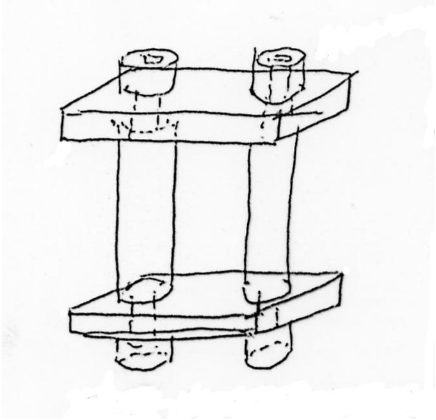
Loading system

Marie VIOLAY

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

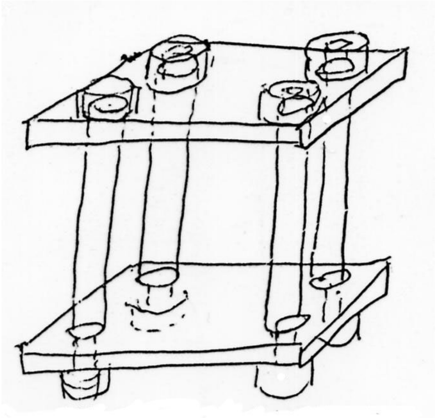
Load frame

Two column press



Cheap,
low stiffness,
and weak to
torsion

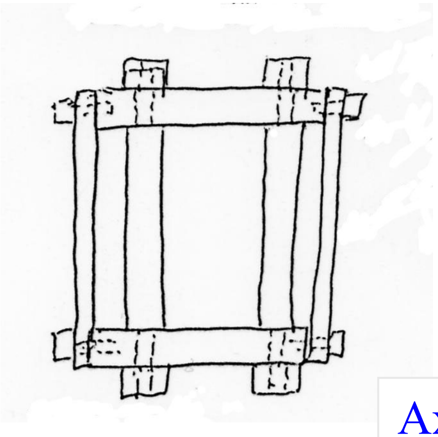
Four column press



Reasonable cost,
improved stiffness
to torsion

Biaxial machine

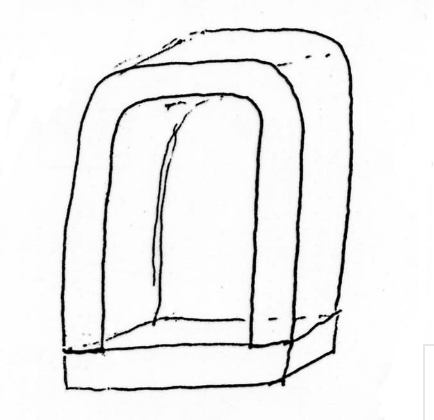
Four column press
with reinforcement plates



