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Air Liquide Advanced technologies

ID : 3125316

Title : NEW COMPONENT DEVELOPMENTS FOR ELECTRIC PROPULSION SYSTEMS

Theme :

Resume :

Electric Propulsion is a major breakthrough in platform architecture, reducing dimensions and mass thus leading to different options for launchers, modifying daily operation program and orbit raising program. Electric propulsion is now used for all range of satellites, from scientific missions to telecom bus, from nano-satellites to 6 tons platforms, from one time project to constellations.
Electric propulsion uses mainly xenon as propellant; other gases like krypton may also be used. Propulsion subsystems are very conservative in their way of handling propellant and delivering it to thrusters. Air Liquide Advanced Technologies has developed a high pressure gas mass flow controller which brings a new breakthrough in propulsion subsystem design. This paper presents development status and roadmap of Electric Propulsion products at Air Liquide.

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Technologies

New component for electric propulsion

Space Propulsion Forum

Roma, 05/05/2016 I Aurélien Moureaux I SPACE BUSINESS UNIT

Mass flow regulation

Power

1 kg/s — Energy flow

Pressurisation

Keep pressure in tanks — 200g/s

Launcher — 30g/s

Control

5 g/s — Controlled cold massflow

20 mg/s — Xenon massflow

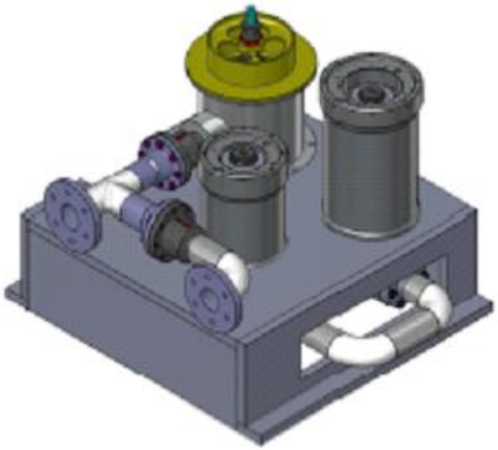
Chromatography

Chemical composition analysis — fuite

µg/s

- Whatever the gas:
  - Helium
  - Hydrogen
  - Oxygen
  - Nityrogen
  - Xenon
  - Specific Mixtures
  - ...
- From capillary ... to DN 50

Ariane – Helium Pressure regulator



- Pressure regulation on Ariane 5 EPS :
  - 2 stages mechanical pressure regulator
  - Operational temperature: de –100°C à +70°C
  - Still in production
- Developments for A5 ME & A6:
  - Full pressurization plate: regulator/relief valve/plenum/back-flow control
  - Operational temperature: de –120°C à +50°C
  - Extension based on A5 EPS pressure regulator (modified mass-flow and pressure)

