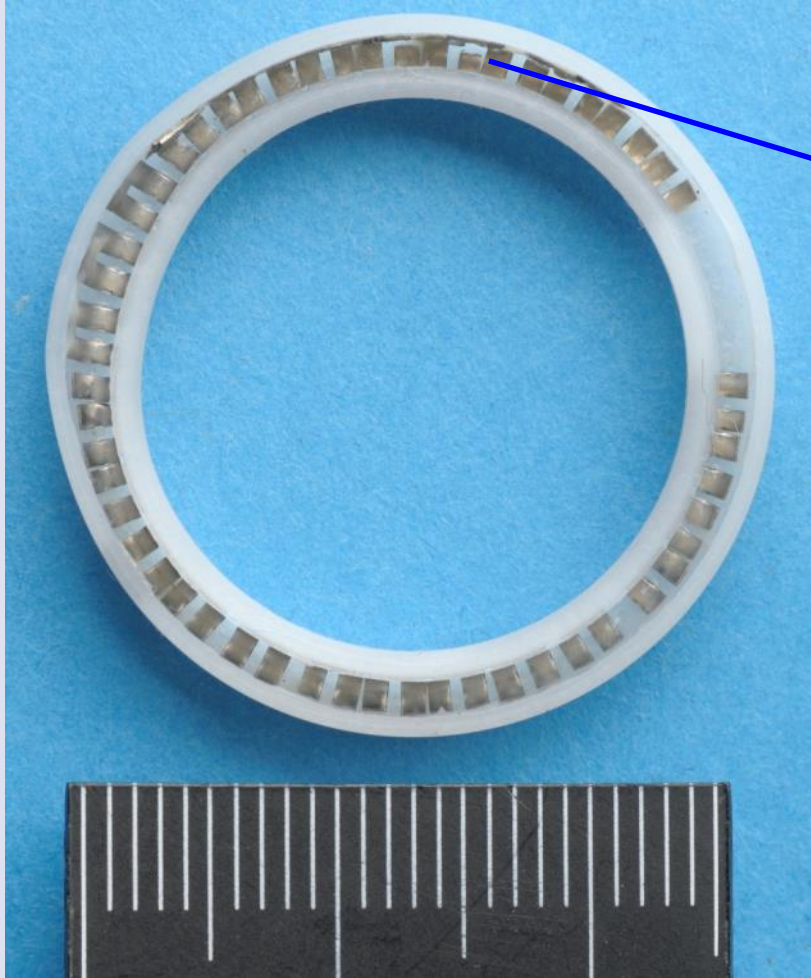


# *O-ring seal failure*



- **Post hot test (on decompression)**
- **Test not compromised**
- **Seals a consumable item.**

# Seal spring failure



***Thank you for your attention***

**Any questions?**