Reasonable cost,
Fairly high stiffness
to torsion

Axial/torsion apparatus

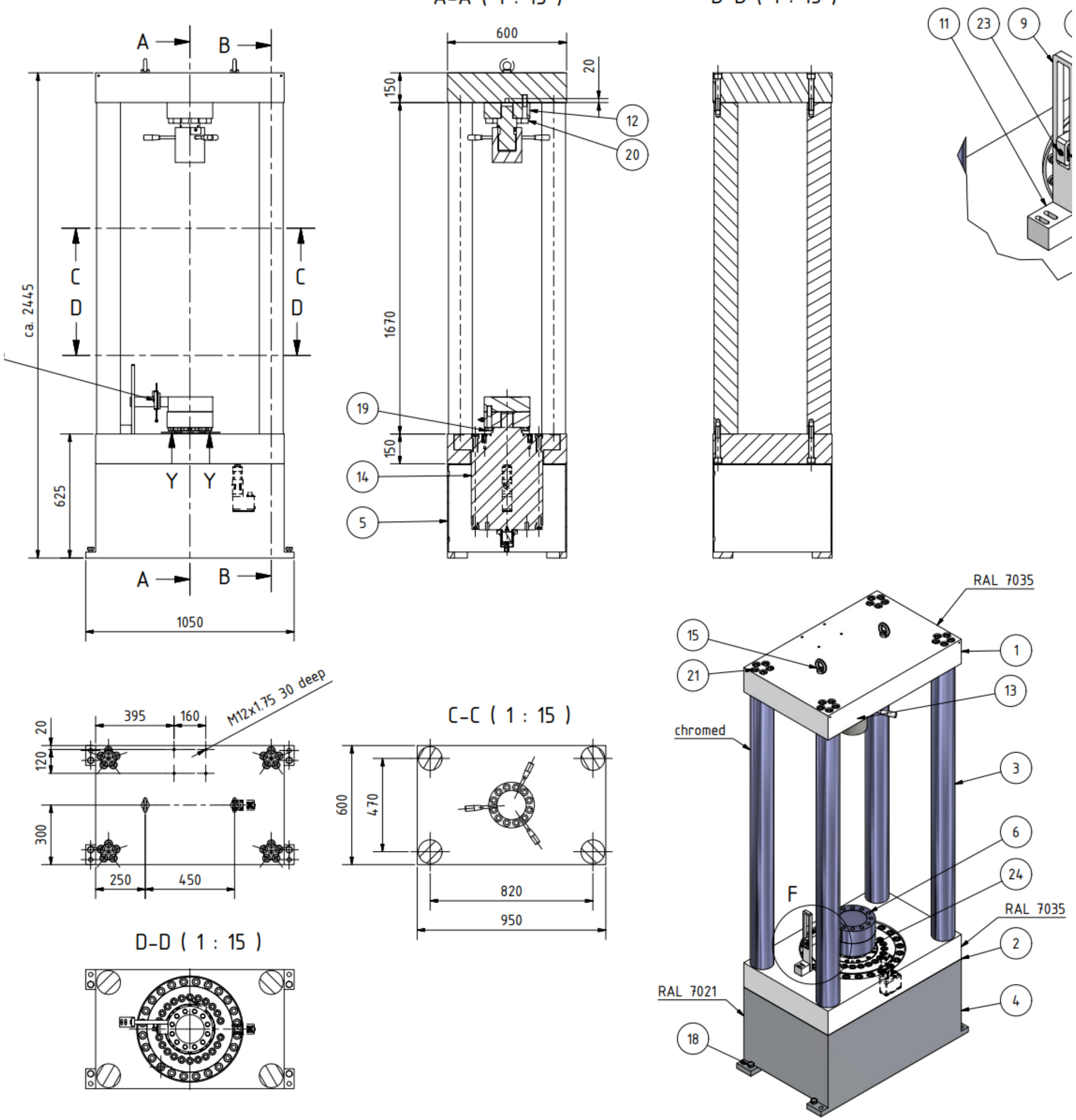
Arch-type press

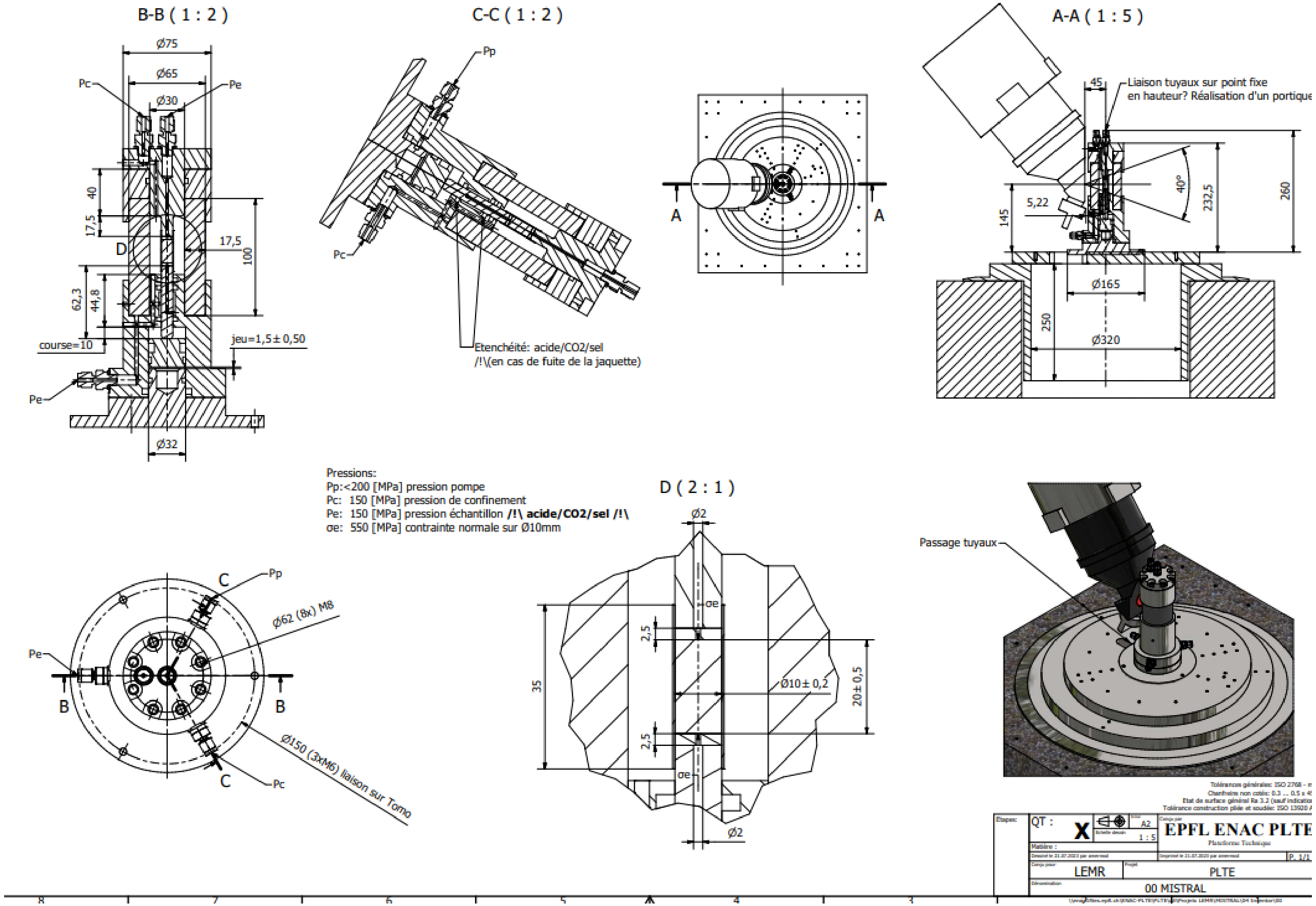


Expensive,
but stiff, and
very stiff to
torsion.

Gas apparatus

Compression uniaxiale

