Temperature

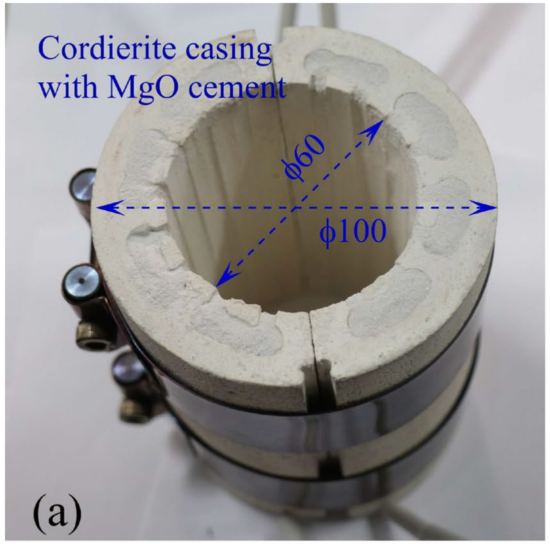
Ref :T. **Shimamoto, Seminar design (2013),** Tullis and Tullis, Experimetal deformation techniques (1986), Paterson and Wong Experimental rock déformation: the brittle field (2005), ...

External Furnace

(IGCEA/UNIPD Hydrothermal Pressure Vessel)

Coiled Kanthal AF was used in MgO casing *(different sizes are available!)*.

MICROTHERM (the best Insulator in the world) is used outside of the furnace.



Split Furnace

[1] Series connection

R = ca. 70 Ω, V = 220 V (Italy)

Power P ~ 690 W

$P_w = VI$ = 220 x (220/70)