Solutions – Downscale

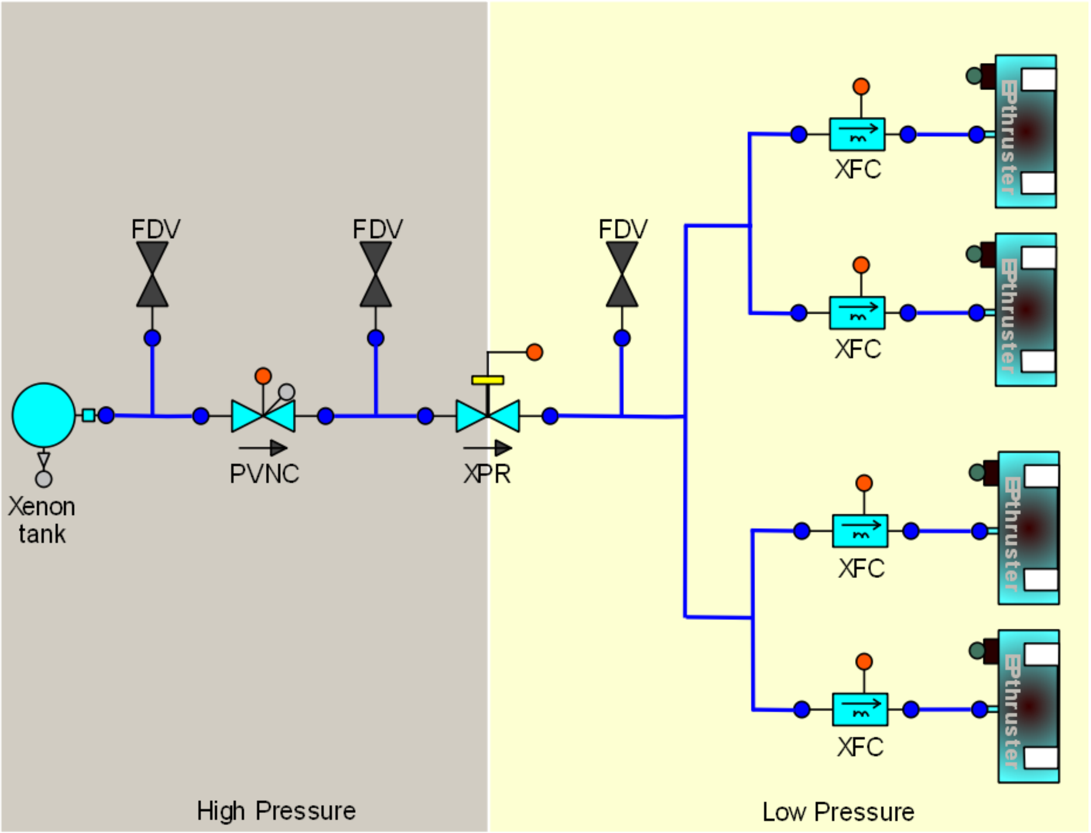
- Space products downscale

Space Development →

Mass	✓
Performances	✓
Costs / Time	✗

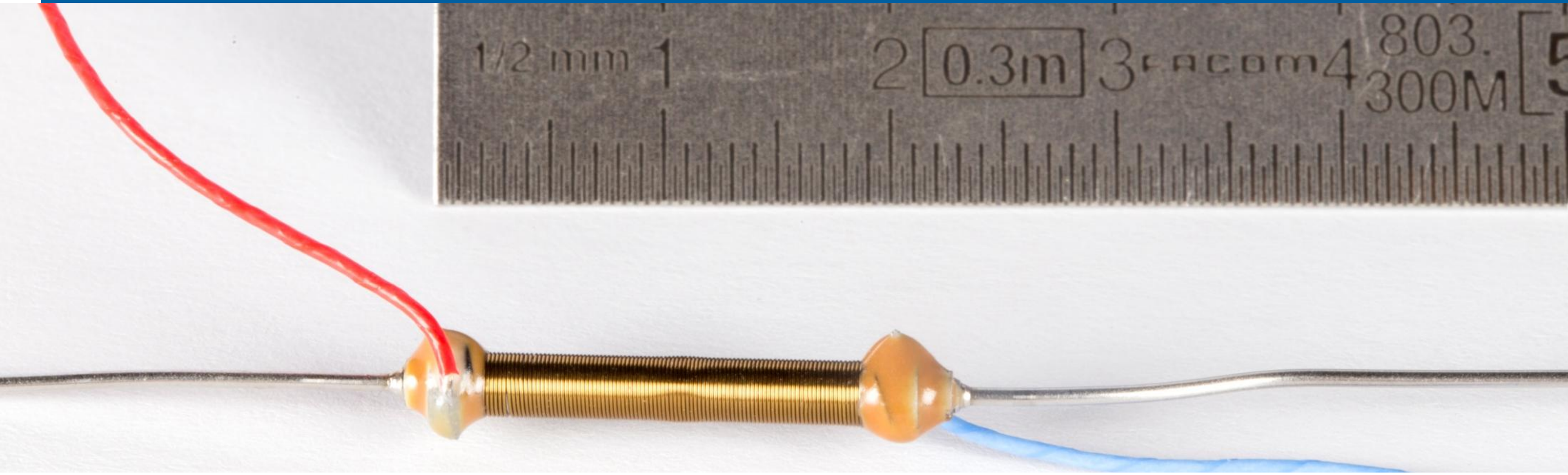
Typical Electric Propulsion System

- Pressure regulator
  - Up to 200 bar
- 4 XFC
  - Low inlet pressure 2-3 bar
  - Complex elements
  - Electronically driven
- +Filters
- +Latch valves
- +redundances...