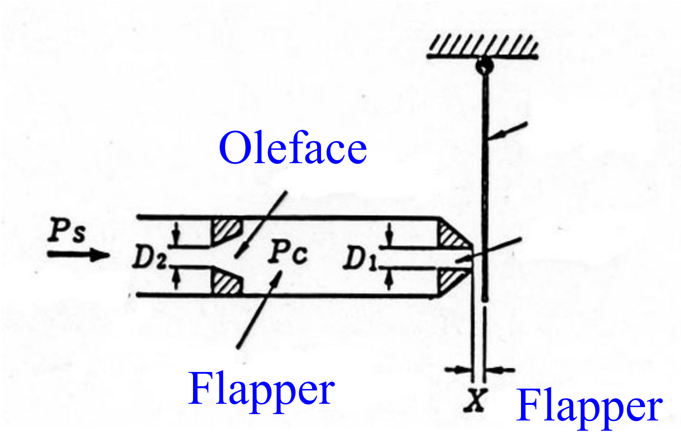

A
B
C
D
Y
ca. 2445
625
1050
600
20
150
1670
150
12
20
19
14
5
11
23
9
RAL 7035
15
21
1
13
chromed
3
6
24
F
RAL 7035
2
RAL 7021
4
18
395
160
M12x1.75 30 deep
20
120
300
250
450
C-C (1 : 15)
600
470
820
950
D-D (1 : 15)

