A High-Purity Gas Supply and Purification System for Cluster-Jet and Pellet Target(s)

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Requirements Cluster-Jet Target

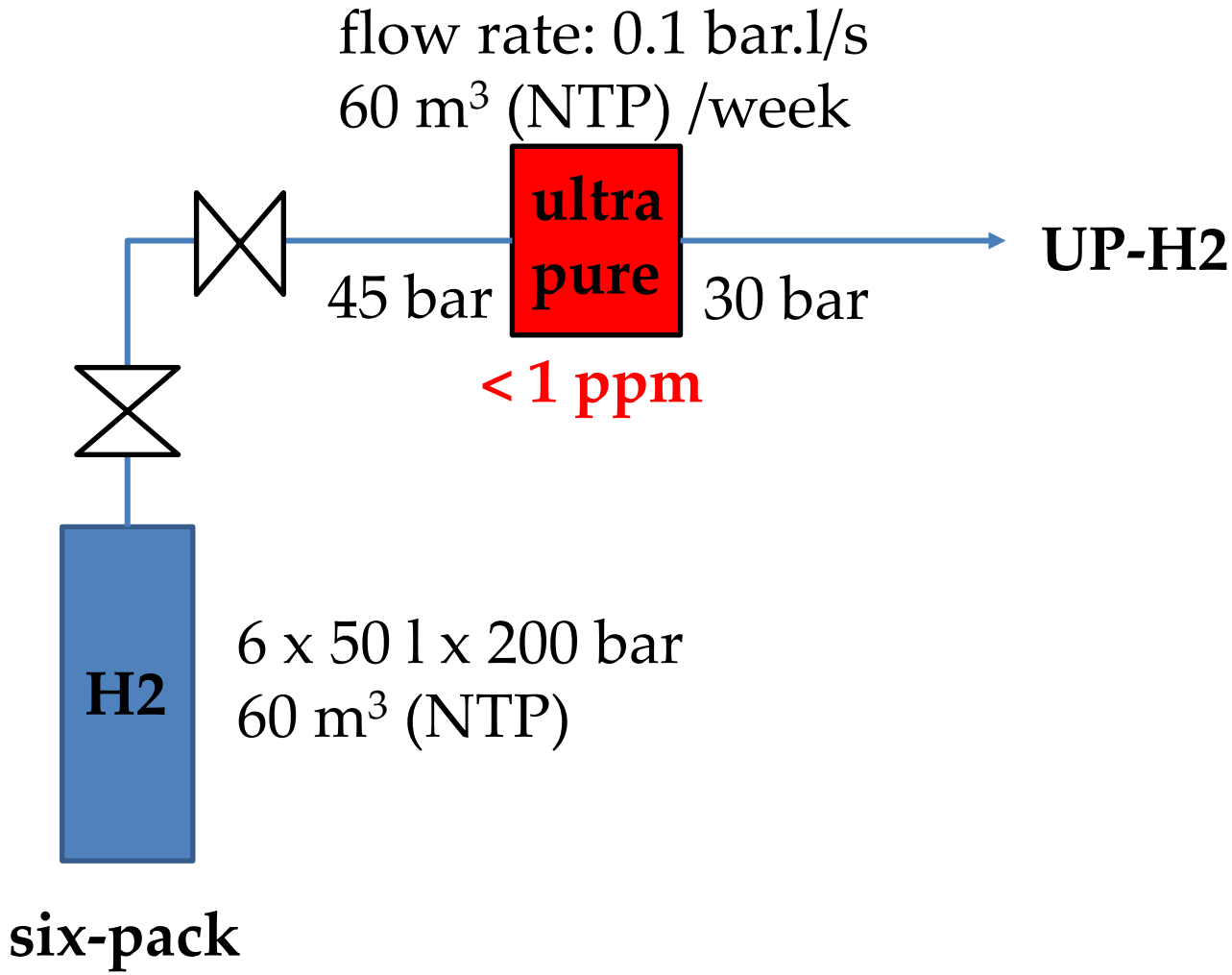
- High flow rate: ~ 0.1 bar.l/s [10 Pa.m^3/s]

  $\rightarrow$ 0.2 bar.l/s

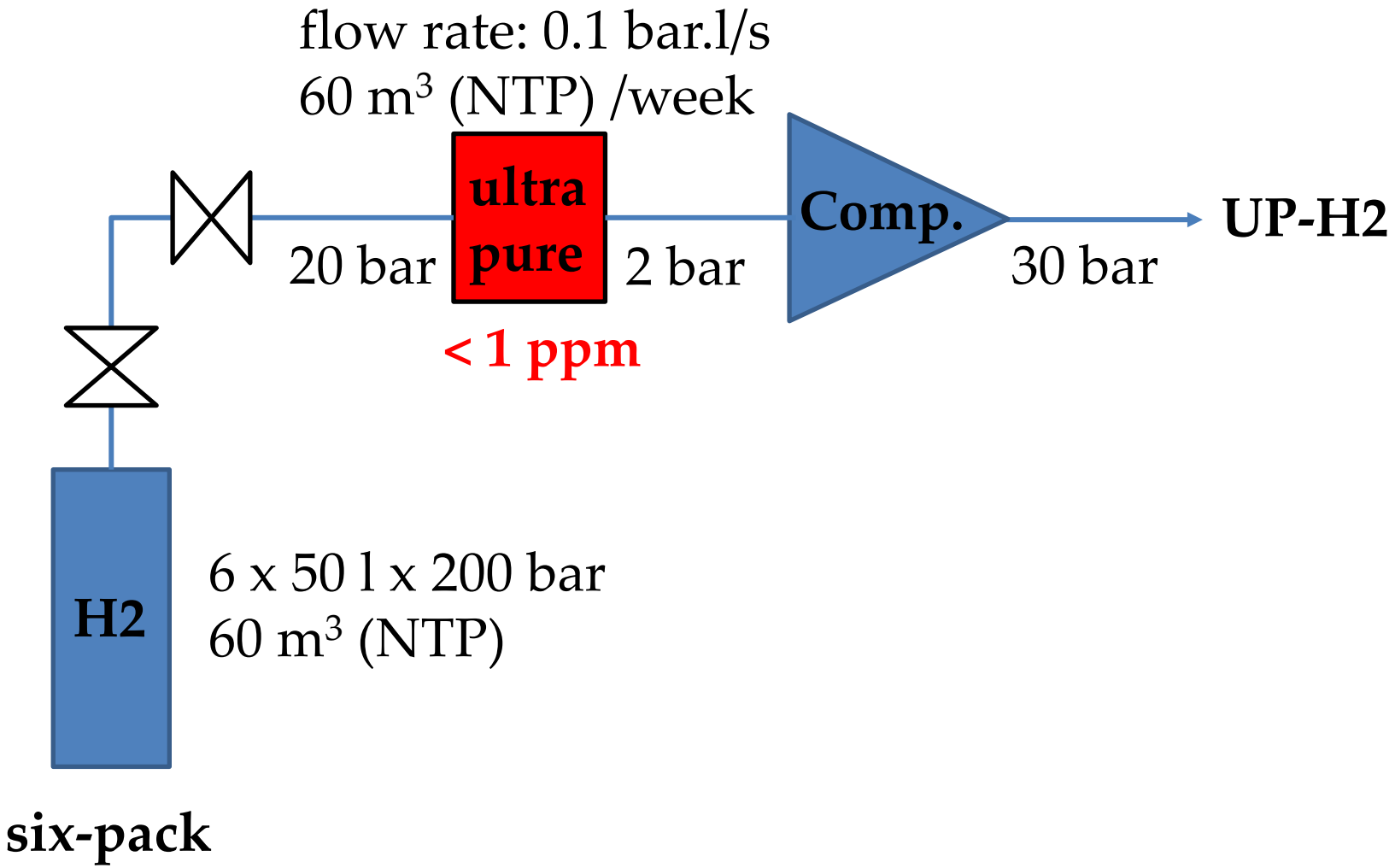
- High purity: < 0.1 ppm

- High pressure: ~ 30 bar [3 MPa]

