Pressure generating system

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

Gas Booster (GS Booster)

Function:
A gas booster is designed to increase the pressure of gases such as Argon, Nitrogen, or CO_2, reaching high levels necessary for gas-medium deformation experiments.

How It Works:
It operates using a piston-cylinder system, where a low-pressure gas is progressively compressed to achieve high pressures. This process effectively transforms the input gas into a high-pressure output, suitable for experimental use.

Application:
Widely used in Paterson-type gas-medium apparatus, the gas booster controls the confining pressure up to 150 MPa, simulating high-pressure conditions found deep within the Earth.

Setup Requirements:
The gas booster must be connected to both a compressed air supply and the gas supply/discharge system for effective operation.

Compression Stage:
Typically operates with a single stage of compression, efficiently raising the pressure to required levels.

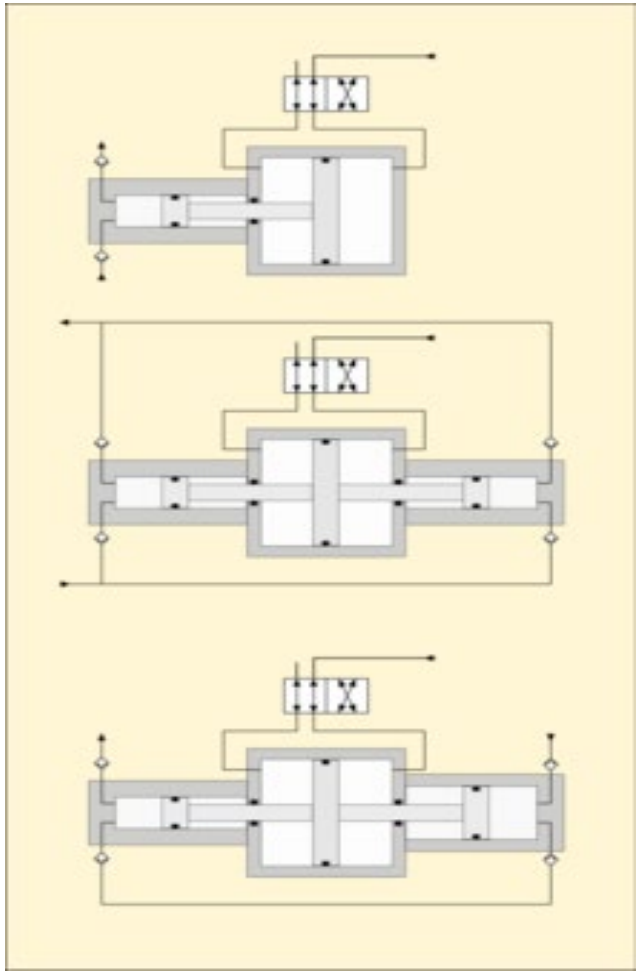


diagram of pneumatic powered gas booster types. Top to bottom: Single stage, single action; single stage double action; two stage double actio

Hydraulic Pump

Function:

A hydraulic pump is a machine that converts mechanical power into hydraulic energy, which generates pressure and liquid flow (typically oil or water). The driving force for the pump is supplied by a main engine, such as an electric motor, human effort … This power drives a wheel, gear or blade to create fluid flow within the pump body.

How It Works:

Different types of pumps (gear, vane, and piston pumps) use different mechanisms to generate fluid flow and pressure:

•**Gear Pump**: Two gears rotate in opposite directions, creating chambers that expand and contract, generating fluid flow and pressure.

•**Vane Pump**: Vanes are pushed outward by centrifugal force and then pushed back into the rotor as they pass the pump's inlet and outlet, generating fluid flow and pressure.

•**Piston Pump**: A piston moves back and forth inside a cylinder, creating chambers of varying sizes that draw in and compress the fluid, generating flow and pressure.