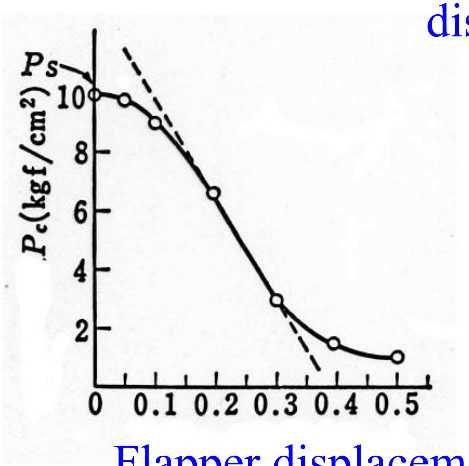


B-B (1 : 2)
Ø75
Ø65
Ø30
Pc
Pe
40
17,5
D
17,5
100
62,3
44,8
course=10
jeu=1,5 ± 0,50
Pe
Ø32
C-C (1 : 2)
Pp
Pc
Etenchéité: acide/CO2/sel
/!\(en cas de fuite de la jaquette)
A
A
A-A (1 : 5)
45
Liaison tuyaux sur point fixe
en hauteur? Réalisation d'un portique
40°
5,22
145
232,5
260
Ø165
250
Ø320
Pressions:
Pp:<200 [MPa] pression pompe
Pc: 150 [MPa] pression de confinement
Pe: 150 [MPa] pression échantillon /!\ acide/CO2/sel /!\
σe: 550 [MPa] contrainte normale sur Ø10mm
D (2 : 1)
Ø2
σe
2,5
35
Ø10 ± 0,2
20 ± 0,5
2,5
σe
Ø2
C
Pp
Ø62 (8x) M8
Pe
B
B
C
Pc
Ø150 (3xM6) liaison sur Tomo
Passage tuyaux
QT :
X
A2
1 : 5
EPFL ENAC PLTE
Plateforme Technique
LEMR
PLTE
00 MISTRAL

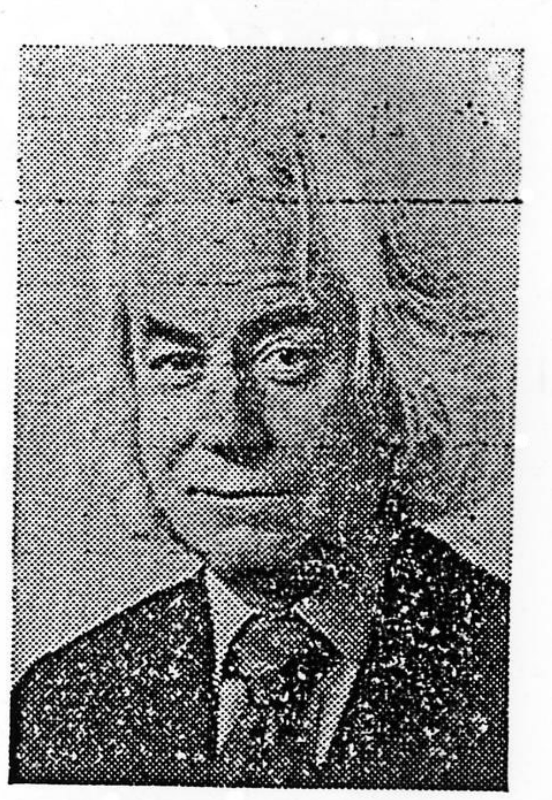
Principle of Servo-valve Operation

The system is very expensive, but quick and arbitrary control is possible
A servo-controlled system.





By reducing x, flapper pressure increases.



Willam C.Moog

He invented nozzle-flapper-type servo-valve in 1947.

Principle of Servo Valves

A servo valve is an electro-hydraulic control device that precisely regulates fluid flow and pressure to control the movement of hydraulic actuators such as cylinders or motors.

Key Components:

- •Torque motor: Converts electrical signals into mechanical motion
- •Nozzle-flapper or jet-pipe system: Controls hydraulic pressure
- •Spool valve: Adjusts fluid flow direction and volume
- •Position feedback system: Ensures precise closed-loop control

2.How It Works

1.Input Signal: An electrical signal (voltage or current) is sent to the servo valve

2.Electromechanical Conversion: The torque motor moves a small mechanical component like a flapper or jet-pipe, influencing hydraulic pressure

3.Spool Movement: The pressure change moves the spool, which adjusts the hydraulic fluid flow to the actuator

4.Actuator Response: The actuator moves accordingly, and a feedback sensor corrects errors to maintain precise control

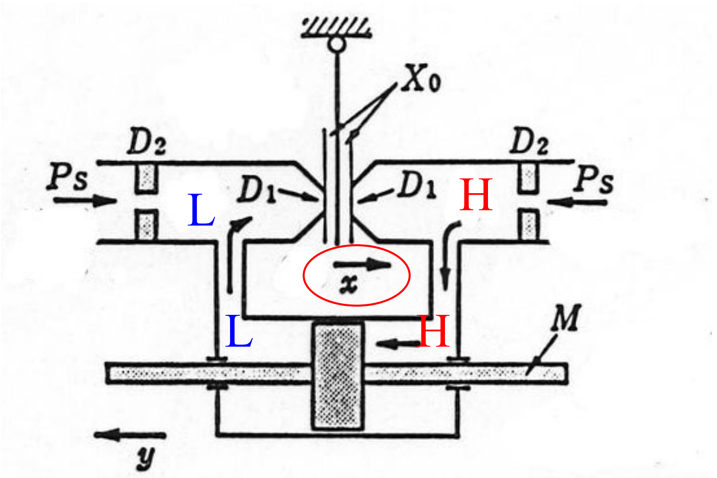
Closed-loop feedback ensures accuracy and stability