→ Complex
→ Heavy
→ Costly

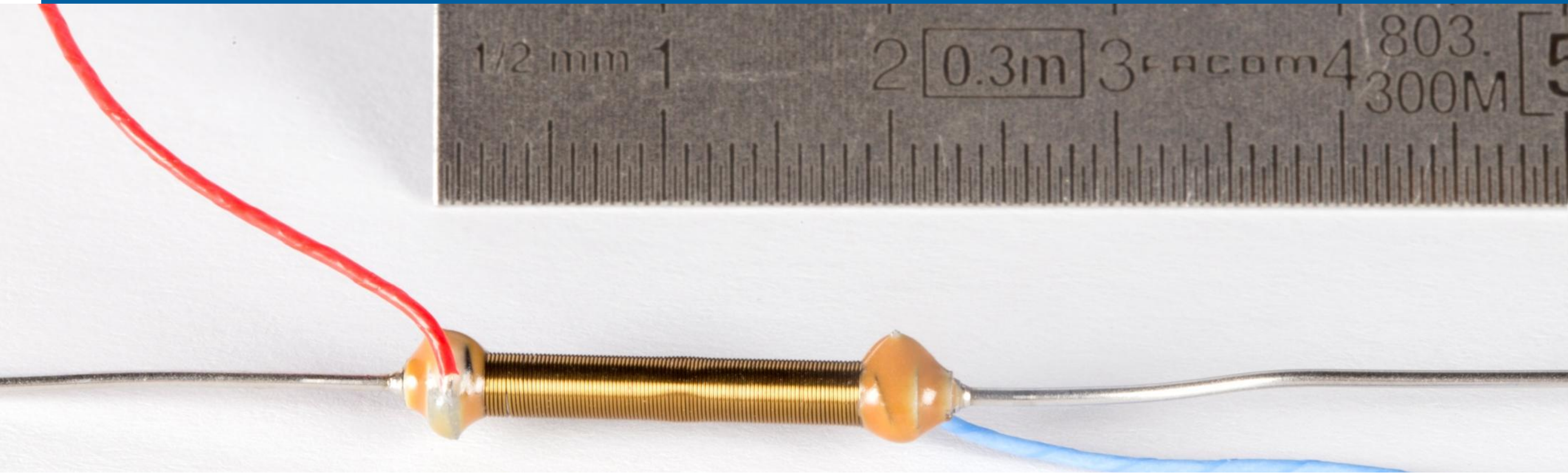
Thermally controlled Valve



- Onboard:
  - Rosetta
  - ExoMars (MOMA)
- Mass # 5g
- Electric power # 2 W

- Xenon / Krypton / N_2 / He etc.
- Inlet pressure: 5-200 bar
- Temperature range: -60/+60 °C
- Tightness < 1.10-8 mbar.l/s Ghe

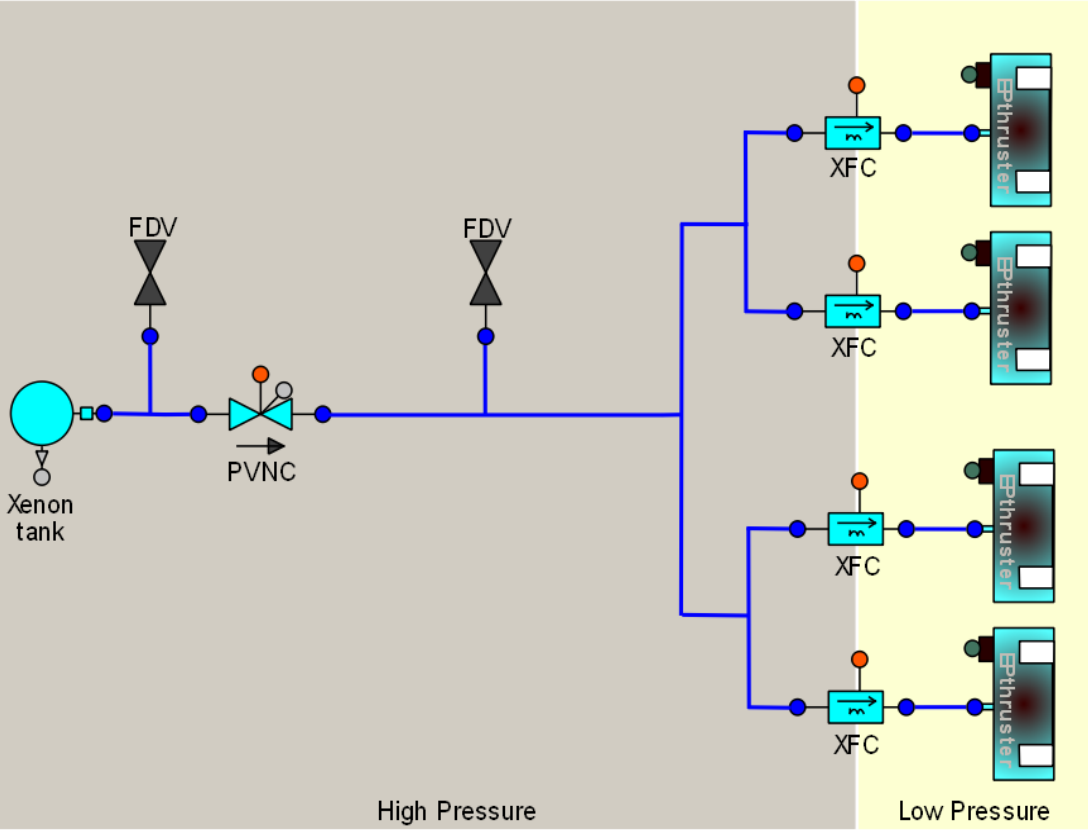
Thermally controlled Valve



- Pressure Regulation
  - Gas Chromatograph
  - Thruster
- Mass flow control
  - Thruster
    Current driving