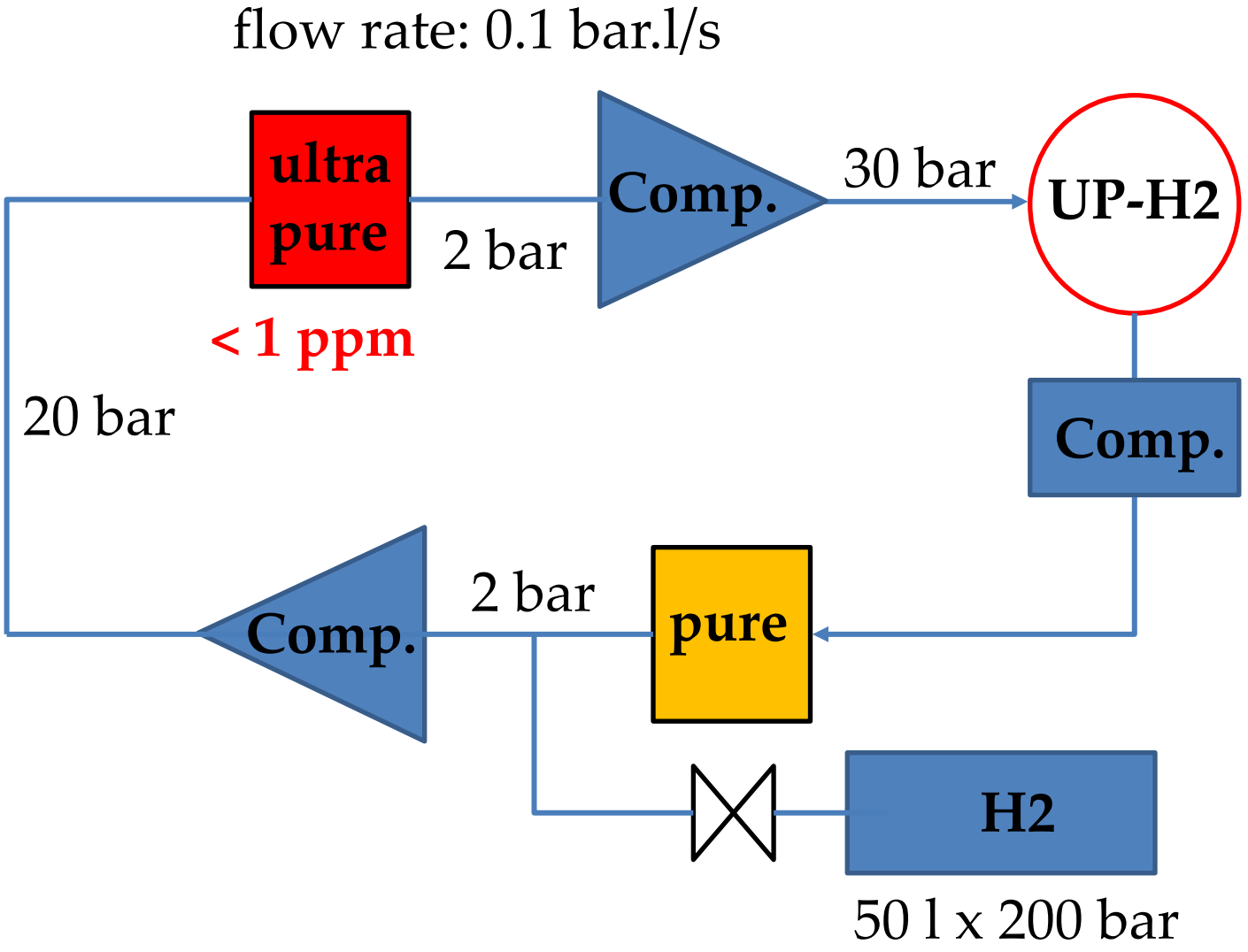
Scenario I


flow rate: 0.1 bar.l/s
60 m³ (NTP) /week
ultra pure
45 bar
30 bar
UP-H2
< 1 ppm
H2
6 x 50 l x 200 bar
60 m³ (NTP)
six-pack

Scenario Ia


flow rate: 0.1 bar.l/s
60 m³ (NTP) /week
ultra pure
Comp.
UP-H2
20 bar
2 bar
30 bar
< 1 ppm
H2
6 x 50 l x 200 bar
60 m³ (NTP)
six-pack

Scenario II - closed hydrogen cycle



Hydrogen purification system

Palladium purifier - theory of operation

Palladium (Pd) membrane purifiers operate on the principle of diffusion:

- The Pd membrane absorbs hydrogen molecules onto its surface, where each hydrogen molecule dissociates into two hydrogen atoms.
- Each hydrogen atom loses its electron to the Pd alloy and diffuses through the Pd metal lattice as a proton.
- The protons recombine with two electrons on the far side of the lattice to form a hydrogen molecule that is desorbed from the Pd alloy membrane.

The partial pressure of hydrogen on each side of the palladium membrane determines the direction and flow rate of hydrogen across the membrane:

- typical temperatures for the diffusion process are about 300° - 350°C
- Typical pressure difference about 1.0 to 1.5 MPa.

For leak-free purifier membrane, the total concentration of impurities has been shown to be less than 1 ppb.

Advantage of Pd-membrane technology

- solid barrier with no breakthrough

Catalytic purifiers will allow hydrogen and impurities to flow through the purifier, while the palladium alloy is a solid barrier to all contaminants.

Catalytic purifiers may under some conditions (flow rate, temperature, vessel orientation) desorb impurities, resulting in breakthrough.

Disadvantage of Pd-membrane

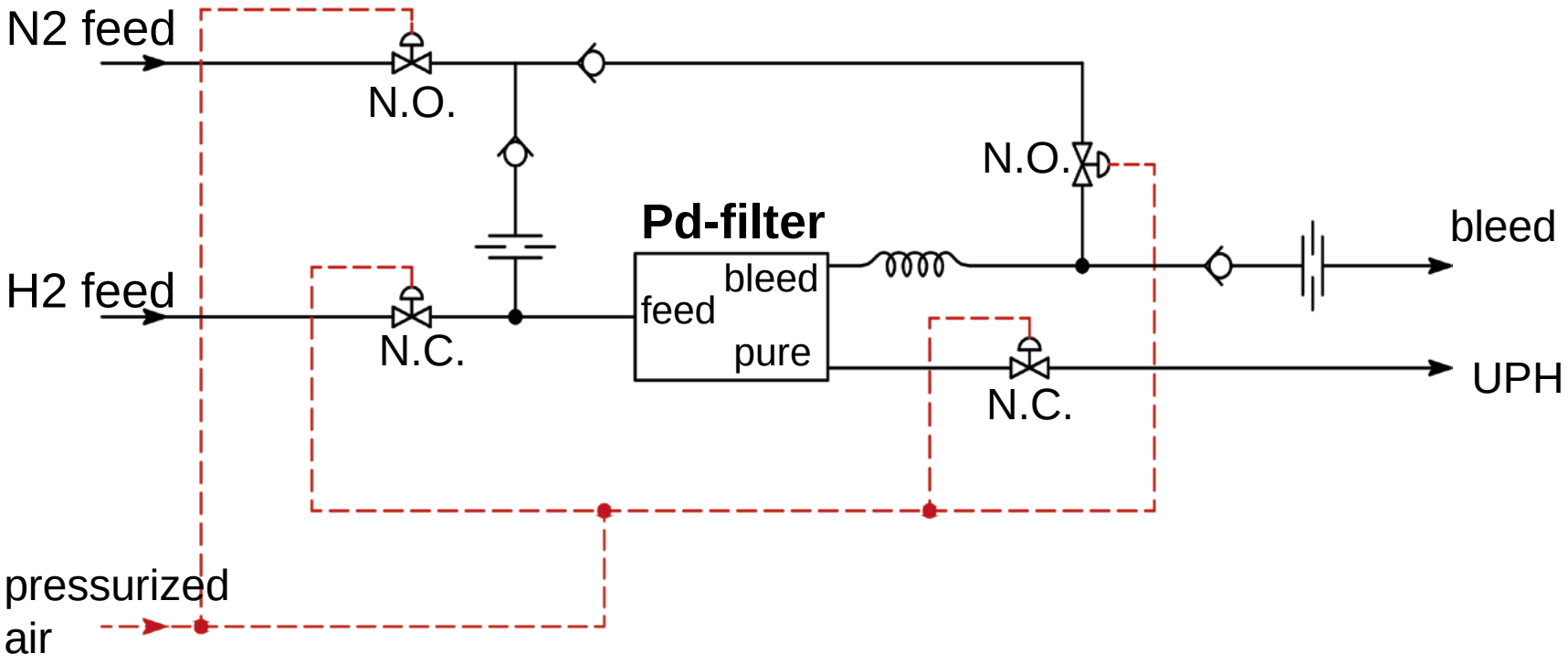
- membranes can crack

  Pd-membrane purifiers can crack when the cell is repeatedly allowed to cool (i.e., from power failure) in presence of hydrogen

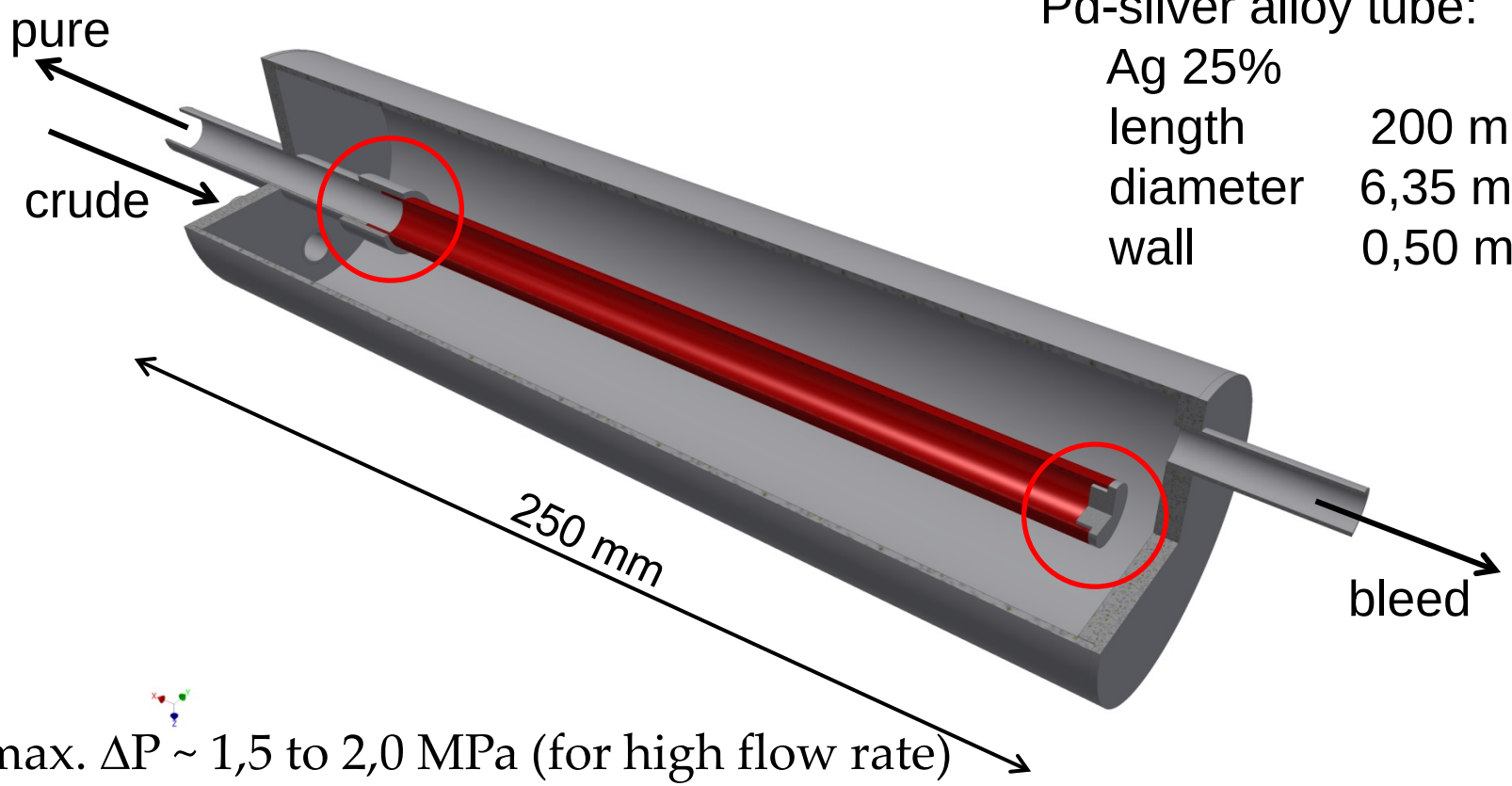
- solution

  A control system has to protect the membrane by removing most of the hydrogen automatically (within minutes); e.g. replacing the hydrogen with non-reactive nitrogen