Performance Factors:

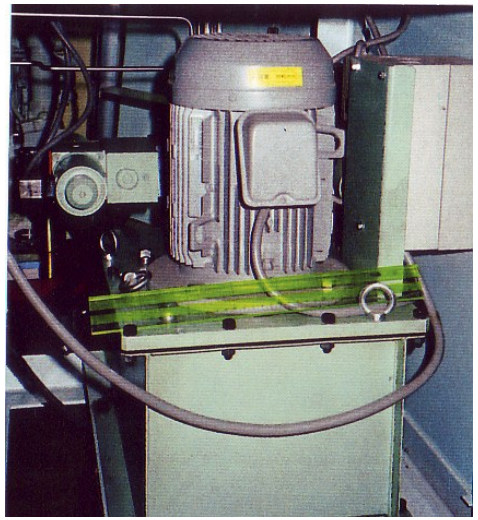
A hydraulic pump's performance is determined by the size and shape of its internal chambers, the speed at which the pump operates, and the power provided to the pump. Hydraulic pumps use an incompressible fluid, typically petroleum oil the working fluid. **Types**:

•**Manual Pumps**: Require hand operation.

•**Motor-Driven Pumps**: Automatically generate pressure via electric motors.

Application:

Hydraulic pumps are used in piston-cylinder systems and Griggs-type deformation apparatus to generate the pressure required for deforming solid materials.



Electronic pump to 70 MPa with 1.8 liter/min flow rate

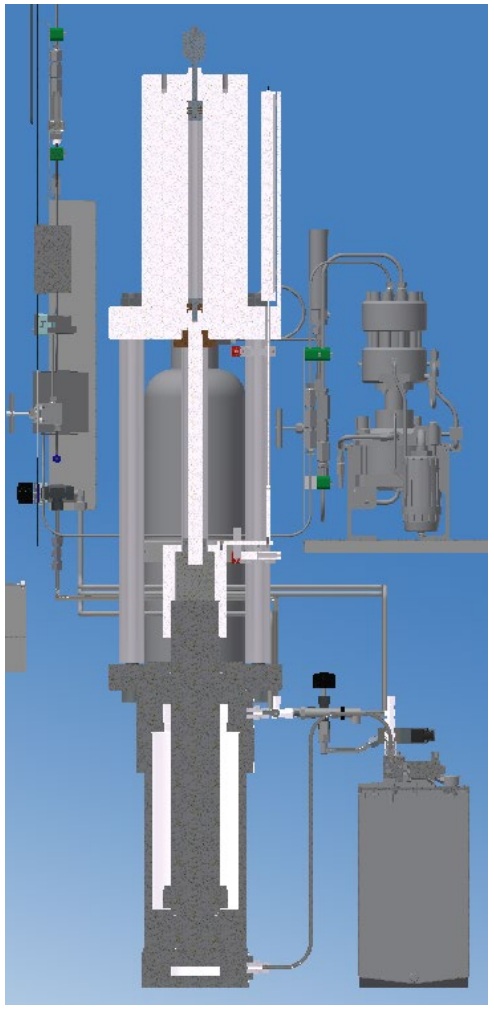
Gas Rig in Hiroshima

Intensifier

Function:
An intensifier converts low-pressure hydraulic fluid into high-pressure output with reduced volume.

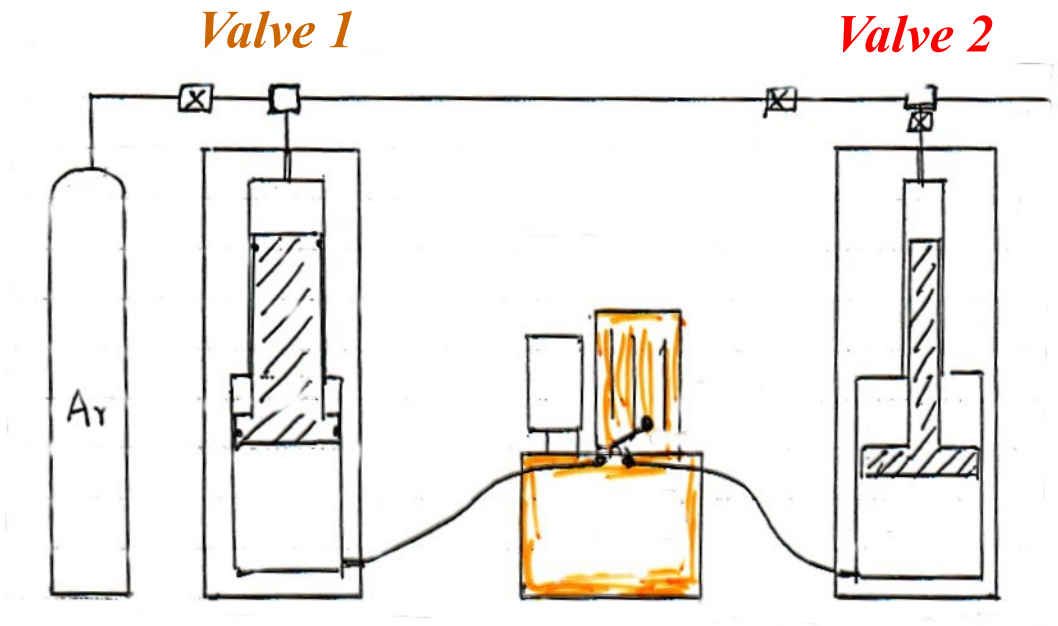
How It Works:
It uses two mechanically linked pistons of different diameters. The larger piston moves the smaller piston, which results in a higher pressure. The pressure is inversely proportional to the area of the piston, meaning the smaller piston creates a much higher pressure based on its reduced area.