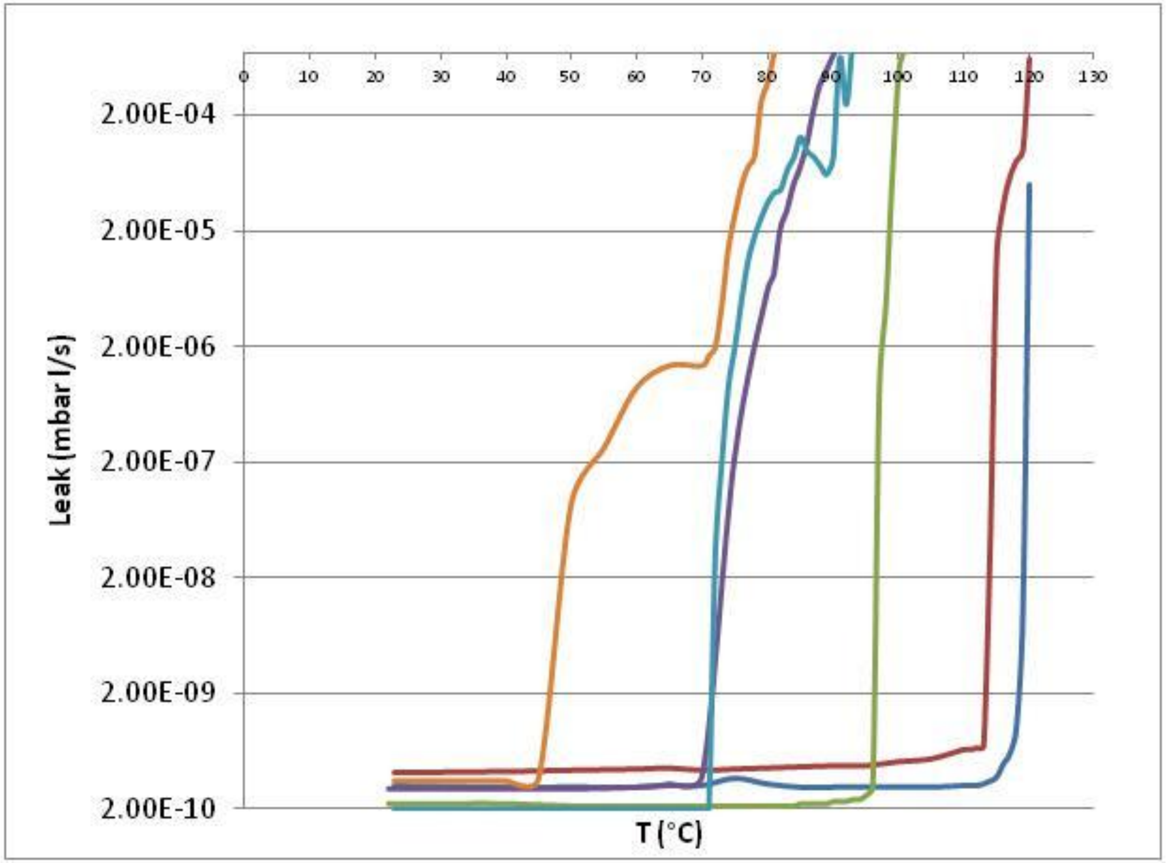
Proposed architecture

- No pressure regulator
- 4 XFC
  - High inlet pressure
  - High leak tightness
  - Electronically driven