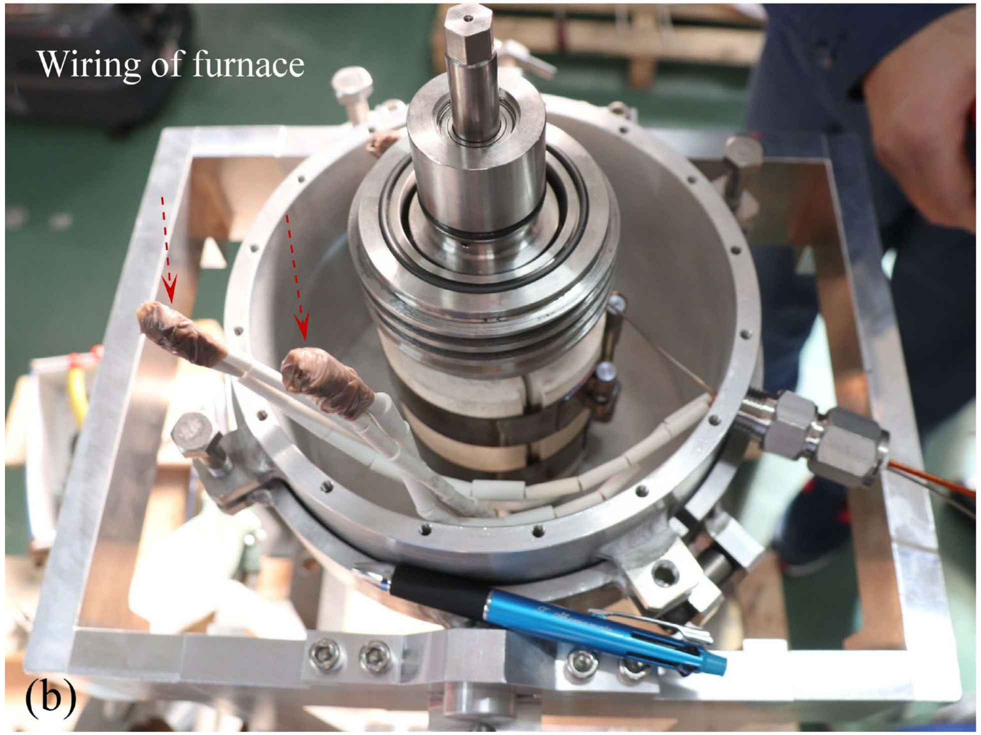
T_{max}: 380°C at full power

[2] Parallel connection

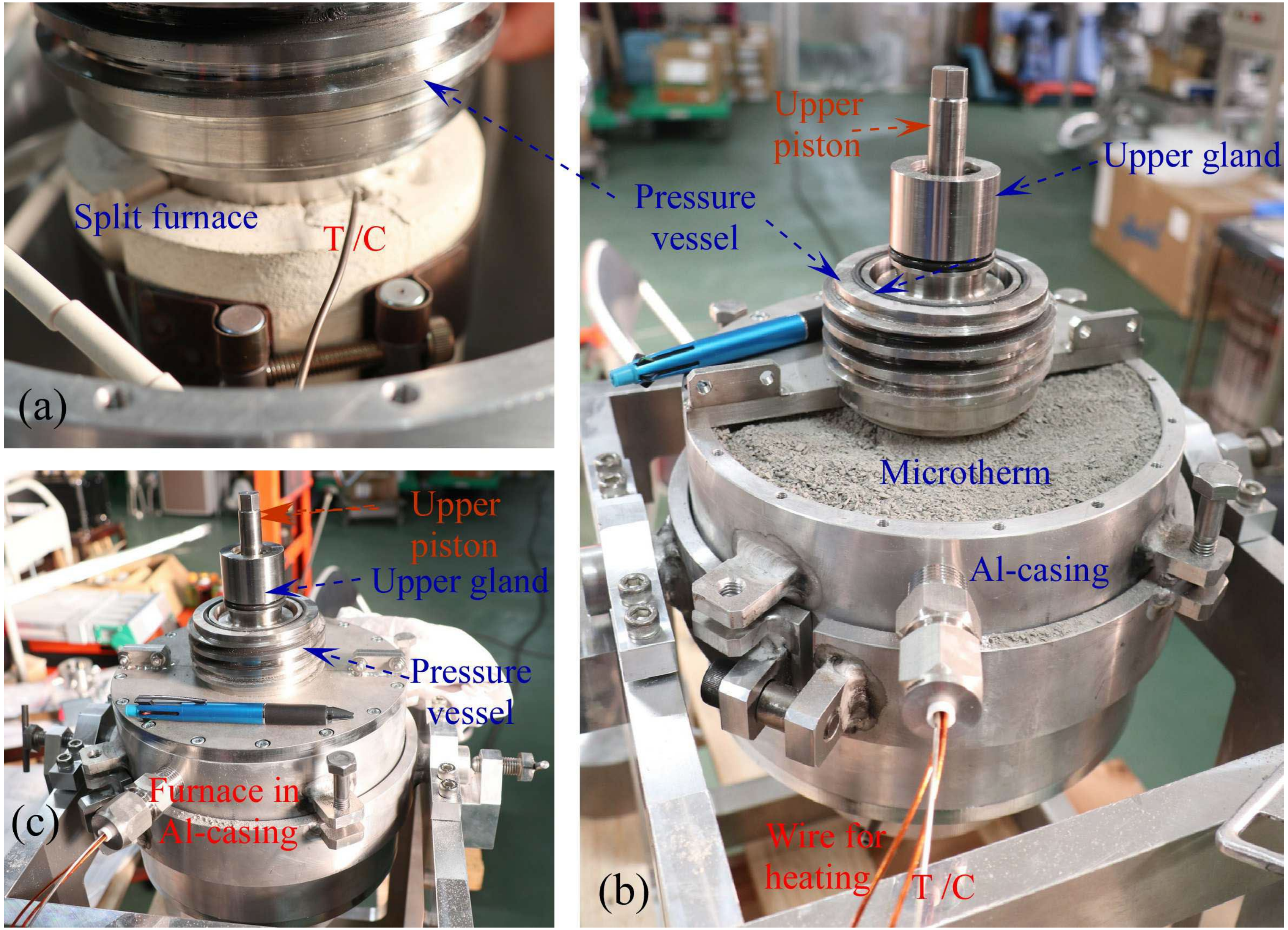
Resistance: 17.3 Ω

Power P ~ 2,800 kW

T : 500°C at P_w ~ 1,600 W

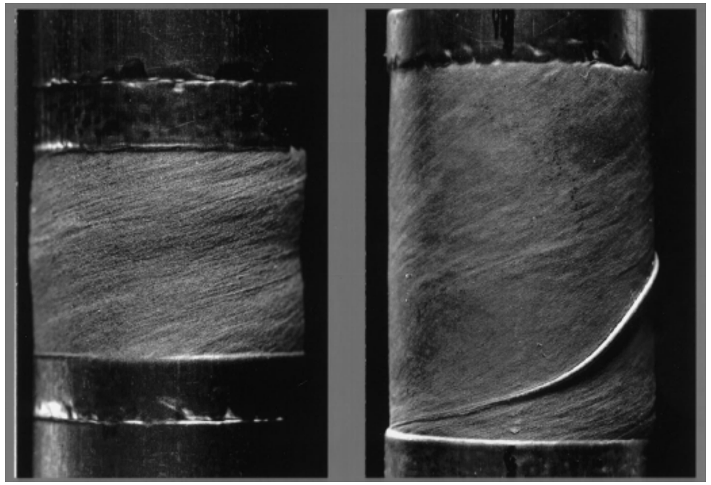


Setting up of the External Furnace

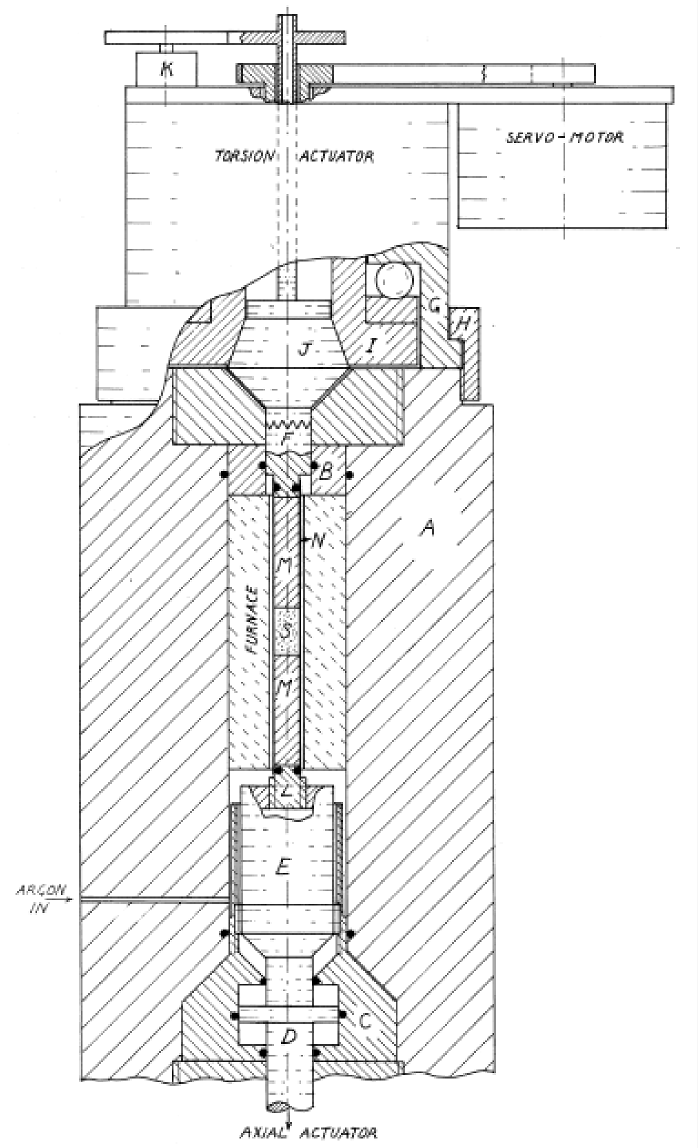


Torsion Gas Apparatus
(M. S. Paterson)

[6] **M. Paterson** extended capability of gas apparatus to torsion in 2000.



Specimens with iron jackets after torsion experiments.



Paterson, M. S. & Olgaard, D. L. (2000) Rock deformation tests to large shear strains in torsion. J. Struct. Geol., 22: 1341-1358.

[7] Frictional contact with pistons: It works for weak rocks at high temperatures.