Application:
Used in Paterson and other high-pressure systems to achieve very high pressures, typically in the range of 1–3 GPa.



Target appartus intensifier

2 steps Pressure générating system



To:
pressure
vessel

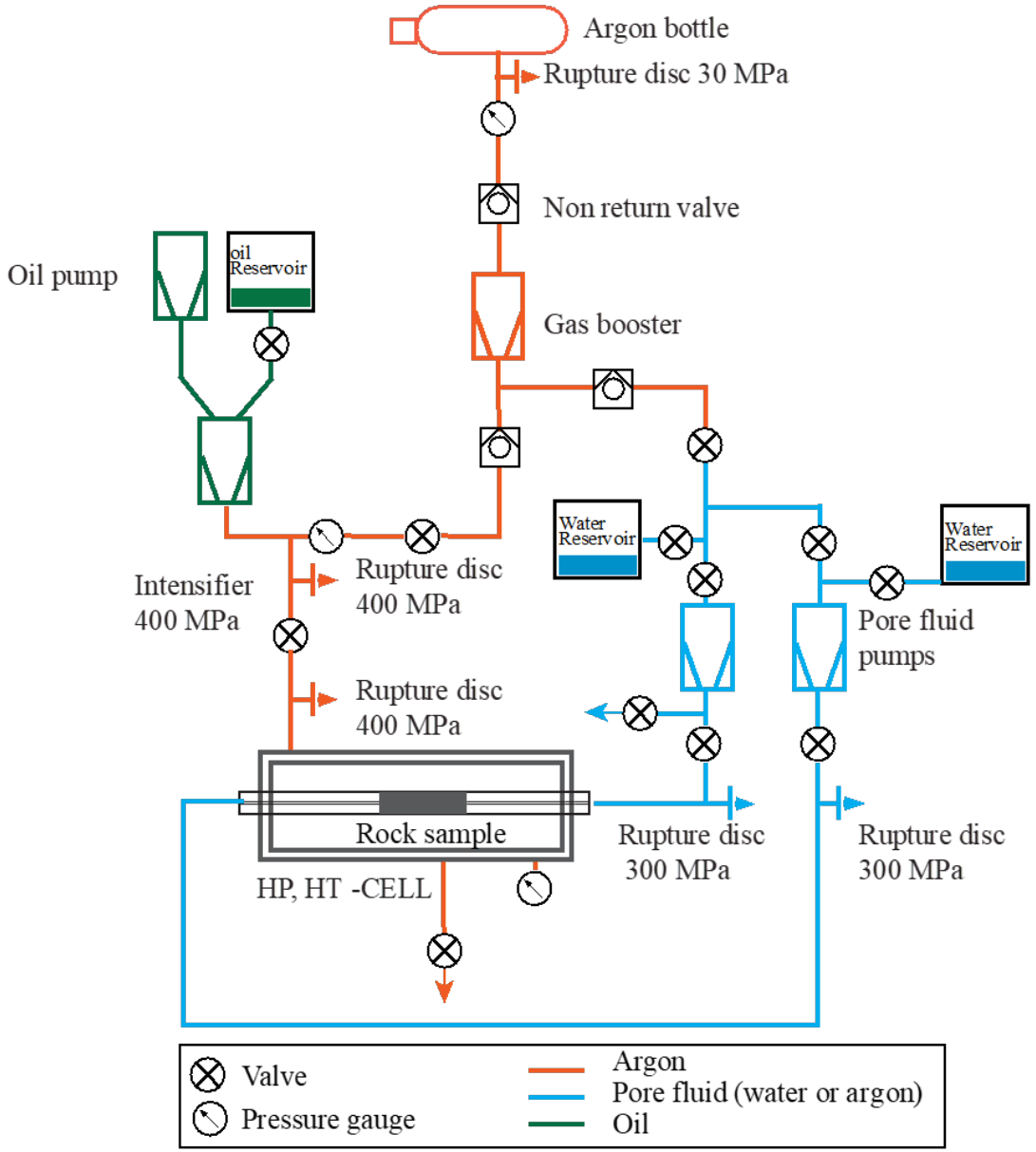
Pressure
generator
To 140 MPa

Intensifier
to 350 MPa

Electronic pump to
70 MPa with 1.8
liter/min flow rate

Pressure Generating System in Kyoto

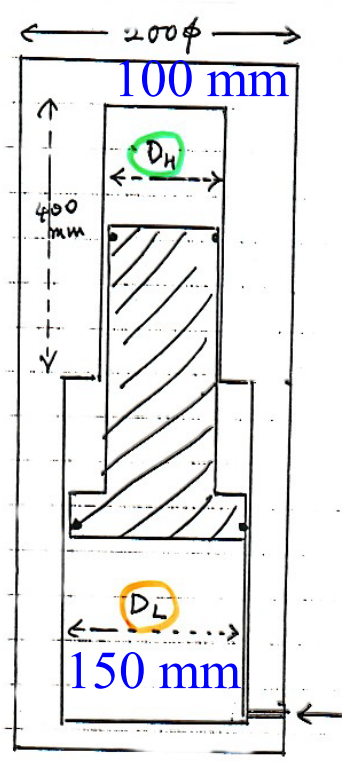
2 steps Pressure générating system