3.Advantages of Servo Valves

- •High precision: Controls small position and force changes
- •Fast response: Ideal for dynamic applications
- •Smooth operation: Reduces mechanical wear
- •Closed-loop feedback: Automatically corrects errors

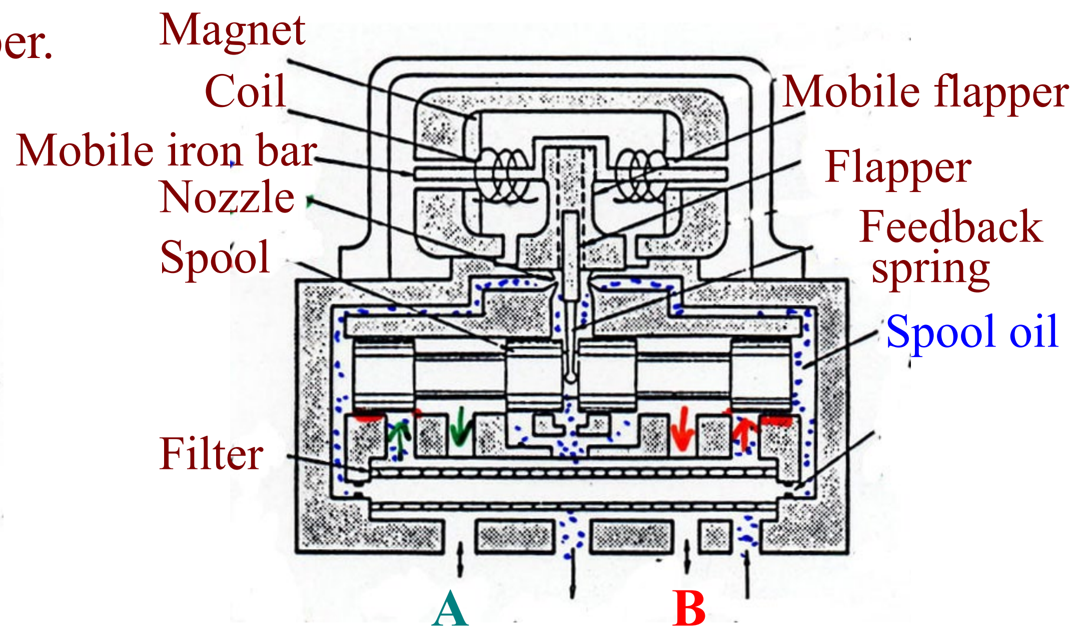
How a Servo-valve Operates?

Move heavy spool hydraulically
with a pair of nozzle-flapper,
by changing the position of flapper.



(1) If the flapper moves to the right, spool will move to the left, and vice-versa.
(2) Flapper can be operated very quickly electromagnetically.

Perfect combination of electromagetic and hydraulic powers!