Hydrogen purifier control circuit



Pd-tube test cell



Pd-silver alloy tube:

Ag 25%

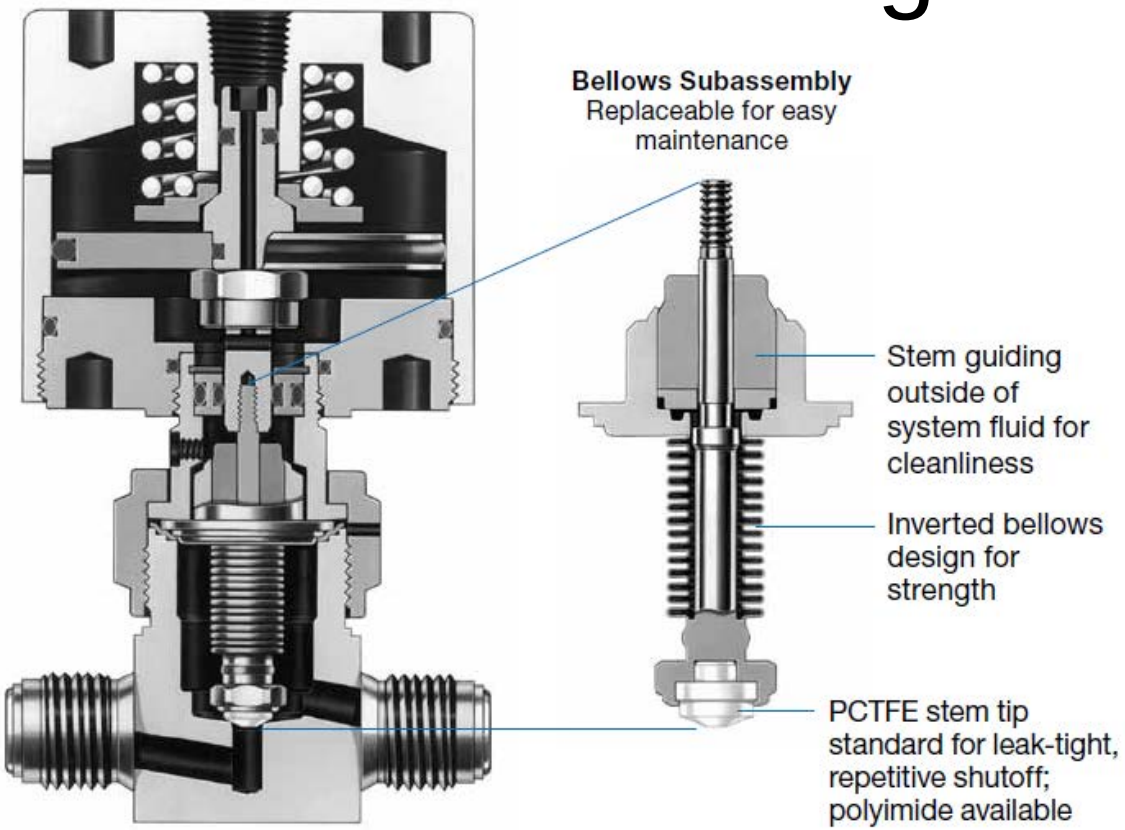
length	200 mm
diameter	6,35 mm
wall	0,50 mm

max. ΔP ~ 1,5 to 2,0 MPa (for high flow rate)
max. temperature 350°C

- total pressure 5,0 MPa
  for output pressure of 3,0 MPa

Valves, fittings, material selection

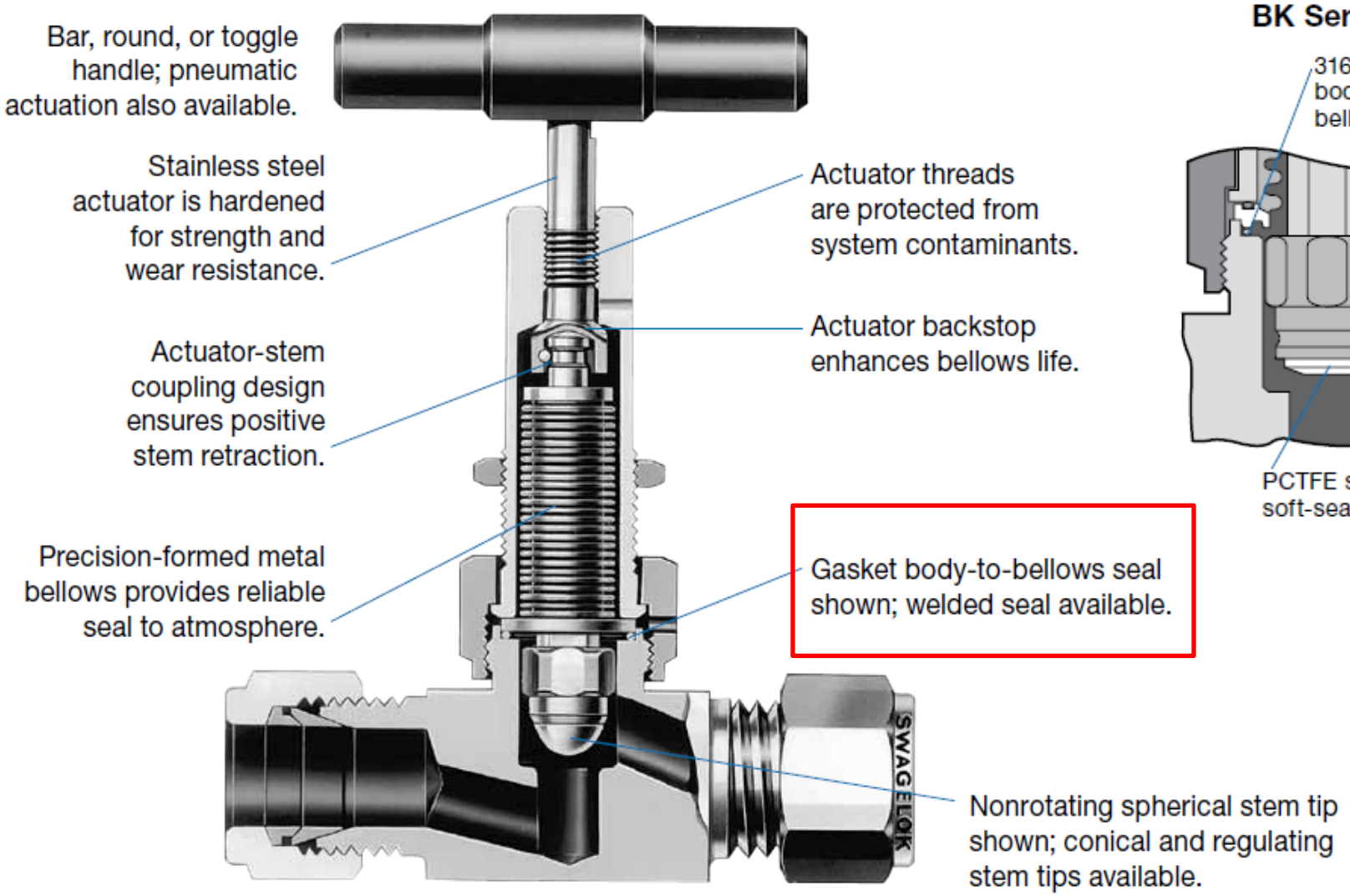
Swagelok



HB Series

- Packless valves with all-metal seal to atmosphere
- Working pressures up to 3500 psig (241 bar)
- Temperatures up to 400°F (204°C)
- VCR® face seal fitting, Swagelok® tube fitting, and weld end connections

Swagelok


Bar, round, or toggle handle; pneumatic actuation also available.
Stainless steel actuator is hardened for strength and wear resistance.
Actuator-stem coupling design ensures positive stem retraction.
Precision-formed metal bellows provides reliable seal to atmosphere.
Actuator threads are protected from system contaminants.
Actuator backstop enhances bellows life.
Gasket body-to-bellows seal shown; welded seal available.
Nonrotating spherical stem tip shown; conical and regulating stem tips available.
SWAGELOK

BK Series
316 SS gasket body-to-bellows seal
PCTFE stem tip for soft-seat shutoff