--- **Can this be extended to brittle regime?**

You can download Paterson's design diagrams from: https://archivescollection.anu.edu.au/index.php/paterson-mervyn

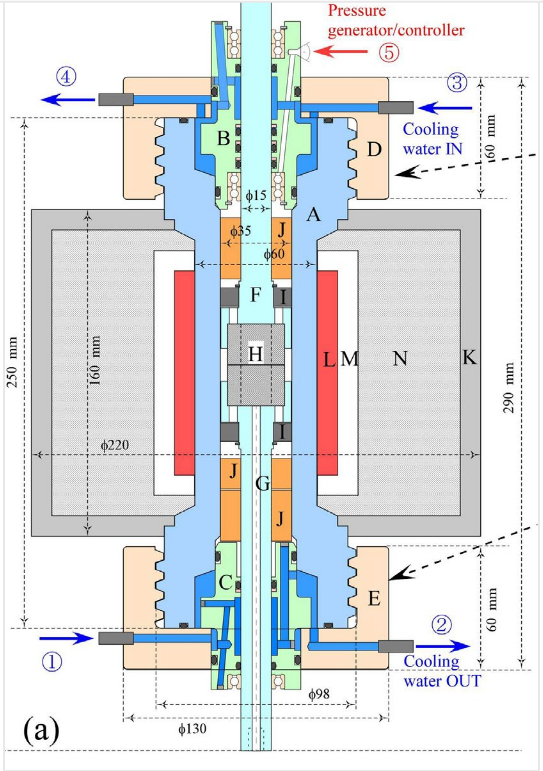
Big Difference between Hydrothermal and Gas Pressure Vessels

[1] Hydrothermal PV: Jackets rupture → Water is in contact with PV. T ~ 750℃

[2] Gas-medium PV: Pore water is separated from PV. → T ~ 1,400℃

[3] Gas-medium PV: Dry experiments are possible without jackets!

Can't we use a pressure vessel for hydrothermal and gas PV?



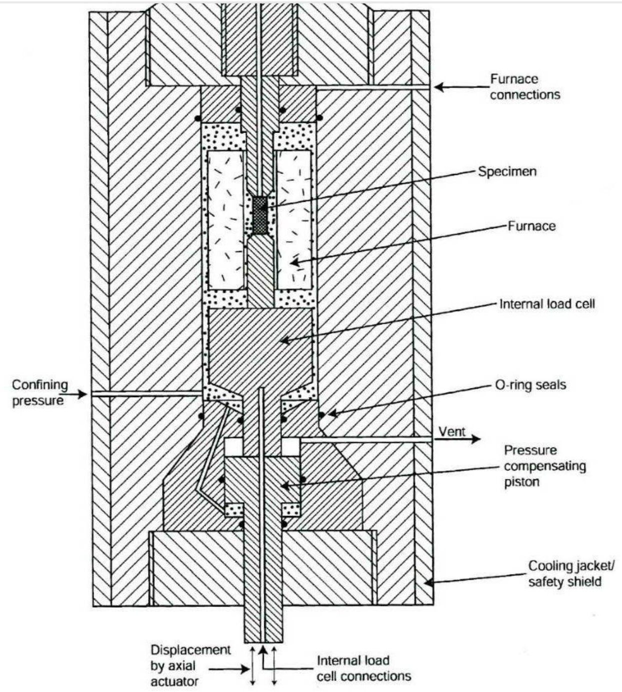
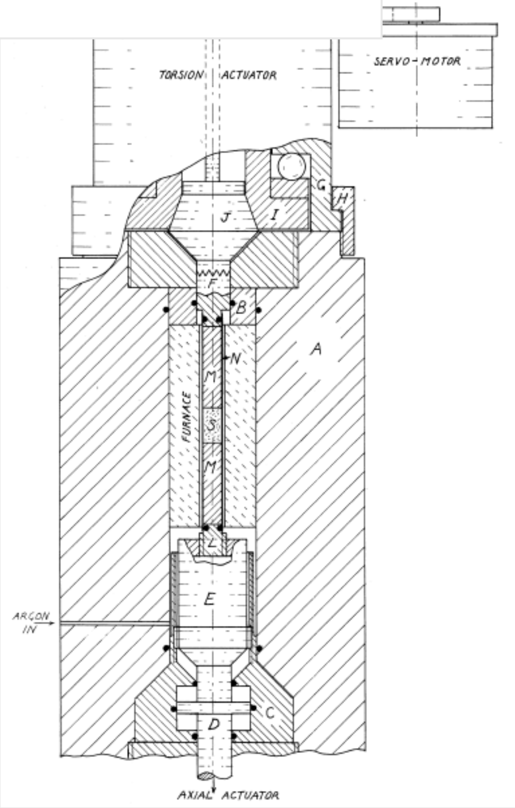
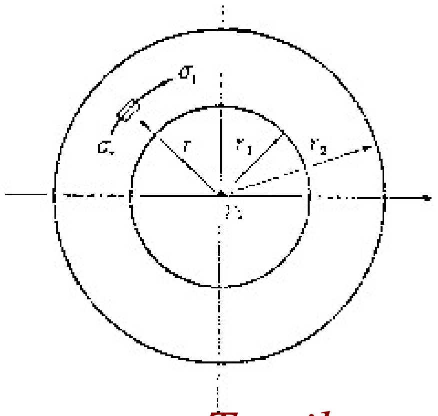