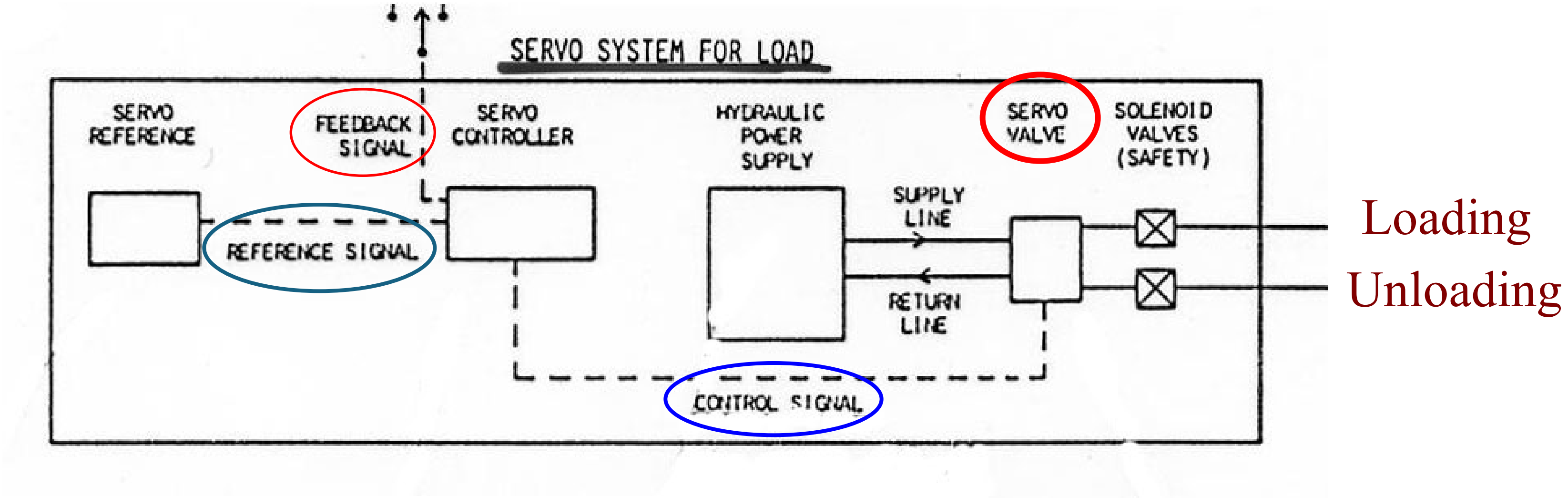


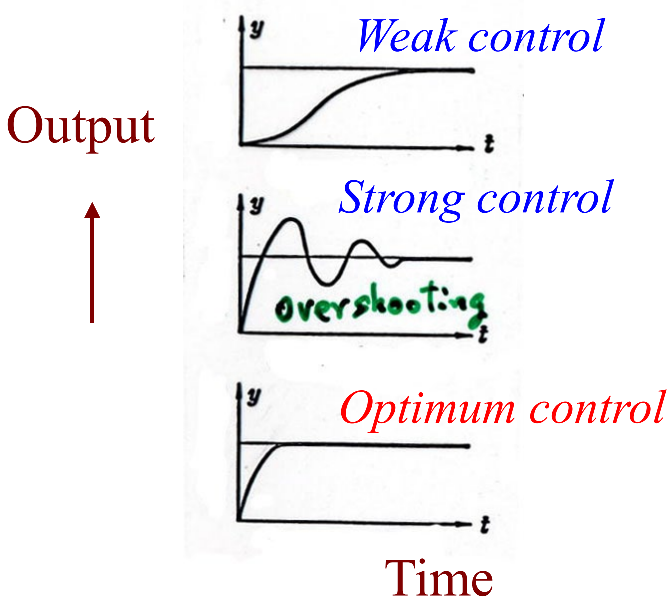
Electromagnetic force moves flapper by lever and Its displacement is determined by the balance in electromagnetic and spring forces.

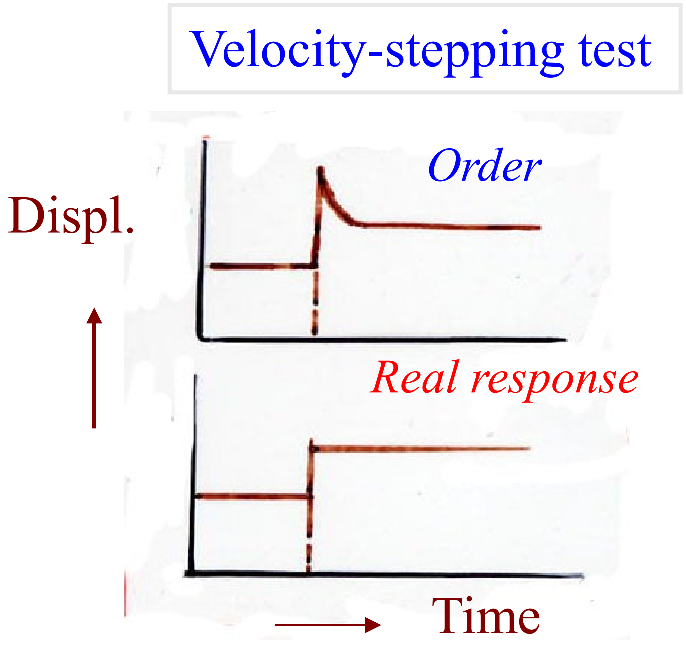
Flatter/right→ spool/left→ oil/port A

Flatter/left→ spool/fight→ oil/port B

Servo-controlled System







A Simple Story to Understand Regulation Principles

Imagine Driving on the Highway

You’re driving on the highway and want to maintain a steady speed of **120 km/h**. In practice, this isn’t too difficult. But how does your brain intuitively regulate your speed?