Target , EPFL

Sizes of Pressure Generator and Intensifier

How to determine sizes of intensifier and pressure generator?



Pressure generator
To 157 MPa

High P chamber:
(Pressure generator)

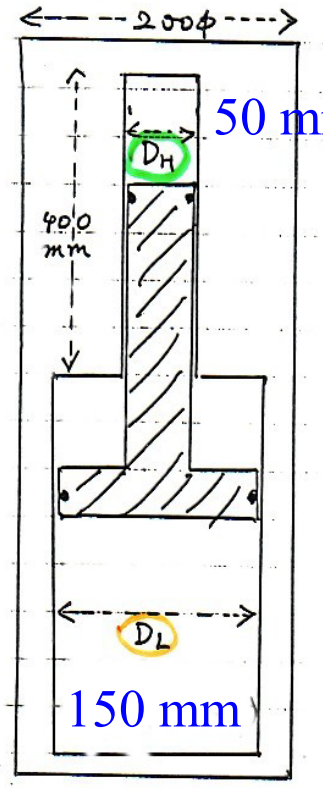
D_H = 100 ϕ
Stroke = 400 mm
V_L = 3.14 liters

1 stroke = 3.9 min
(7.1 *l*)/(1.8 *l/min*)

Low P chamber:

D_L = 150 ϕ
Stroke = 400 mm
V_L = 7.1 liter

2.25 times pressure amplification



Intensifier
to 630 MPa

High P chamber:
(Intensifier)