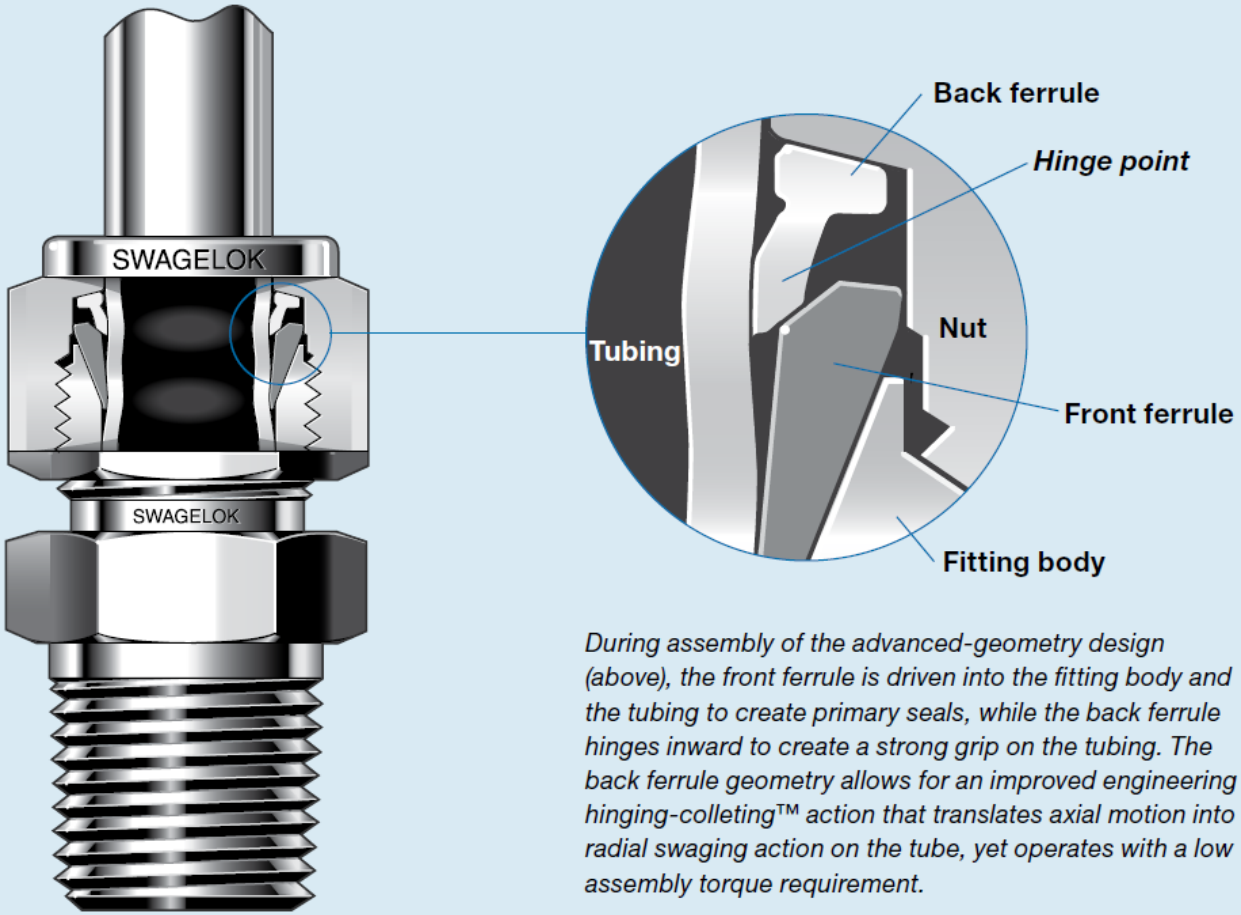
Gaugeable Tube Fittings and Adapter Fittings

Swagelok

Swagelok

Features

- Live-loaded, two-ferrule design.
- Easy to install.
- No torque is transmitted to tubing during installation.
- Swagelok® gap inspection gauge ensures sufficient pull-up upon initial installation.



During assembly of the advanced-geometry design (above), the front ferrule is driven into the fitting body and the tubing to create primary seals, while the back ferrule hinges inward to create a strong grip on the tubing. The back ferrule geometry allows for an improved engineering hinging-colleting™ action that translates axial motion into radial swaging action on the tube, yet operates with a low assembly torque requirement.

Swagelok

Allowable Stress

Stress values are based on ASME Code for Pressure Piping B31.3, Process Piping, at ambient temperature.

Material	Allowable Stress	
	psi	bar
316 SS	20 000	1378
Brass	10 000	689
Steel	20 000	1378

Pressure Ratings

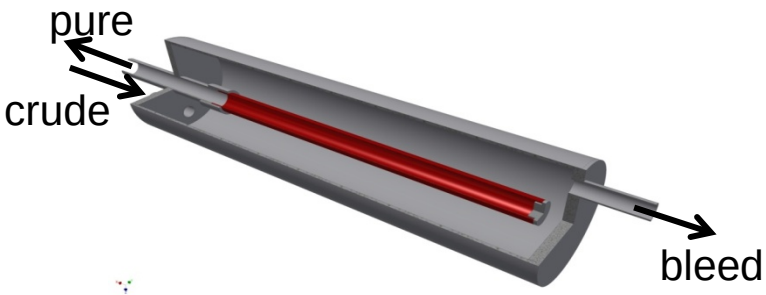
Ratings are based on ASME Code for Pressure Piping B31.3, Process Piping, at ambient temperature.

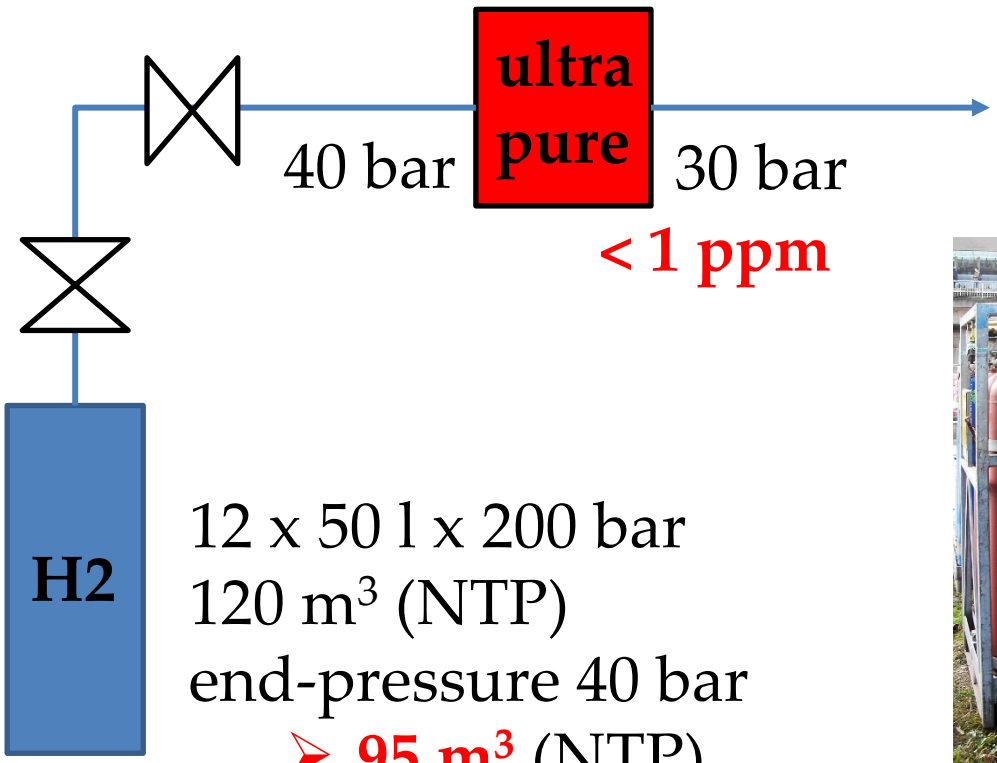
NPT/ ISO Pipe Size	316 SS and Carbon Steel				Brass			
	Male		Female		Male		Female	
in.	psig	bar	psig	bar	psig	bar	psig	bar
1/16	11 000	757	6700	461	5500	378	3300	227
1/8	10 000	689	6500	447	5000	344	3200	220
1/4	8 000	551	6600	454	4000	275	3300	227
3/8	7 800	537	5300	365	3900	268	2600	179
1/2	7 700	530	4900	337	3800	261	2400	165
3/4	7 300	502	4600	316	3600	248	2300	158
1	5 300	365	4400	303	2600	179	2200	151
1 1/4	6 000	413	5000	344	3000	206	2500	172
1 1/2	5 000	344	4600	316	2500	172	2300	158
2	3 900	268	3900	268	1900	130	1900	130

UP-H2 gas supply

Ultra pure hydrogen gas supply

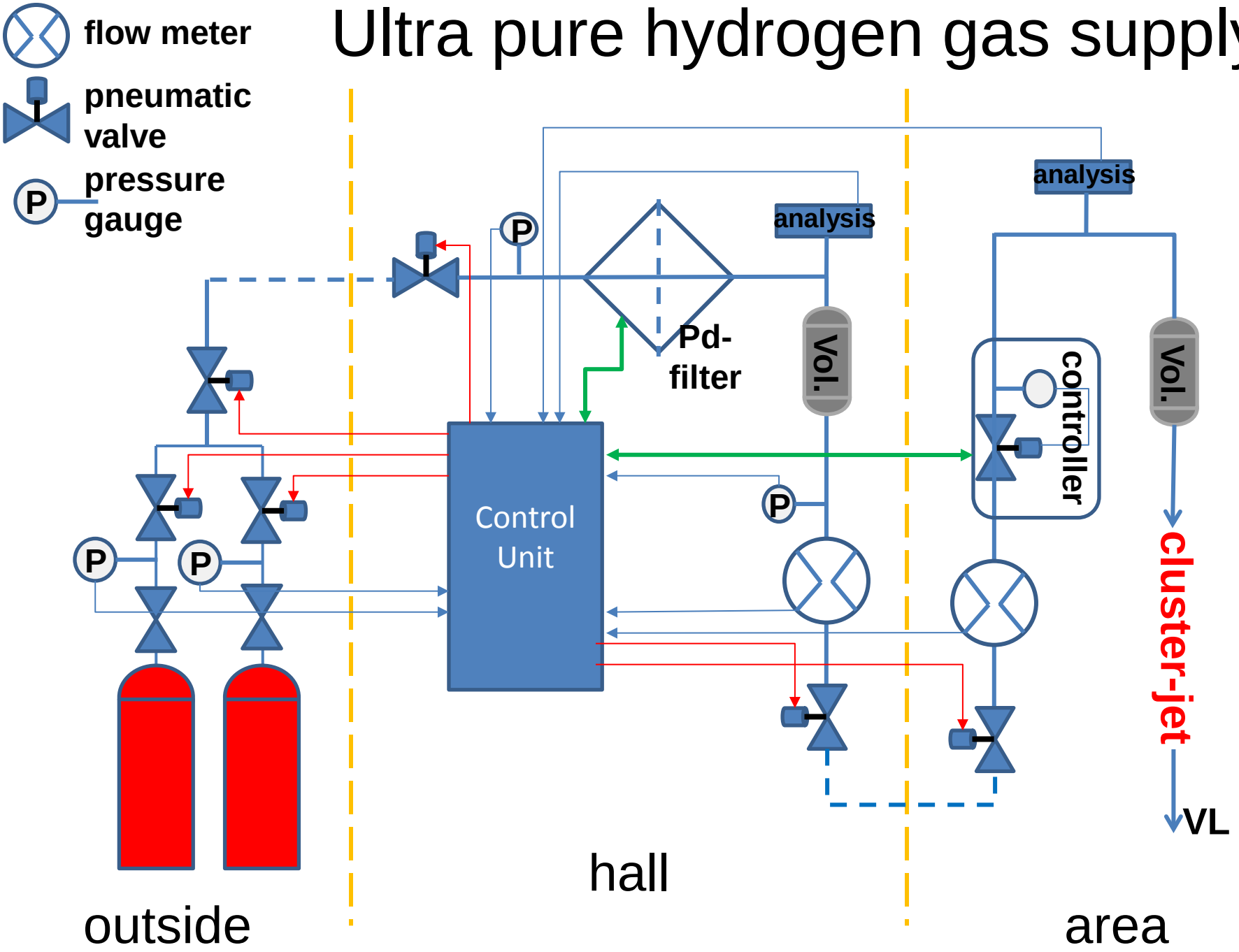
flow rate: 0.1 bar.l/s
60 m^3 (NTP) /week