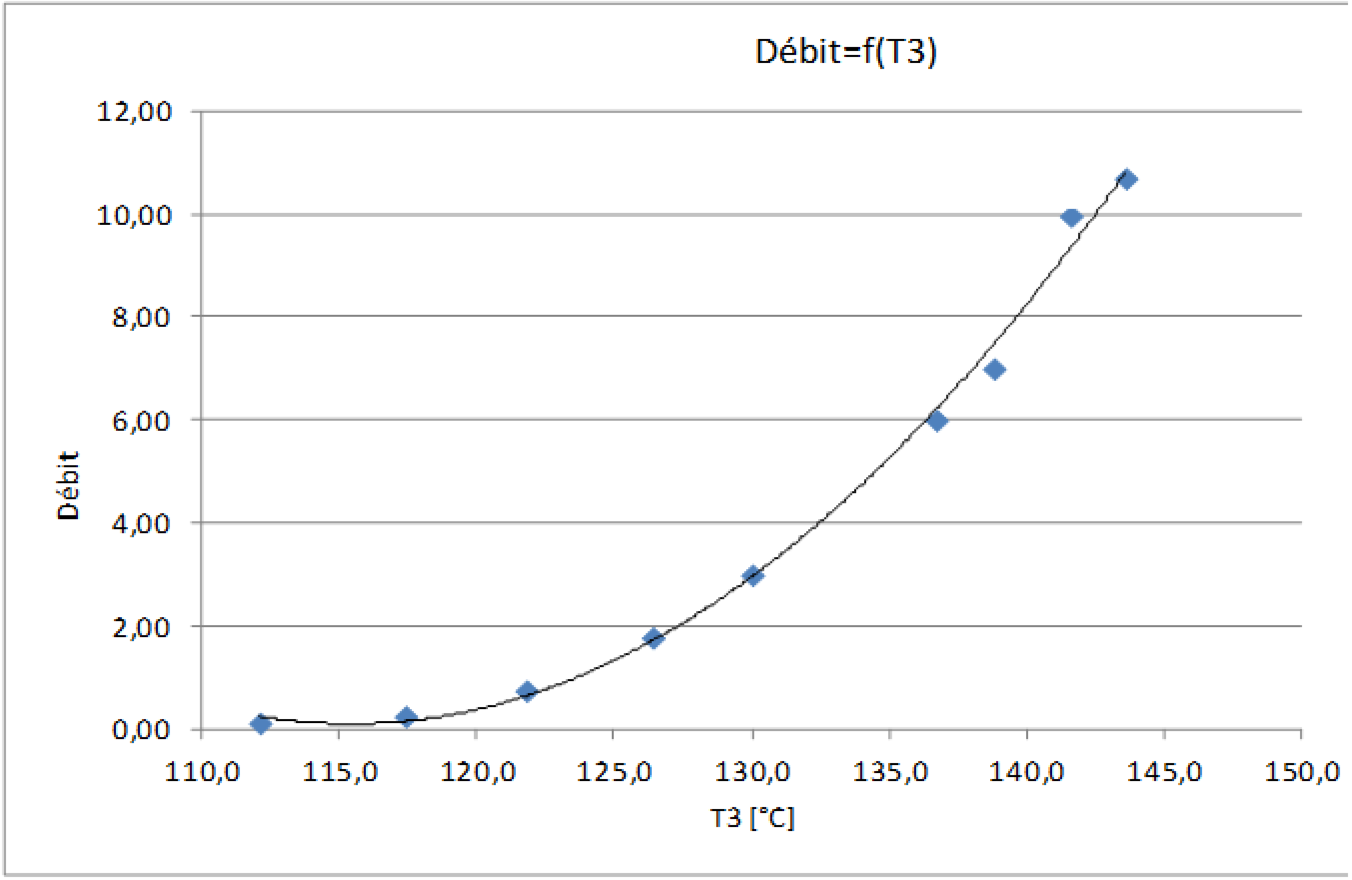
- Simpler
- Lighter
- Cost saving

Thermally controlled Valve



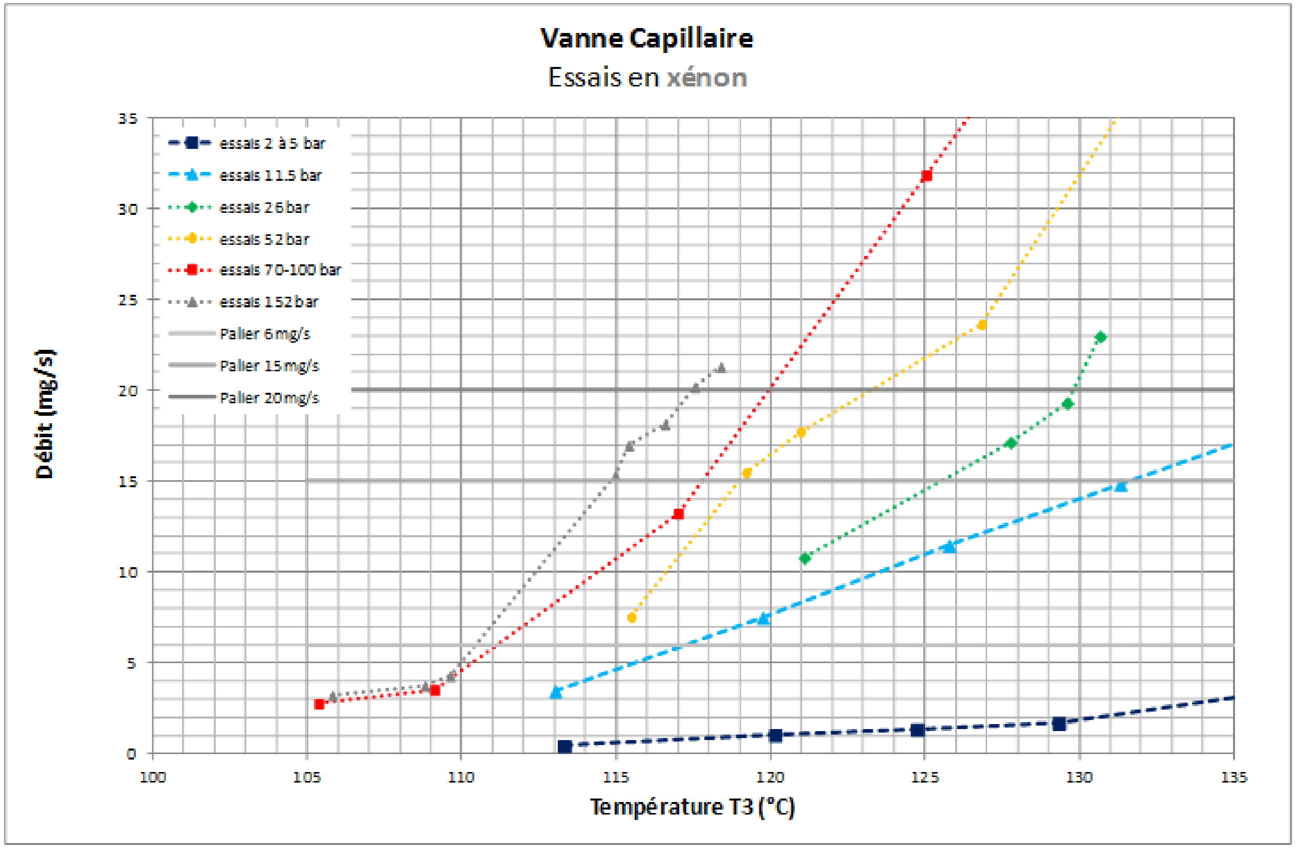
Leakage < 10^{-9} Ncc/s GHe

Thermally controlled Valve



Mass flow as a function of valve temperature
at a constant inlet pressure

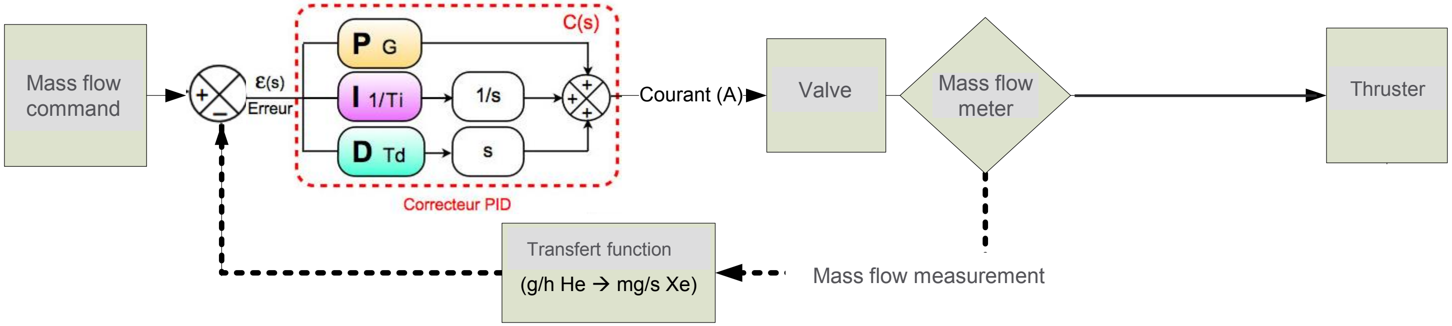
Thermally controlled Valve

