Gas delivery systems.

How to ensure uninterrupted high quality gas delivery from the source to the apparatus?

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May 7, 2014

What it is – gas delivery system?

It is a system containing gas pipes, regulators, safety valves and other devices necessary for safe delivery of gases from a source to end user.

1. From a source (gas cylinder, liquid tank, generator)
2. Through regulators and pipe system
3. To end apparatus (is setting demand for gas and delivery system specification)



Which gases, how much and where will be used?

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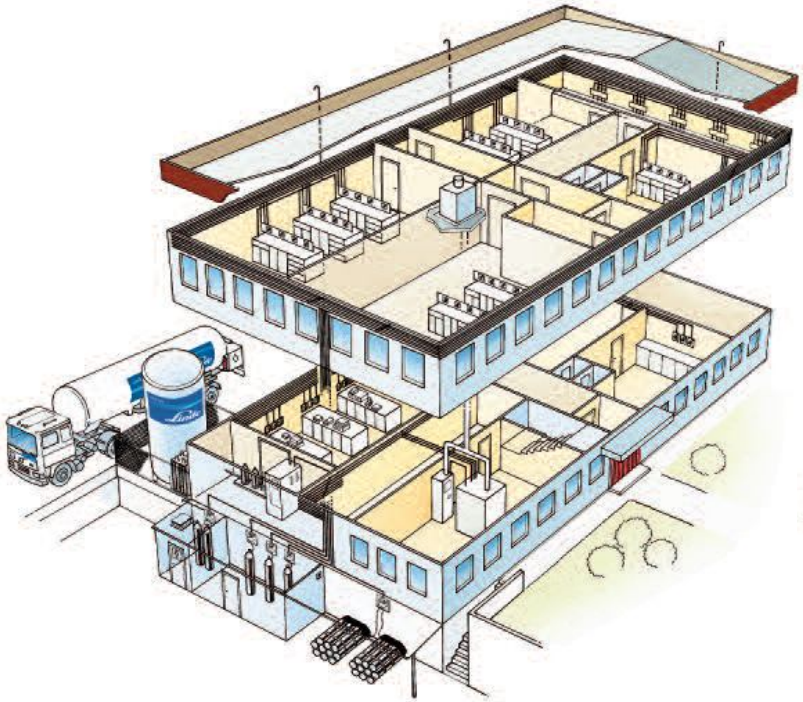