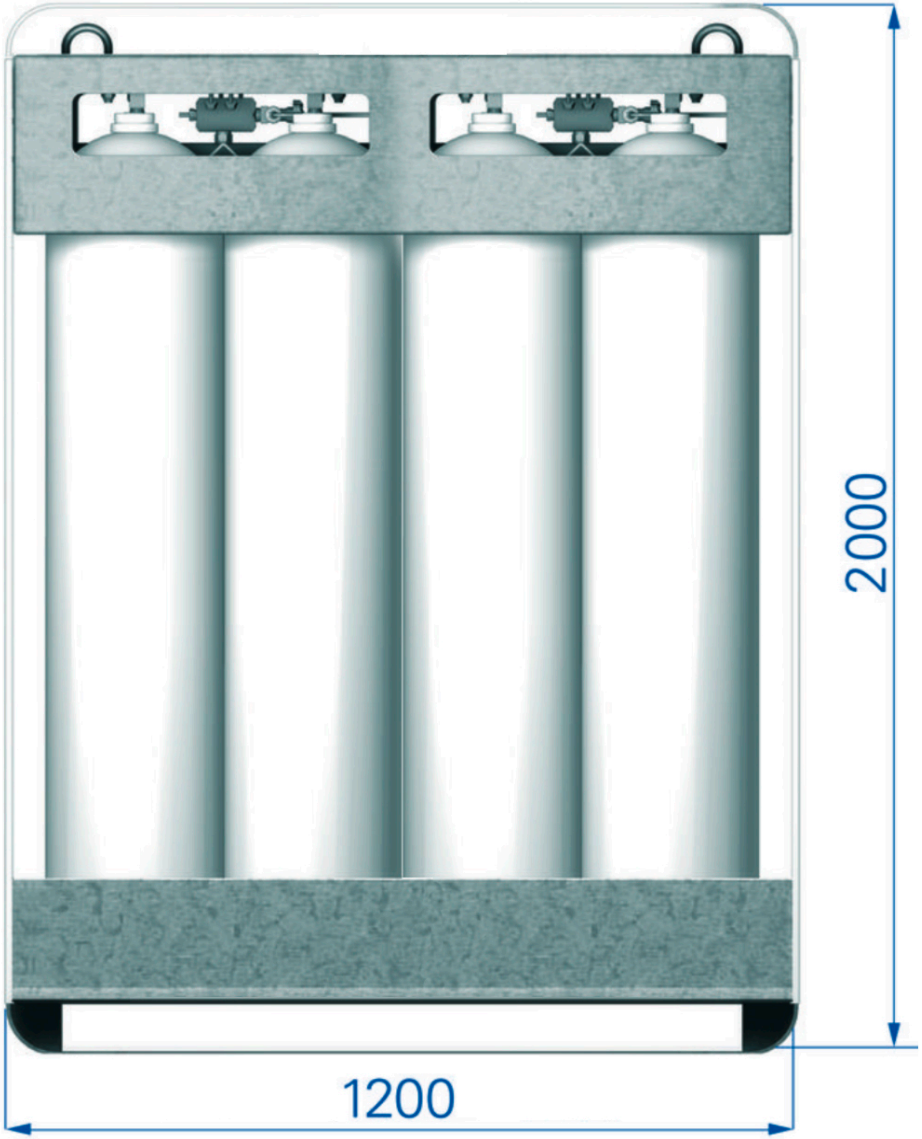
12 x 50 l x 200 bar
120 m^3 (NTP)
end-pressure 40 bar
➢ **95 m^3** (NTP)

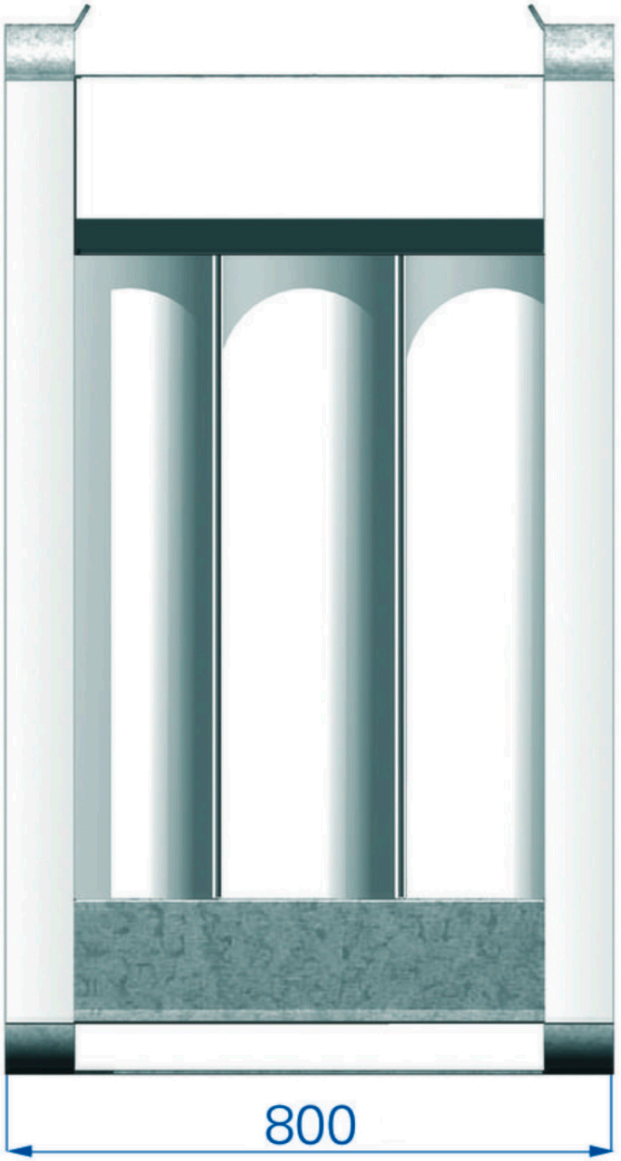
Ultra pure hydrogen gas supply



Hydrogen supply

12 x 50 l x 200 bar / 120 m^3 (NTP)