Rule 1: Proportional Action

The most natural thing you do when trying to reach a target speed is:

👉 **"The slower I am compared to my target speed, the more I press the accelerator."**

This means that the pressure on the accelerator is proportional to the error, i.e., the difference between your actual speed and your desired speed.

✅ **Example:**

- If you're only going **50 km/h**, you press hard on the accelerator.
- Your speed increases rapidly. Once you reach **130 km/h**, you ease off the pedal.
- Due to inertia, your speed overshoots slightly.
- You then slow down, drop below **120 km/h**, and press the accelerator again.

💡 **Problem:** With only proportional control, you end up stabilizing at a speed slightly below the target, say **110 km/h**.

A Simple Story to Understand Regulation Principles

Rule 2: Integral Action
At this point, you think:
👉 **"I'm not quite reaching 130 km/h. I need an extra rule!"**
So, you decide that if your speed remains too low for too long, you will **increase acceleration gradually over time**.
✅ **Example:**
- At **110 km/h**, you keep pressing slightly harder on the pedal until you reach **130 km/h**.
- However, by the time you reach **130 km/h**, the accumulated error makes you **overshoot** again!
- Now you're above **130 km/h**, so you ease off the accelerator.
- This creates a cycle of **overshooting and undershooting** before eventually stabilizing.

💡 **Problem:** The system oscillates a lot before reaching stability.

A Simple Story to Understand Regulation Principles

Rule 3: Derivative Action

Now you think:

👉 **"I got to 130 km/h, but I wasn't very efficient. Can I do better?"**

So, you decide to **anticipate** speed changes:

✅ **Example:**

- If you are approaching **120 km/h quickly**, you ease off the pedal **before** reaching the target to avoid overshooting.
- If you are far from **120 km/h**, you accelerate more aggressively.
- This smoothens the ride and reduces oscillations.

🎯 **Final Result:** You quickly reach and maintain **120 km/h** with minimal fluctuations.

Understanding PID Control Actions

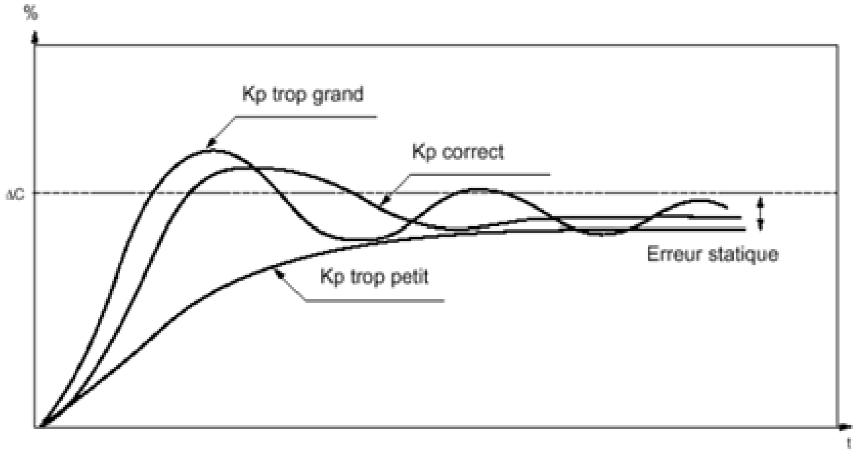
1) Proportional Action

The **proportional action** controls the **speed of response** in the system.

✅ **Effects:**

- The higher the **gain**, the faster the response.
- A higher gain reduces **static error** (in pure proportional control).
- However, excessive gain leads to **instability**.

💡 **Key Takeaway:** A balance must be found between **speed and stability**.