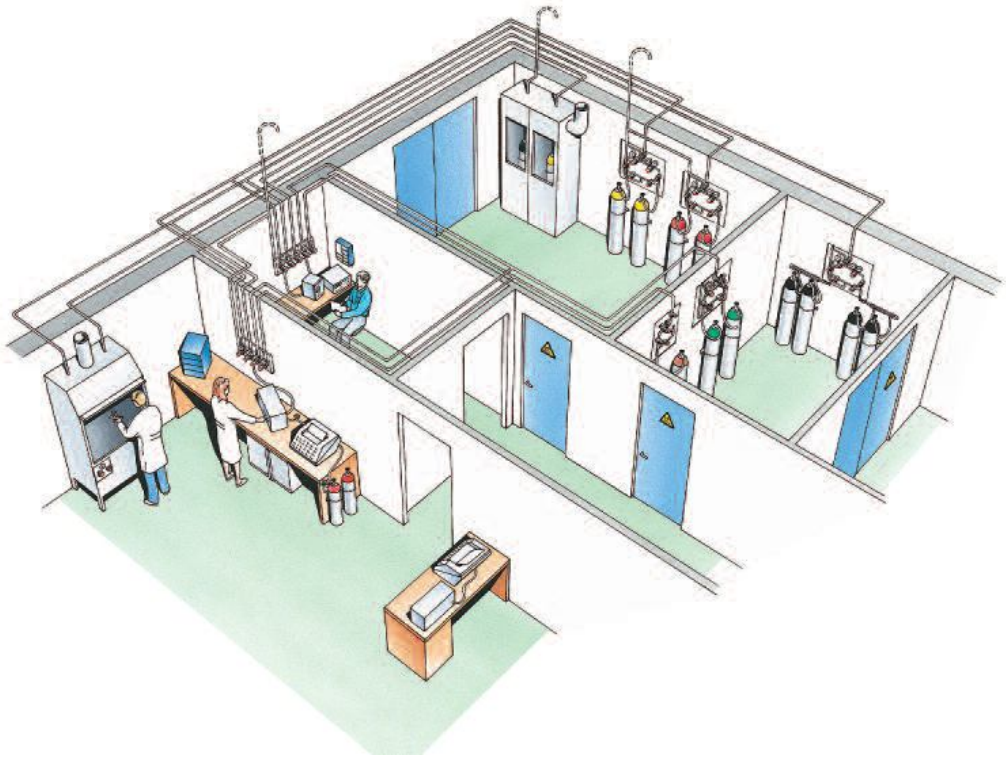

Project of the gas delivery system

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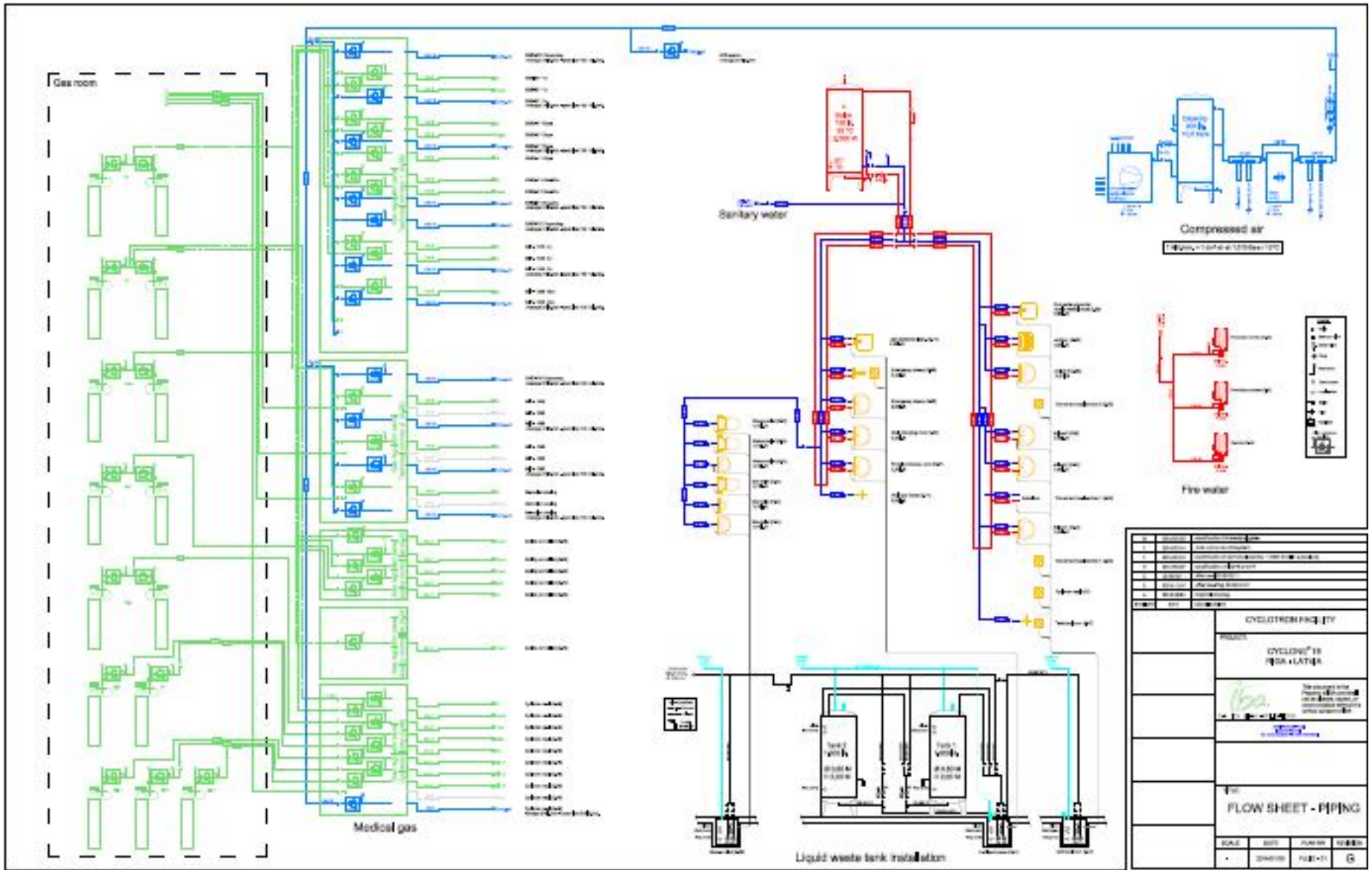