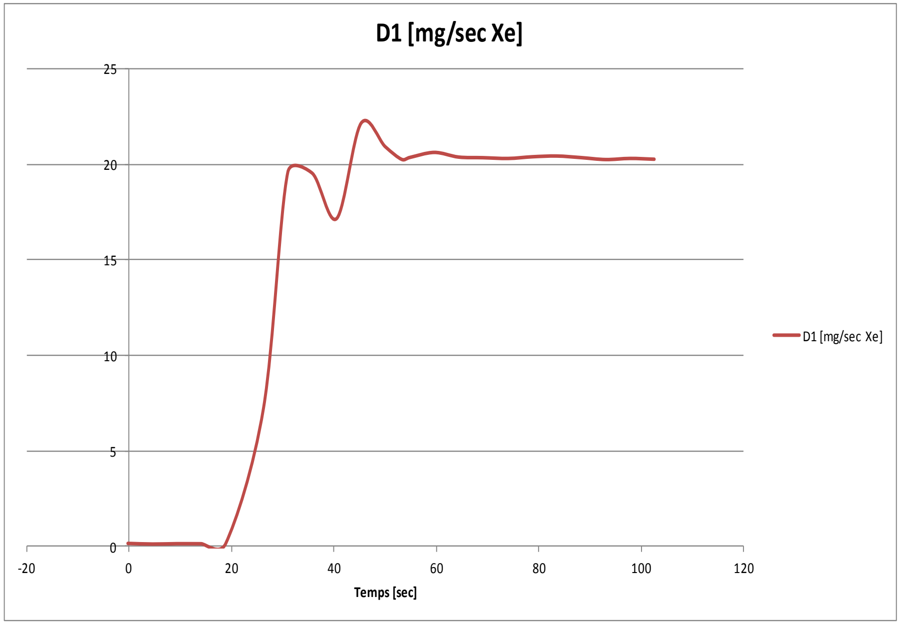


Mass flow: 0 – 20 mg/s

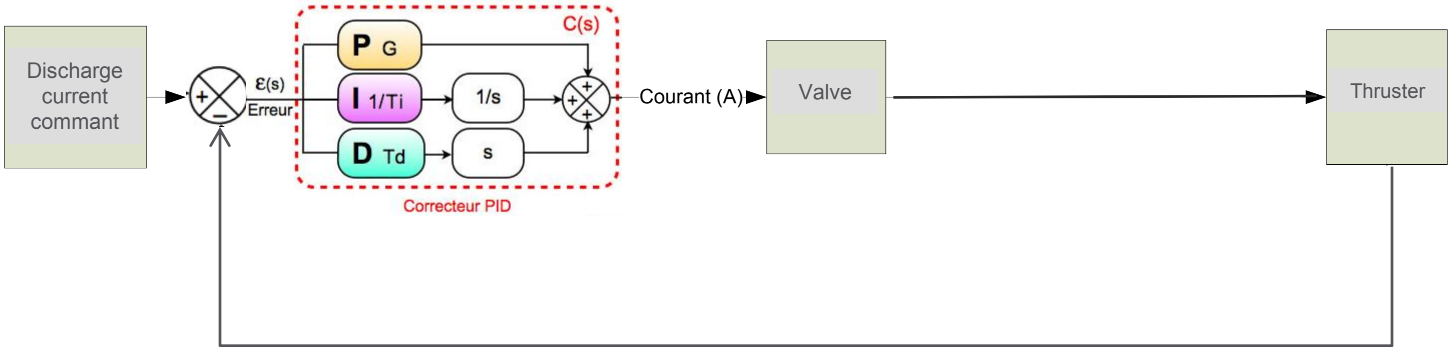
Inlet pressure: 5-150 bar

High presure inlet XFC

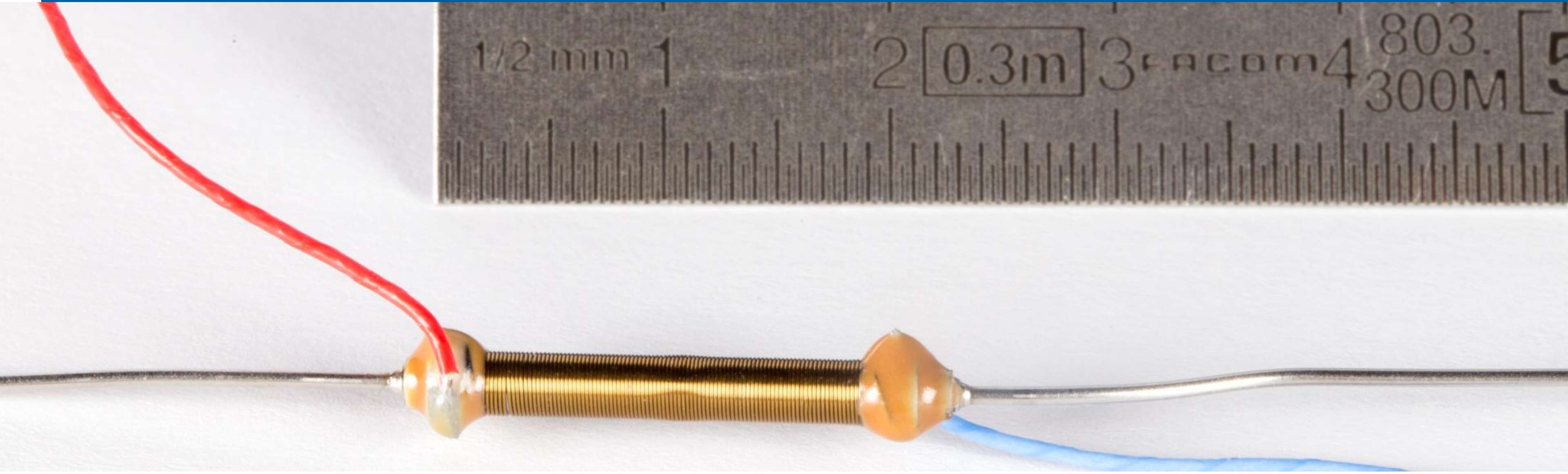




High presure inlet XFC



Thermally controlled Valve



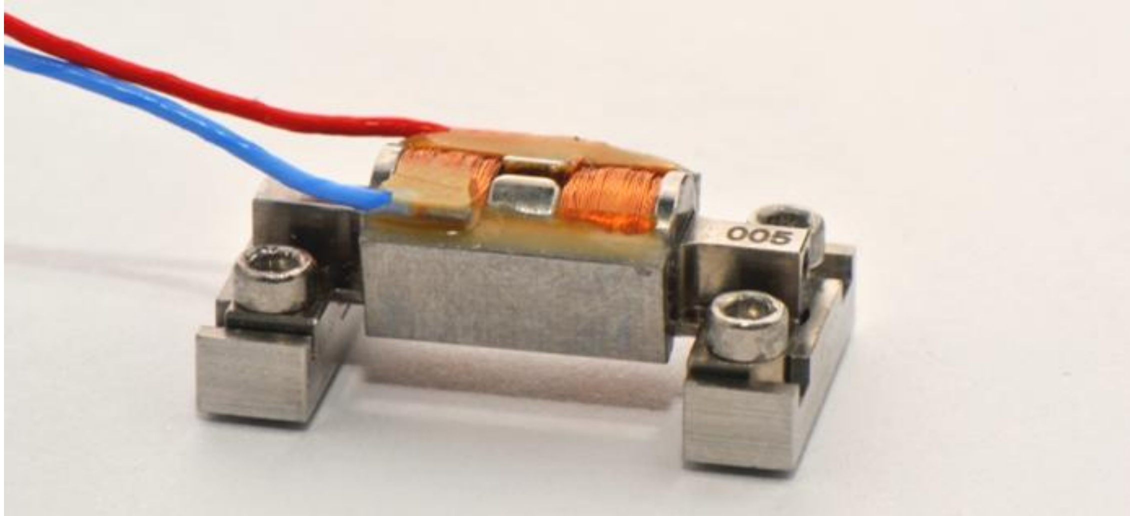
- Pressure Regulator
- Mass flow regulator

- Pulse-width modulation