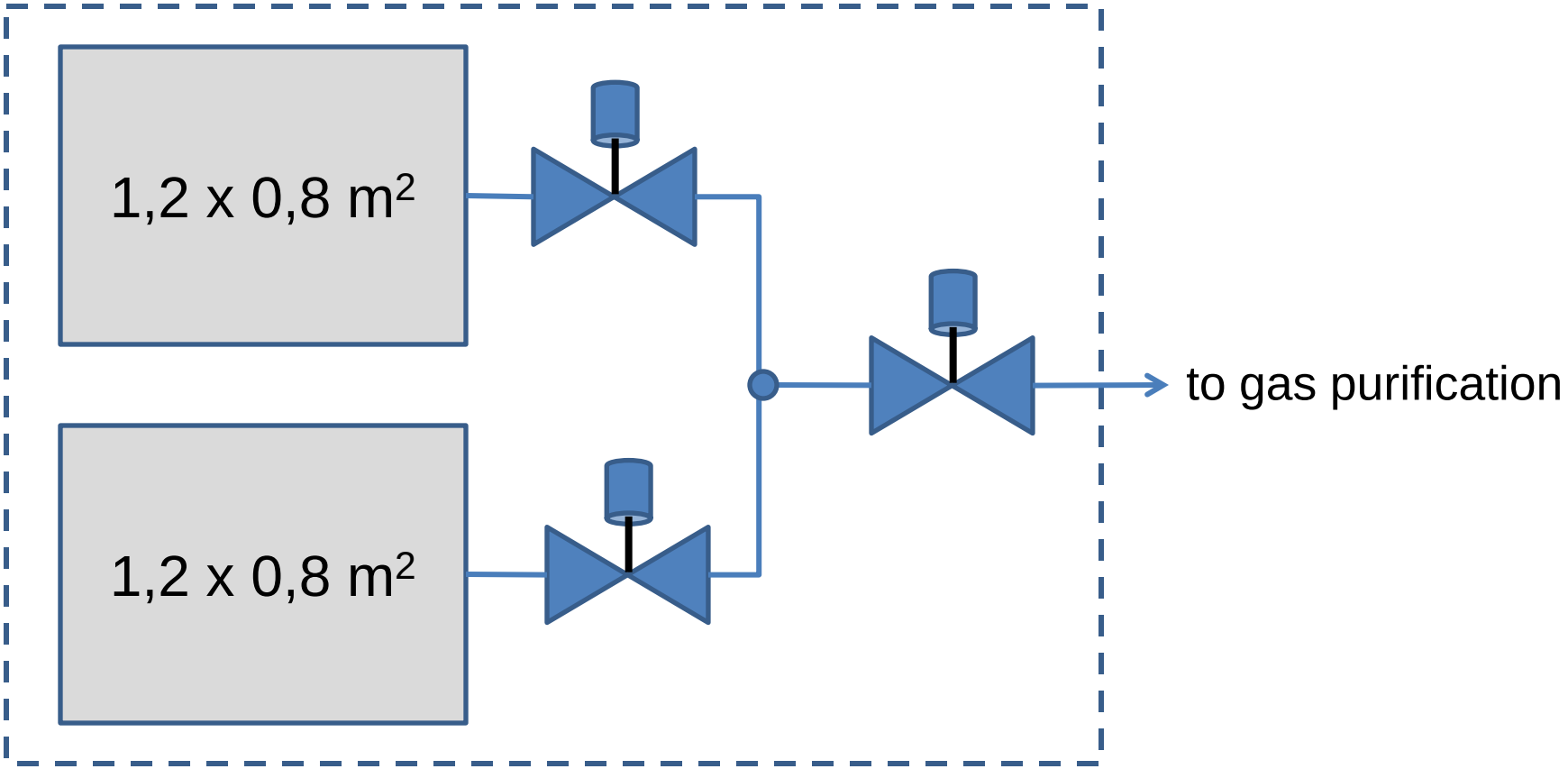




Hydrogen supply / reserve

2 x 12 x 50 l x 200 bar / **2** x 120 m^3 (NTP)

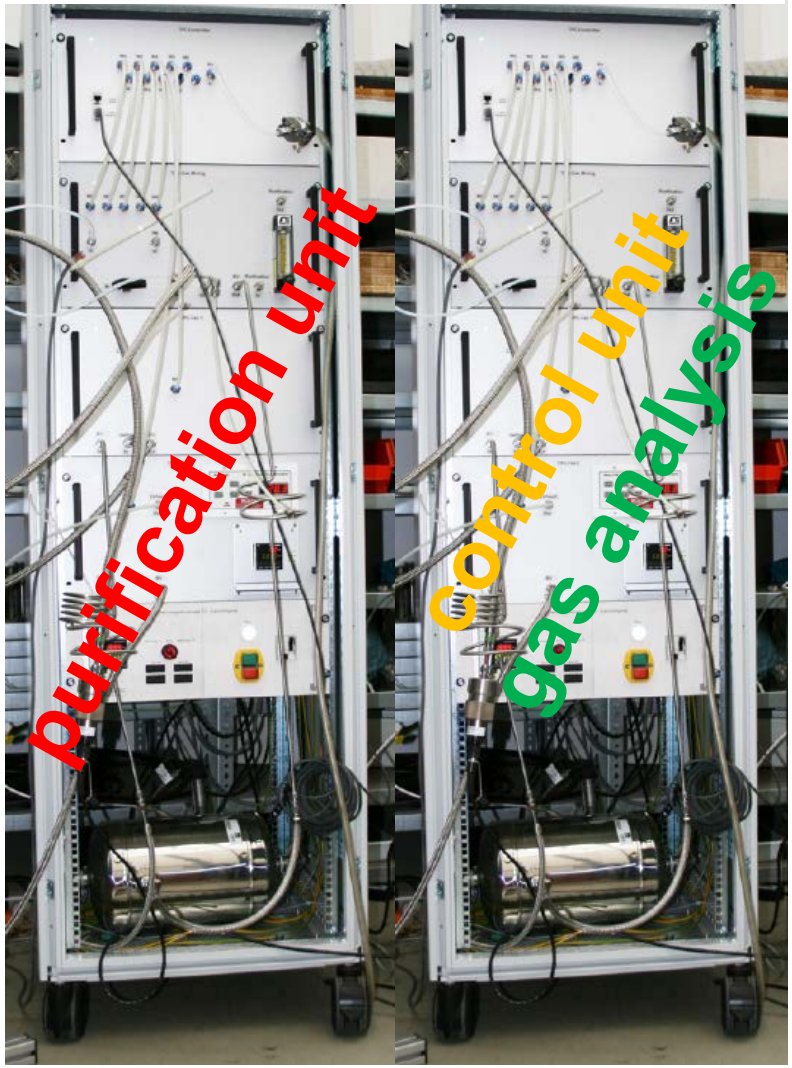
Outside space: approx. **2 x 3 m^2, height ~ 2m**



Easy access for replacement of the empty bottles unit is needed!

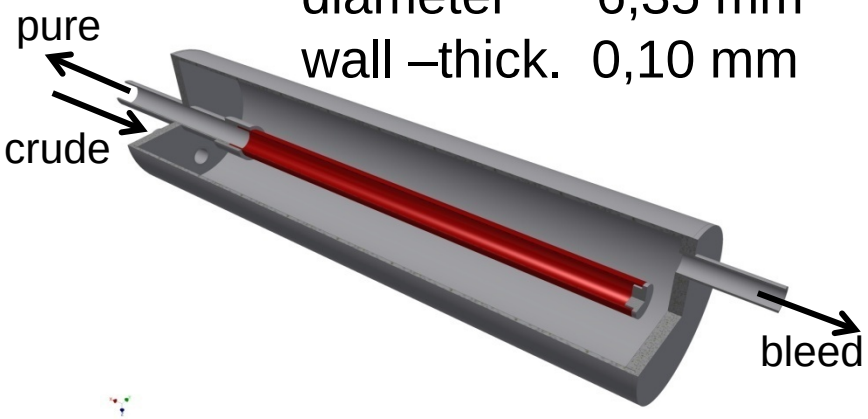
Hydrogen purification and analysis

2 x 19” rack cabinets

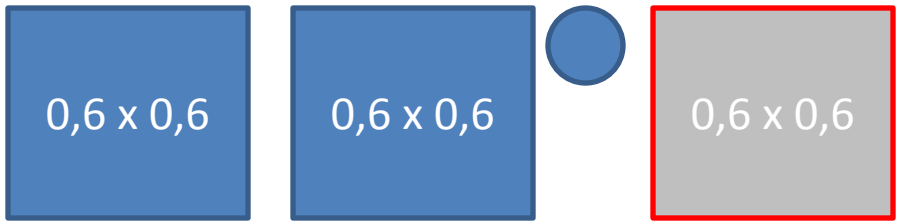


5 x Pd-silver alloy tubes:

length 200 mm
diameter 6,35 mm
wall –thick. 0,10 mm

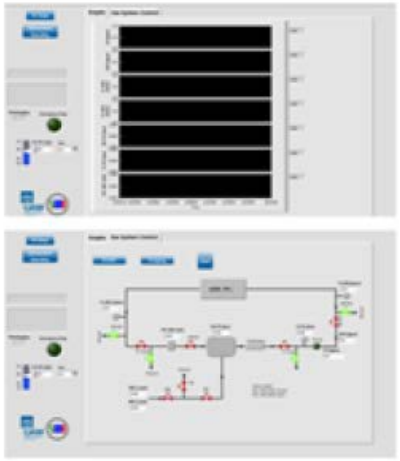


Necessary floor space: ~ 3 x 2 m²



(for closed cycle system)