Fig. 4. Schematic representation of a high-pressure high-temperature triaxial testing apparatus, incorporating compensating piston and showing specimen set-up for a compression test. Details of the internal load cell and displacement-measuring arrangements not shown (after Paterson 1990a)



Stresses for an internally pressurized cylinder

Stresses for an internally pressurized cylinder



σ_t : tensile stress

σ_r : radial stress

σ_z : axial stress

Tensile stress: positive!

Most dangerous component:

$$\sigma_t^{max} = \left[\frac{(\kappa^2 + 1)}{(\kappa^2 - 1)}\right] P_i$$

with $\kappa = r_o/r_\iota$

r_o, r_ι : external & internal diameters

Ri = ϕ80, Ro = ϕ200, k = R1/R2 =2.5

$\sigma_t^{max} = (k^2 + 1)/(k^2 - 1)\ P_I = 1.38\ P_I$

$$\sigma_r = -\frac{P_1}{k^2-1}\left\{\left(\frac{r_2}{r}\right)^2 - 1\right\} \text{ kg/cm}^2$$

$$\sigma_t = \frac{P_1}{k^2-1}\left\{\left(\frac{r_2}{r}\right)^2 + 1\right\} \text{ kg/cm}^2$$

$$\sigma_z = \frac{P_1}{k^2-1} \text{ kg/cm}^2$$

Inconel 625: σ_T = 909 MPa/500ºC, 880 MPa/610ºC

P_I = (909/4)/1.38 = 165 MPa/500ºC, 15MPa/610ºC.