D_H = 50 ϕ
Stroke = 400 mm
V_L = 0.785 liters

9 times pressure amplification

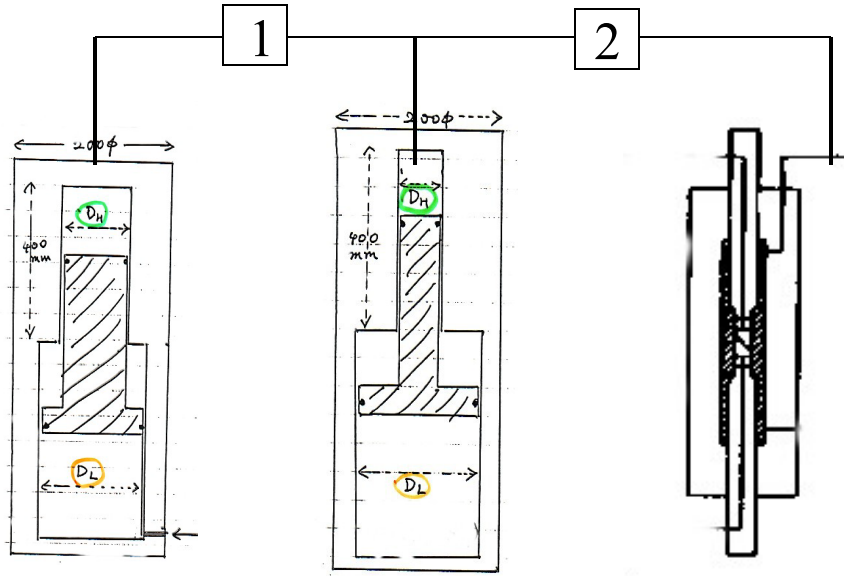
Pressure steps

Gas bottle = 12 MPa

Total vol. = 4.425 liters

(1) Pressure generator (***PG***), 1 stroke: 4.425 *l* → 1.285 *l* (3.44 times reduction)
12 MPa →41 MPa

(2) Close 1, and raise pressure inside ***PG*** to 41 MPa [vol.: 3.14 → 0.913 *l*]
Then open 1 and raise pressure with ***PG*** [(0.913+0.785+0.5) →(0.785+0.5)]
41 MPa → 70 MPa



3.14 liters | 0.785 liters | 0.5 liters

(3) Close 1, and repeat the same with ***PG***: 70 MPa → 99 MPa

(4) Close 1, and repeat the same with ***PG***: 99 MPa → 128 MPa

(5) Then close 1, and pressurize with "Intensifier":
1.285 *l* → 0.5 *l*
(2.57 times reduction)
128 MPa → 329 MPa

Time ~ 40 minutes

Pressurization Steps with one Intensifier

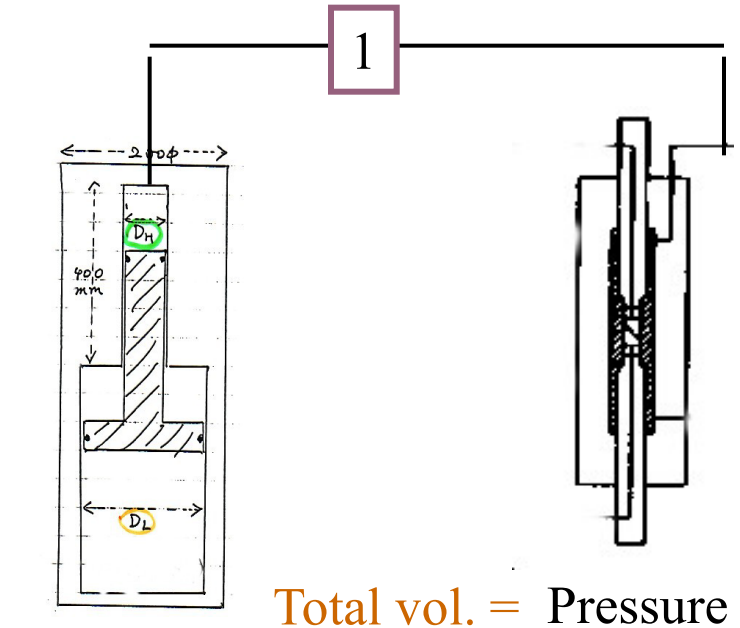
(1) Pressure generator (***PG***), 1 stroke: 2.2 *l* → 0.3 *l* (7.33 times reduction)
12 MPa →88 MPa

Gas bottle = 12 MPa

(2) Close 1, and raise pressure inside ***Intensifier*** to 88 MPa [vol.: 1.9 → 0.259 *l*]
Then open 1 and raise pressure with ***Intensifier*** [(0.259+0.3) →(0.3), 1.863 times]
88 MPa x 1.863 → 164 MPa