- Current driving

- High Pressure
- Very good Tightness
- Xenon / Krypton
- Helium
- N_2

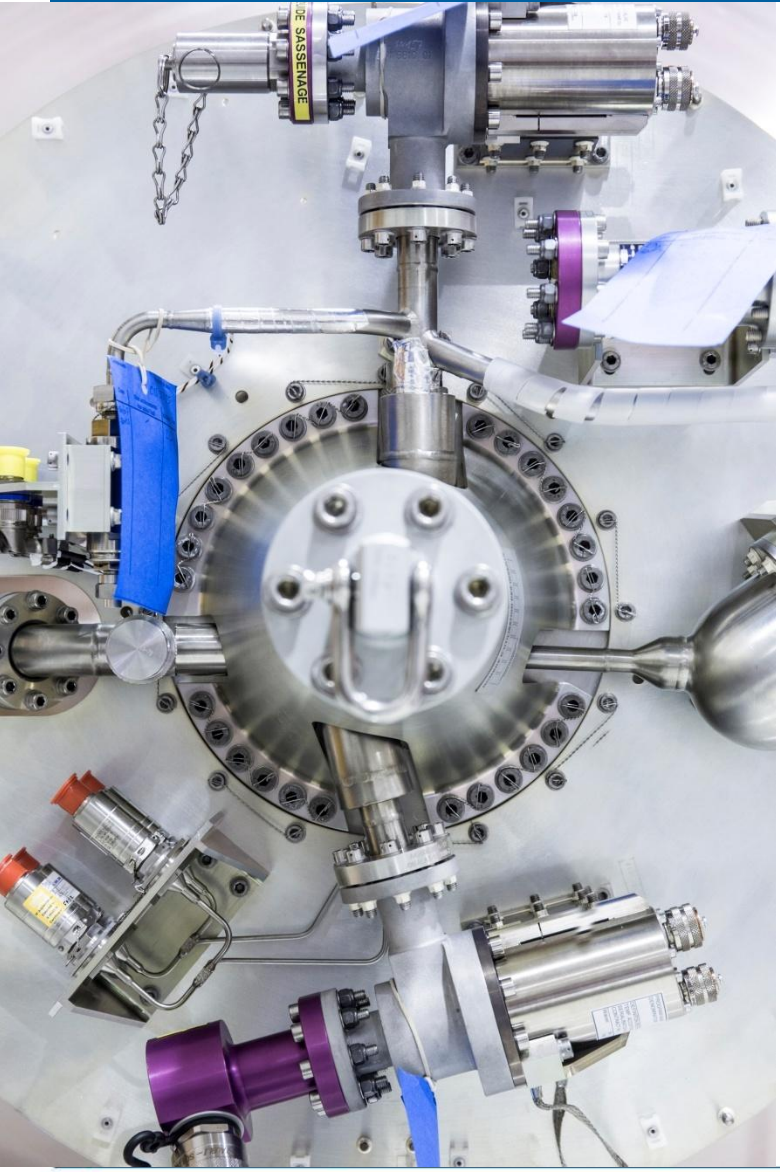
Micro Latched Valve

Magnetic Bi-stable
Latch Valve



Inlet pressure	5 bar
Mass	< 5 grams
Size	10mm x 10mm x 20mm
Power	5 W
Opening time	< 100 ms
Leakage	$<1.10^{-5}$ Ncc (GHe)
Number of cycles	10 000

Conclusion



- Components qualified in Helium
- Onboard ExoMars 2018

- Electronic regulation
  - Any mass flow within the range

- Examples of use:
  - Gas Chromatograph
  - Electric Propulsion
  - Inflatable structures
  - Cold Gas Propulsion

- Firings with thrusters (2016)

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End of presentation
Thank you for your attention