Correct project from the beginning

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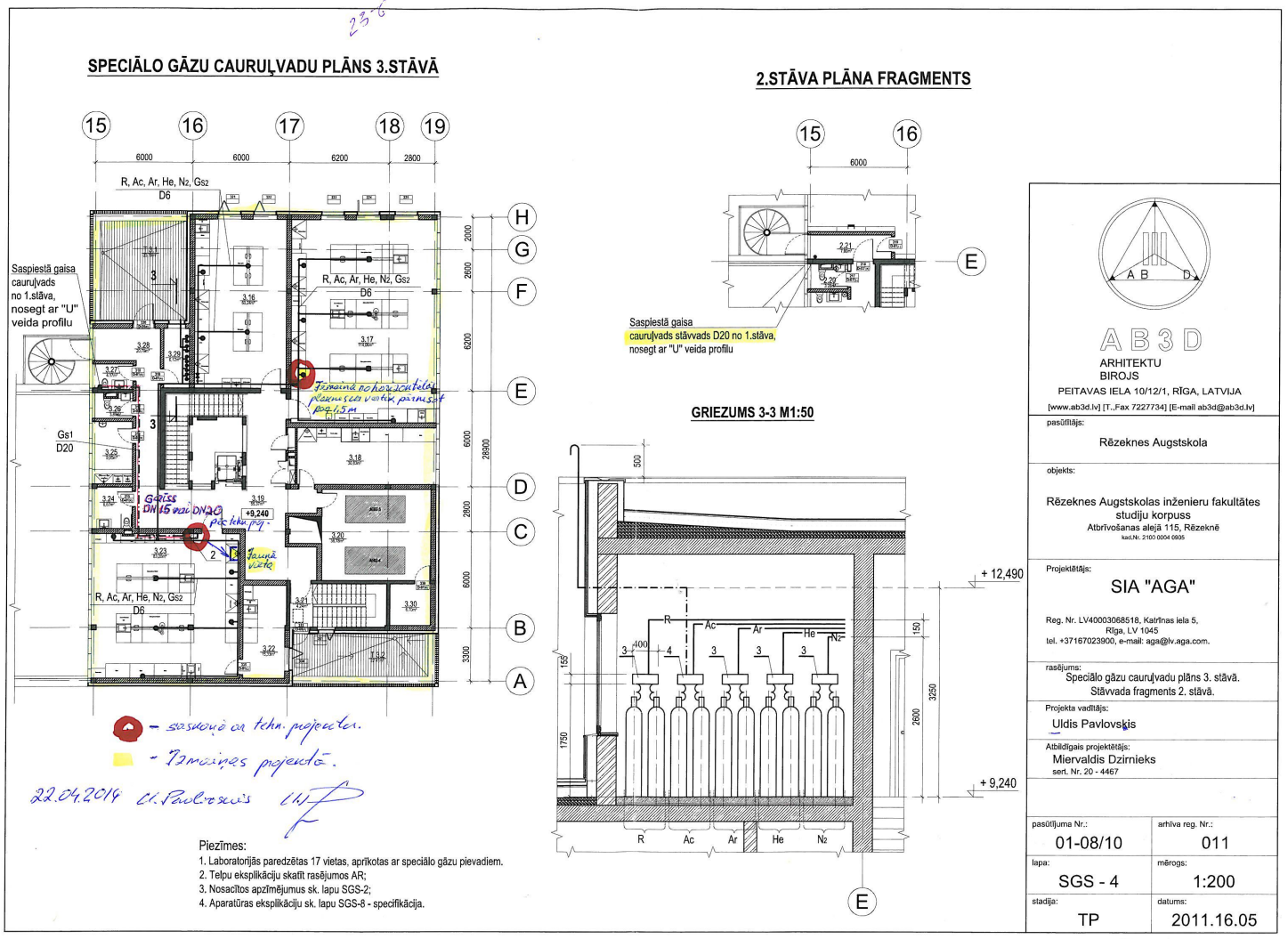