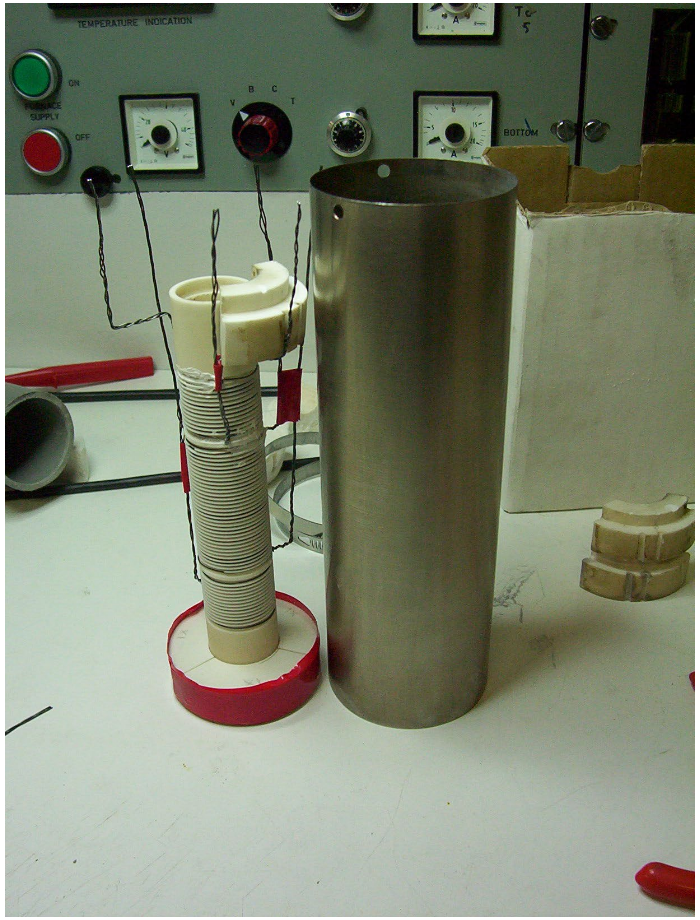
Inconel 625: *PI* ~ 150 MPa

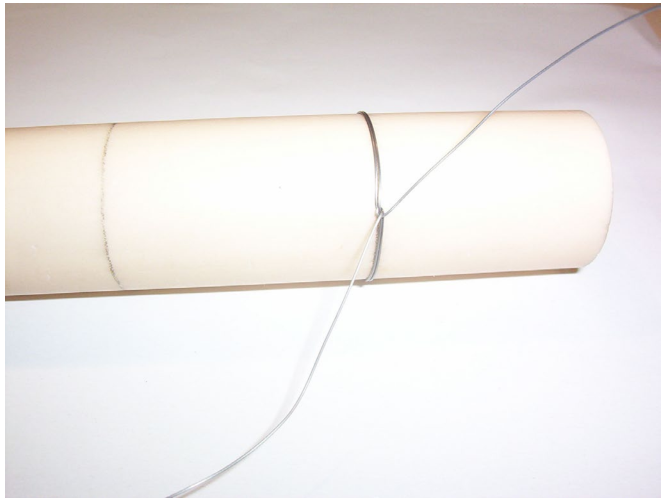
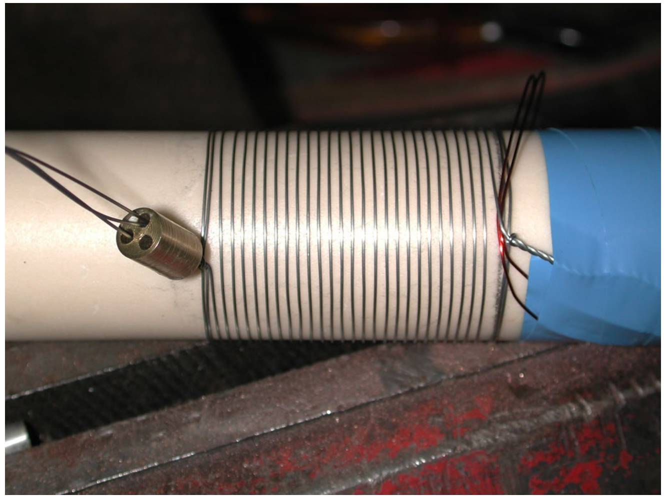
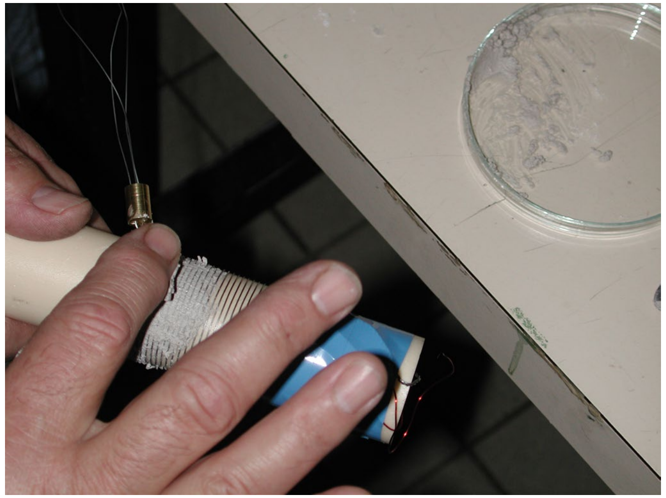
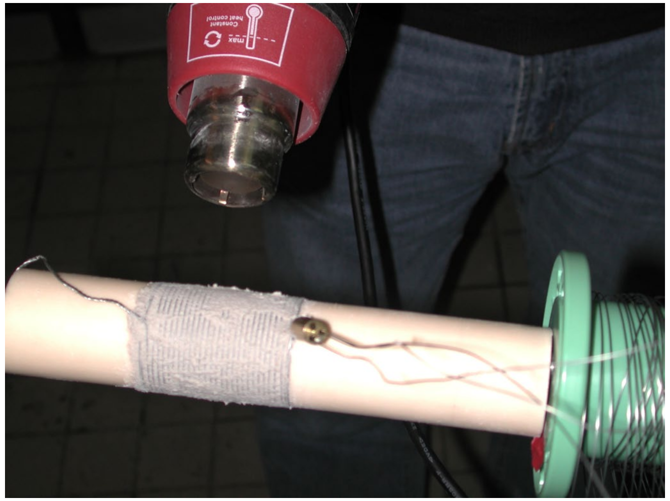
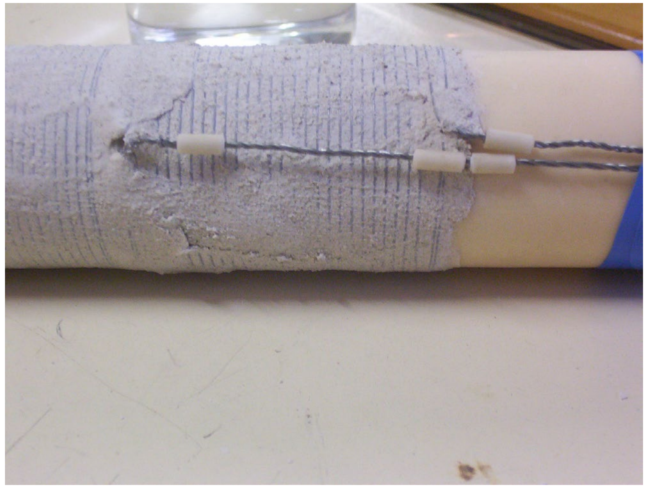
Inconel 718: σ_T = 1275 MPa/578ºC, 1158 MPa/650ºC