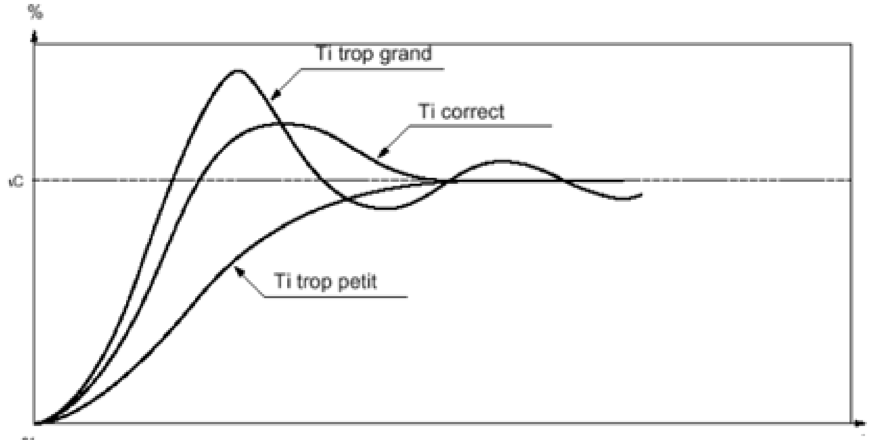
2) Integral Action

The **integral action** eliminates **static error**, ensuring the system reaches the desired setpoint.

✅ **Effects:**

- However, it also reduces stability, causing potential oscillations.
- A stronger integral action (**small TI**) speeds up the response.

💡 **Key Takeaway:** A compromise between **response time and stability** is necessary.



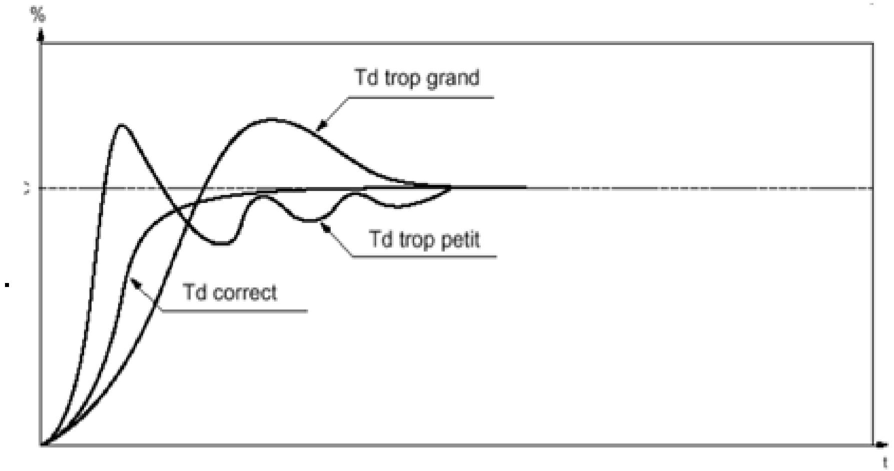
3) Derivative Action

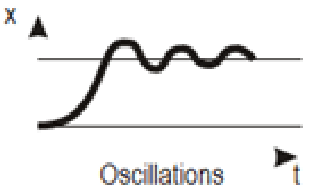
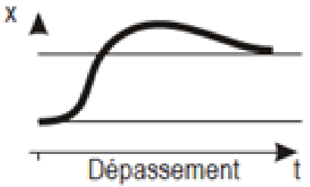
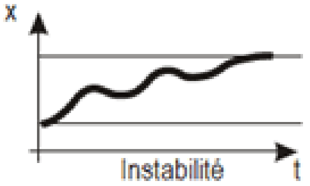
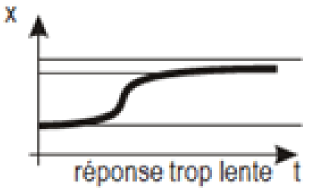
The **derivative action** acts as an anticipator by considering the **rate of change** of the error.

✅ **Effects:**

- It speeds up the response when the error grows.
- It slows the response when the error decreases, reducing overshoot.
- A high derivative action (**large Td**) increases responsiveness.

💡 **Key Takeaway:** A careful balance ensures **efficient control without excessive oscillations**.



Réponse du système	Réglage à effectuer en fonction du type			
	P	PD	PI	PID
 Oscillations	Pb↑	Pb↑ td↓	Pb↑	Pb↑ ti↑ td↓
 Dépassement	Pb↑	Pb↑ td↑	Pb↑ ti↑	Pb↑ ti↑ td↑
 Instabilité		Pb↓ td↓		Pb↓ td↓
 réponse trop lente	Pb↓	Pb↓	ti↓	Pb↓ ti↓