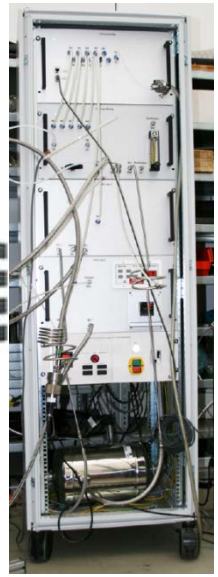
Windows PC
with LabVIEW



Network communication

Online observation
General settings

Control unit,
gas analysis



NI-cRIO

Stand alone device

Purification unit

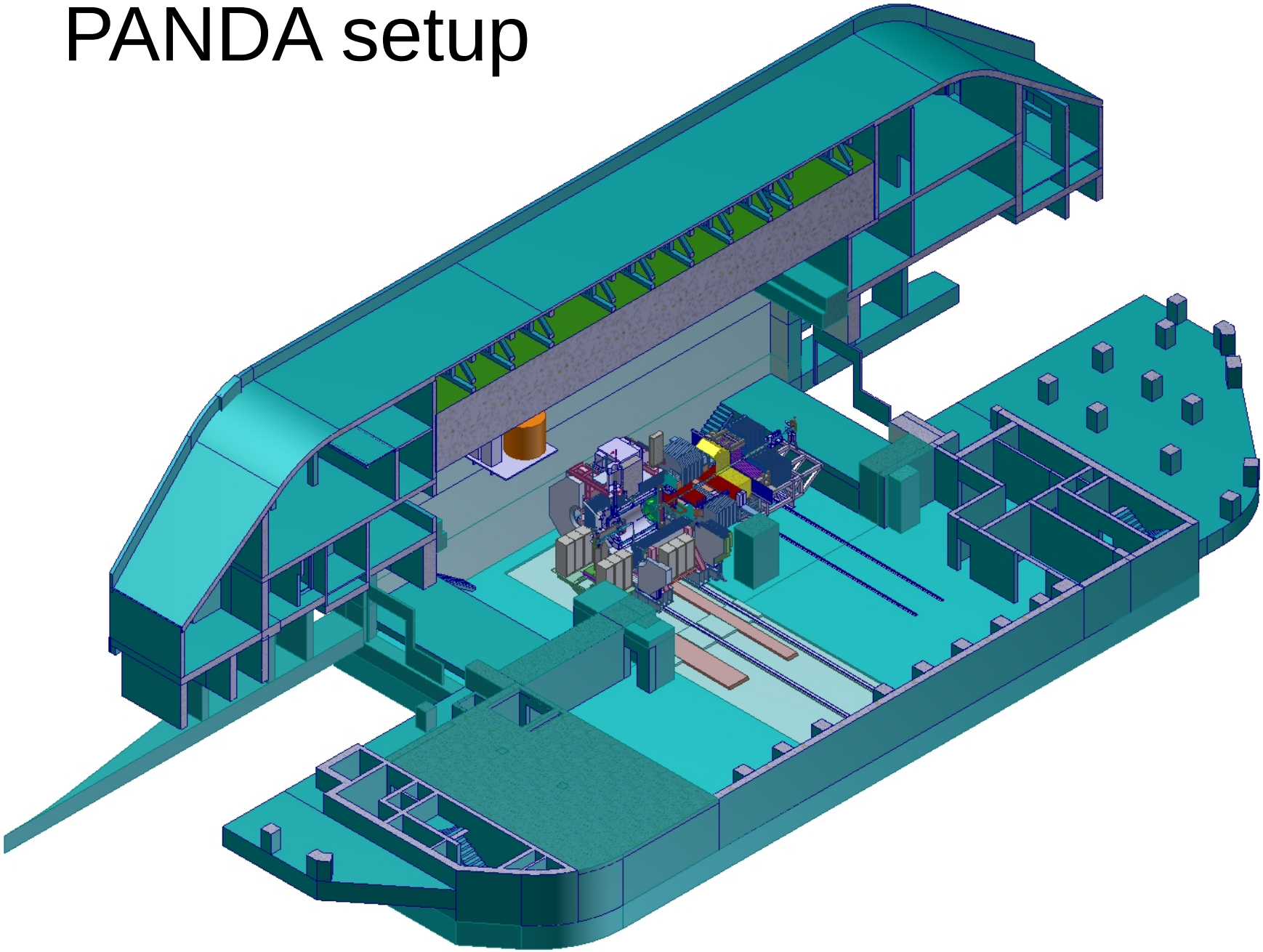
Controlling

MFC, Pump, Valves

Data logging

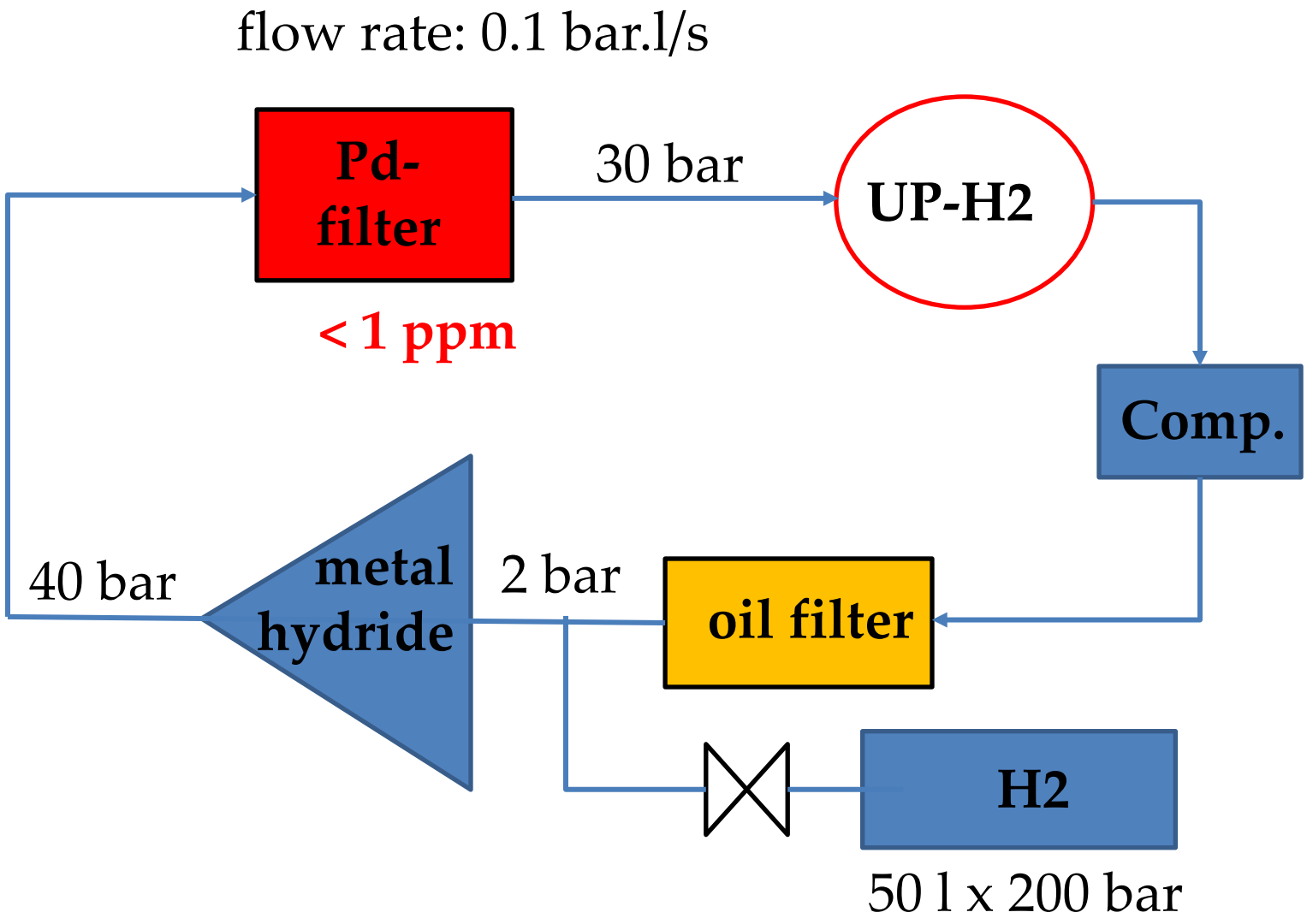
Gas flow, Pressure, Gas Sensors (O_2, H_2O)