(3) Close 1, and repeat the same with ***Intensifier***:
164 MPa → 240 MPa

(4) Close 1, and repeat the same with ***Intensifier***:
240 MPa → 316 MPa



Intensifier

1.9 liters

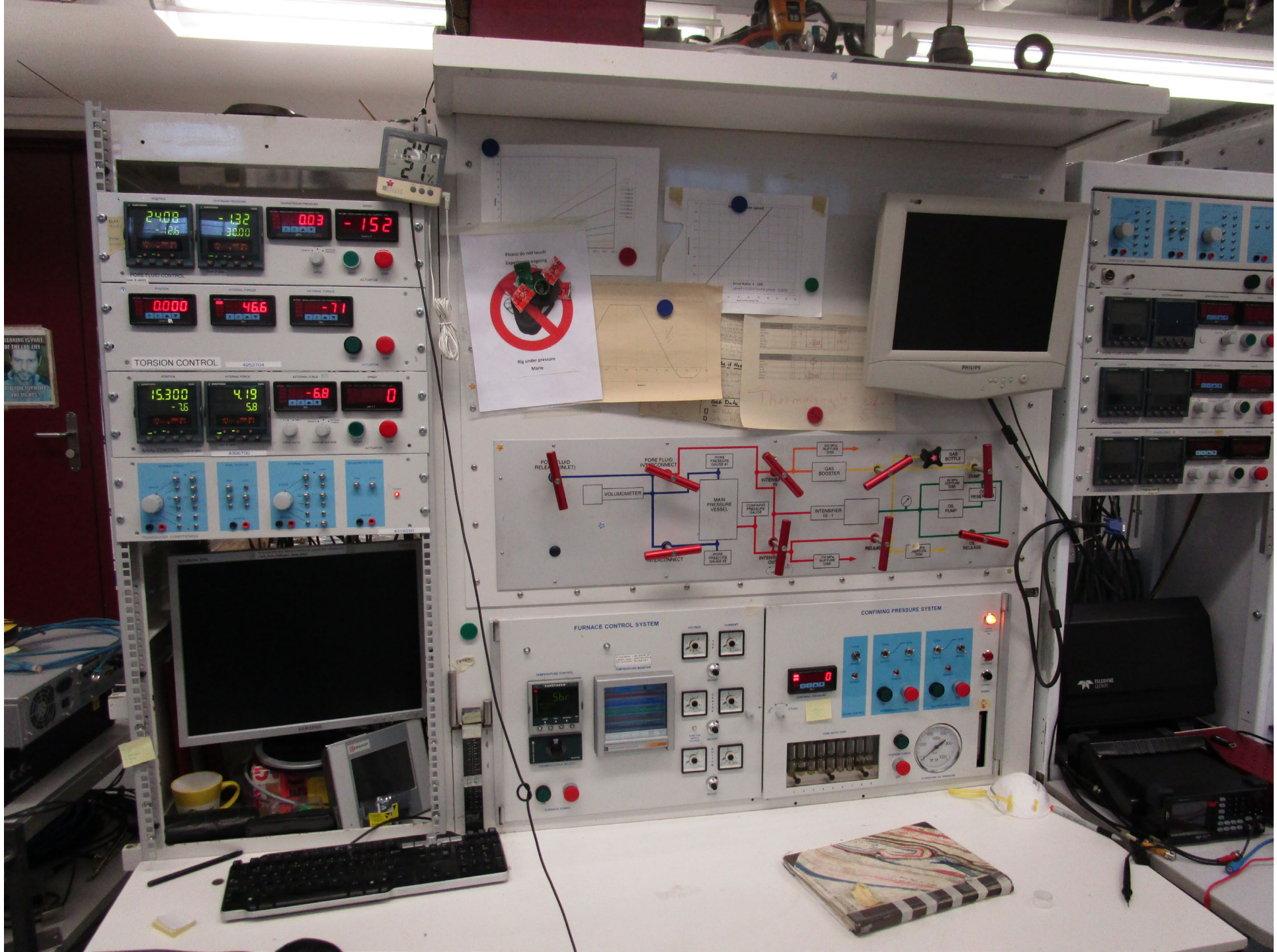
Total vol. = 2.2 liters

Pressure vessel

0.3 liters

Inner diameter = 70φ
Stroke = 500 mm, volume = 1.9 liters
Let inner volume of pressure vessel = 0.3 liter

Is intensifier vessel OK??


TORSION CONTROL
FURNACE CONTROL SYSTEM
CONFINING PRESSURE SYSTEM
VOLUMOMETER
MAIN PRESSURE VESSEL
GAS BOOSTER
INTENSIFIER 10 : 1
OIL PUMP
PHILIPS
Please do not touch
Experiment ongoing
Rig under pressure
Marie