SAFETY ALWAYS AT FIRST!

- Always perform risk analyses.
- Continuous risk management.
- Activities to lower the risks.

The most common risks

- Pressure (>200 bar)
- Gas properties (oxidizing, flammable, toxic, corrosive, etc.)
- Correct materials
- Installation works

Main source of injuries – gas cylinder

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Projecting and risk management - Pressure

SAFETY ALWAYS AT FIRST!

• Working pressure	Normal working pressure from regulator/gas source
• Max working pressure	Max pressure from regulator/gas source
• Projected pressure	Max pressure for the gas delivery system Usually safety valve pressure (> max working pressure)
• Test pressure	(1,43) x Projected pressure
• Safety valve pressure	Pressure when safety valve opens
• Pressure marks (PN25)	Designed pressure for materials (regulators, tubes, etc.) **PN** ⩾ Projected pressure

Gas delivery systems - Gas purity

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High purity systems – impurities at **ppm** level

ppm - parts per million (1 / 1,000,000 or 10-6)

Ultra-High purity systems – impurities at **ppb** level

ppb - parts per billion (1 / 1,000,000,000 or 10-9)

High purity systems

Tightness:

$1x10^{-7}$ cm^3/s (gas leak - 1 cm^3 He at 1 atm in 4 months)

Main requirements to materials:

- Low or unspecified level of solid particles
- Low leakage of gas (pressure tests)
- Surface - Easy to clean / hard to pollute

Materials for pipes:

Stainless steel CQE (Chemistry Quality)

Materials for regulators and valves:

Brass/ stainless steel – Chemically cleaned

Connections:

- Preferably orbital welding
- Swagelok quality compression fittings
- Threads, preferably NPT

Tightness:

>1x10^{-9} cm^3/s (gas leak - 1 cm^3 He at 1 atm in 30 years)

Main requirements to materials :

- Very low level of solid particles
- Very low leakage of gas (He leak tests)
- Surface - Easy to clean / hard to pollute

Materials for pipes:

Electro polished stainless steel, PQE

Materials for regulators and valves:

Electro polished stainless steel, preferably metal to metal sealings

Connections:

- Orbital welding
- VCR connections
- Welded connections

Pipes – which ones?

Right diameter (pressure drop)

- minimum different pipes (lower costs) 6x1 mm, 12x1 mm, 18x1,5 mm

Suitable for required pressures

Right materials – keep unchanged gas quality from source to end apparatus

- do not produce impurities
- prevent diffusion
- do not react with gas

Special requirements:

- insulated pipes;
- double wall pipes;
- pipes in protective coating, ect.

Pipes – which ones?