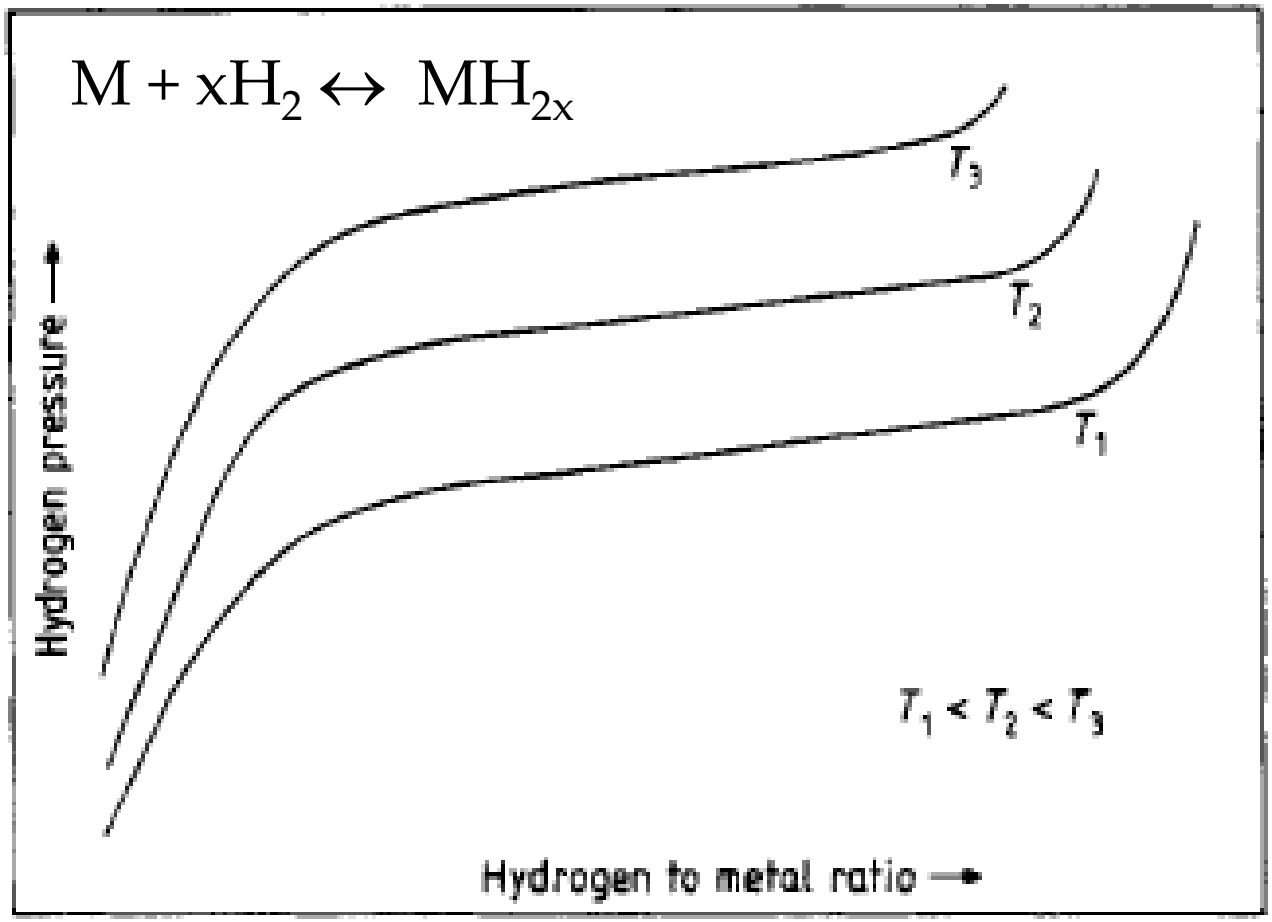
PANDA setup



A metal hydride compressor, towards a closed cycle system

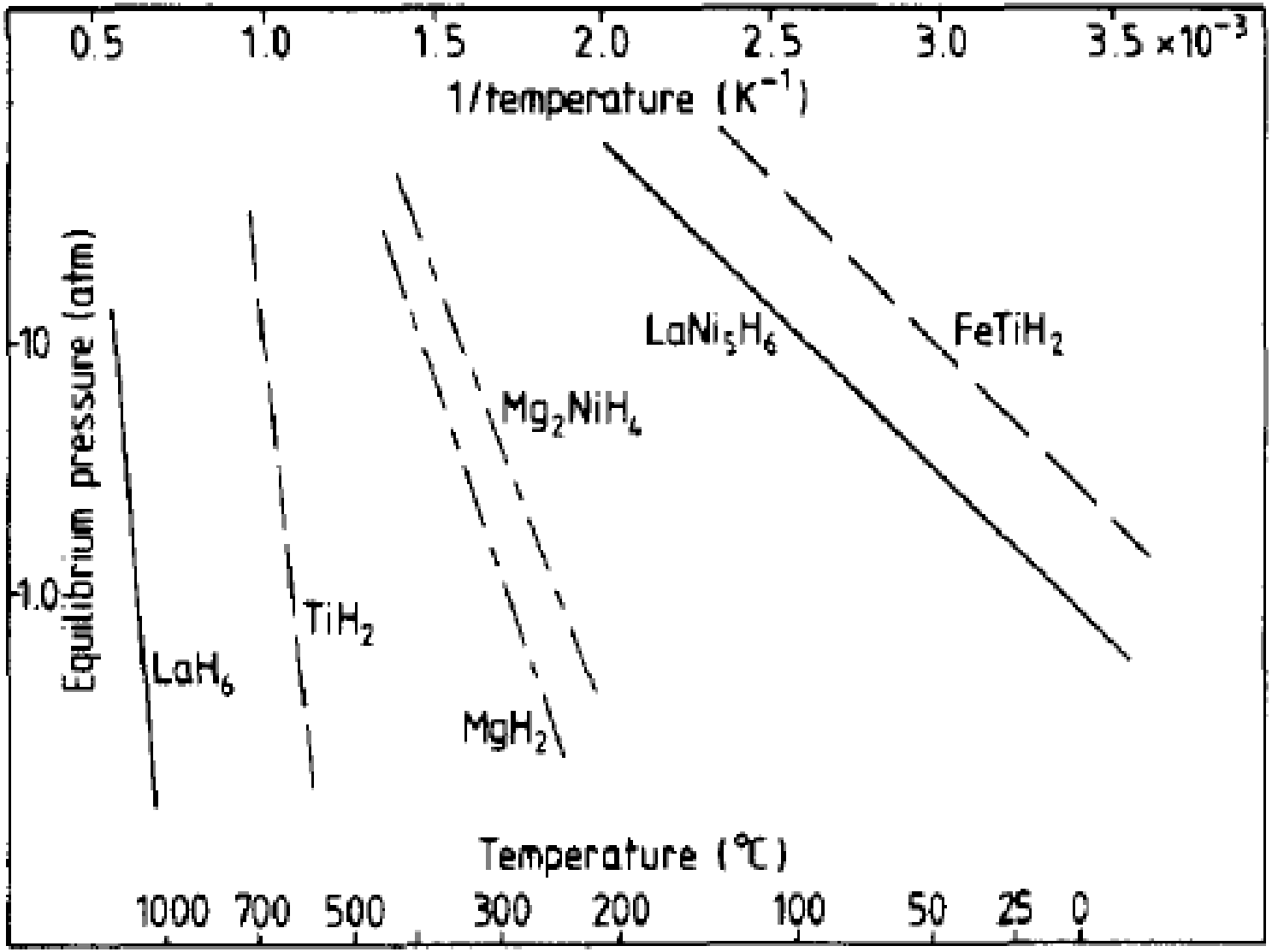
Metal hydride hydrogen compressor

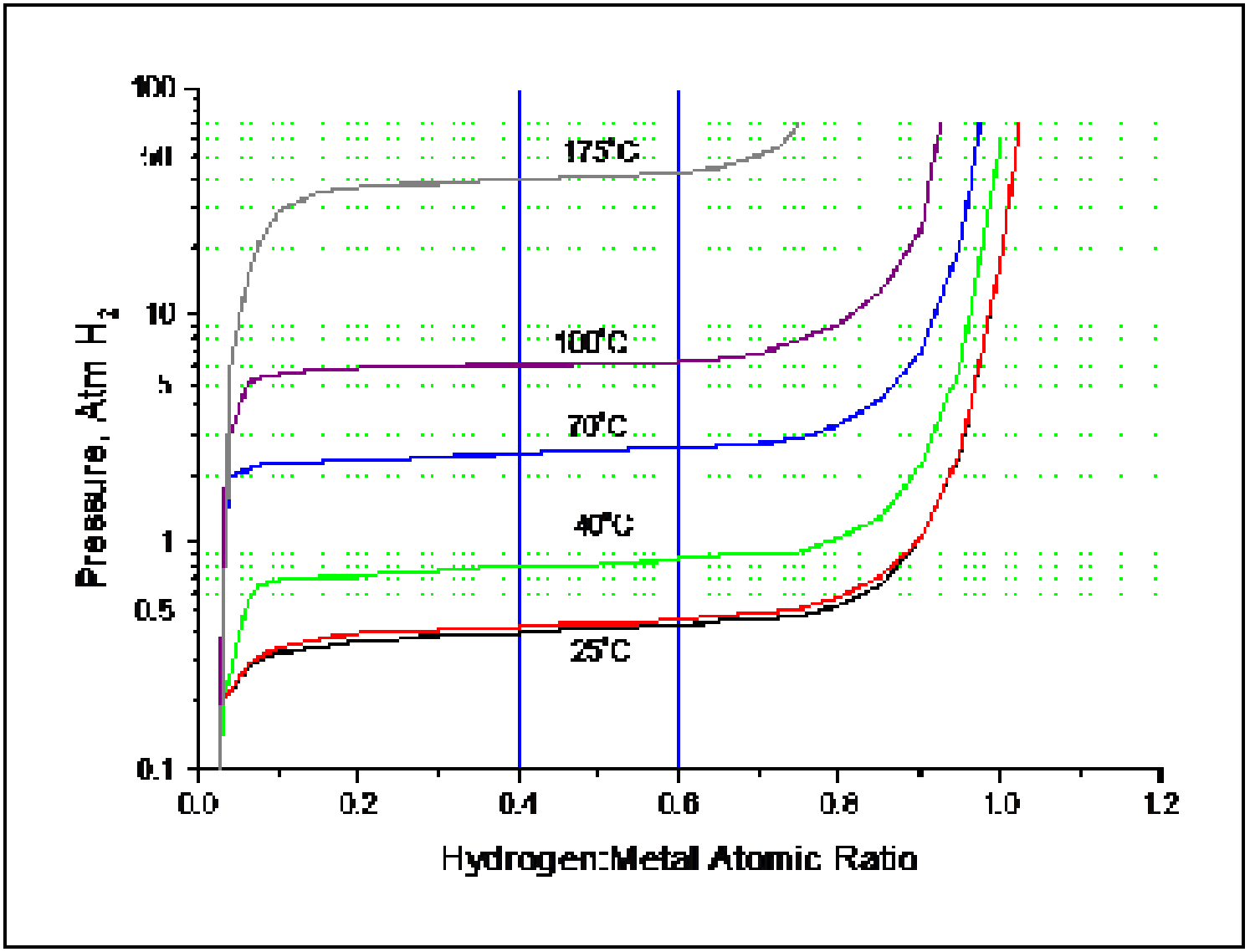




metal hydrides

Equilibrium pressure-temperature relationship





Pressure temperature equilibrium for Ergenics Hy-Stor® 207 alloy. When filled to capacity, Hy-Stor 207 alloy (LaNi4.7Al0.3) holds 1 hydrogen atom for each metal atom to become LaNi4.7Al0.3H6 when fully hydrided.

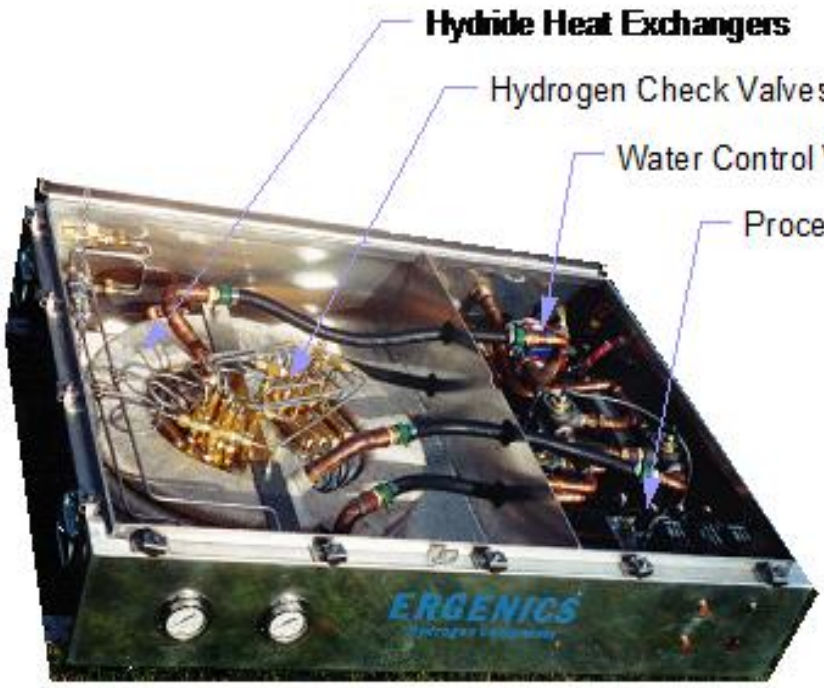
Metal Hydride Hydrogen Compressors

Ergenics supplied metal hydride compressors for a broad range of applications for over twenty years.

Compression of hydrogen using reversible metal hydride alloys offers an economical alternative to traditional mechanical hydrogen compressors.

The simplicity and passive operation of the hydride compression process offer many advantages over mechanical compressors.

Four stage, 90 SCFH Hydride Compressor



- 0.7 bar.l/s

Summary

- Request for hydrogen supply <u>outside hall:</u>
  - 2 x 12 bottle H2 container
  - easy acsess for replacing empty H2 bottles
- Request for hydrogen purification and control system <u>inside hall:</u>
  - 2 x 19″ cabinets + N2 bottle for Pd-filter shut down
  - 3 x 19″ cabinets for closed cycle system
- Pd-filter test cell
  - design ready
  - vacuum brazing tests started
- Metal hydride hydrogen compressor
  - design studies started