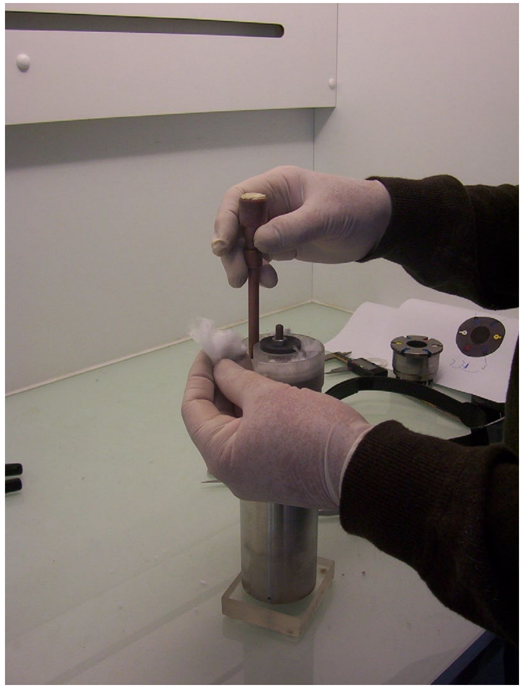
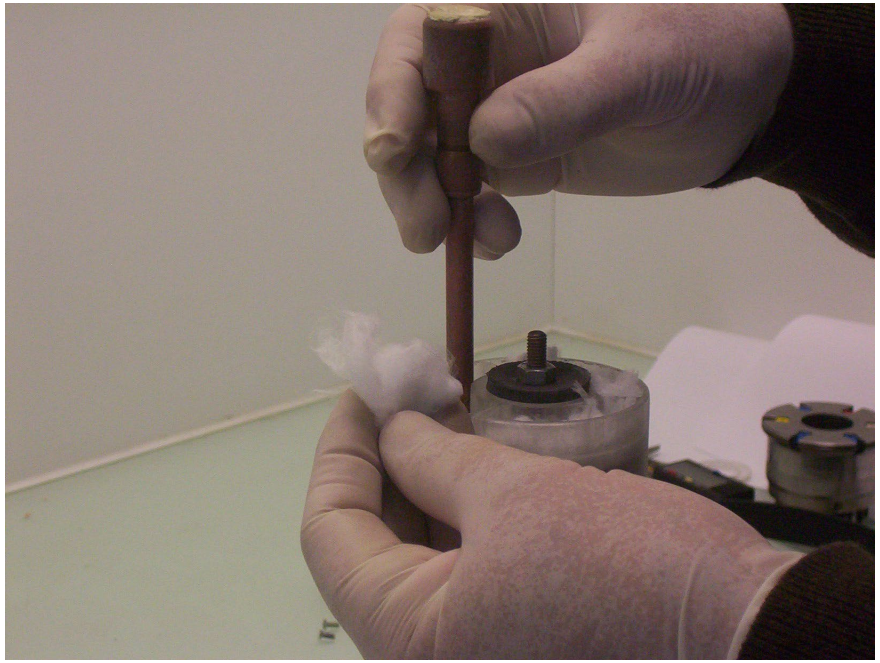
P_I = (1275/4)/1.38 = 229 MPa/578ºC, 208MPa/650ºC.

Inconel 718: *PI* ~ 200 MPa

PATERSON FURNACE




THE SECRET