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Stainless steel (SS)

- CQ – chemically cleaned, inner surface roughness Ra ~ 1,0 µm
- CQE – chemically cleaned, inner surface roughness Ra ≦0,4 µm
- PQE – chemically cleaned, electro polished, inner surface roughness Ra ≦0,2 µm,

~~**Brass**~~ **?!**

- Chemically cleaned – for medical gases

~~Polymers (Teflon, PVC u. c.)~~ ???!

- Teflon – for aggressive gases

Materials compatibility

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Material compatibility.

Gas name	Chemical formula	Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polyethene	PVC	Stainless steel	Teflon®	Viton®
Acetylene	C_2H_2	●	●	●[2]	●	●	■	△	■	△		■	◆	●	△	●
Air, synthetic		●	●	●	●	●	●	●	●	◆	●	●	◆	●	●	●
Ammonia	NH_3	△		■	●	●	●[3]	△	■	△	■		◆	△	●	■
Argon	Ar	●	●	●	●	●	●	●	●	◆	●	●	◆	●	●	●
Arsine	ASH_3	■	△	△		●	●	●	△	△		●	◆	●	●	
Boron trichloride	BCl_3	●		△	■	●	■	△	●	■		△	△	●	●	△
Boron trifluoride	BF_3	△[1]		■	△	●[3]	■	△	●[3]	△		△	△	△[1]	△	
1,3-Butadiene	C_4H_6	●	■	●	■	●	●	●	●	△		△	△	●	●	
n-Butane	C_4H_{10}	●	●	●	■	●	●	●	●	△		■	◆	●	●	●
iso-Butane	C_4H_{10}	●	●	●	■	●	●	●	●	△			◆	●	●	
1-Butene	C_4H_8	●	●	●	■	●	●	●	●	△		■	◆	●	●	
cis-2-Butene	C_4H_8	●	●	●	■	●	●	●	●	△		■	◆	●	●	
iso-Butene	C_4H_8	●		●	■	●	●	●	●	◆		△	◆	●	●	
trans-2-Butene	C_4H_8	●	●	●	■	●	●	●	●	△		■	◆	●	●	
Carbon dioxide	CO_2	●	■	●	●	●	●	●	●	△		△	◆	●	●	△
Carbon monoxide	CO	●	■	●	■	●[3]	●	●	●	■		△	△	●	●	
Carbonyl sulfide	COS	●[3]		●[3]		●[3]	●[3]	●	●[3]		●		◆	●[3]	●	●
Chlorine	Cl_2	■	△	■		△	■	●	■	■	■	■	△	●	●	●
Chlorine trifluoride	ClF_3	●[12]	■	■	■	●[9]	●[12]	●	●[10]	◆			■	●[10]	●	
Cyanogen	CNCN					●	■	●						●	●	
Cyanogen chloride	CNCl						■	●						△	●	
Cyclopropane	C_3H_6	●	●	●	■	●	●	●	●	△		■	◆	●	●	
Deuterium	D_2	●	●	●	●	●	●	●	●	◆		●	◆	●	●	
Diborane	B_2H_6	●		●		●	●	●	●		△			●	●	△
Dichlorosilane	SiH_2Cl_2	■	■	■	■	■	■	●[10]	■	■	■	●[9]		●	●[11]	△
Dimethylamine	$(CH_3)_2NH$	■	■	■	■	●	■	●	■			●	◆	●	●	■
Dimethyl ether	C_2H_6O	●	△	●	■	●	●	■	●	■				●	●	
2,2-Dimethylpropane	C_5H_{12}	●	●	●	■	●	●	●	●	△		■	◆	●	●	■
Ethane	C_2H_6	●	●	●	■	●	●	●	●	◆		△	◆	●	●	
Ethene	C_2H_4	●	●	●	△	●	●	●	●	◆	●	△	◆	●	●	●
Ethylene oxide	C_2H_4O	■	■	■	■	△	■	●	△	■				●	●	■
Ethylamine	$C_2H_5NH_2$	△		■	△	●	■	●	△	△		●	◆	●	●	
Ethyl chloride	C_2H_5Cl	●[3]	●	●[3]	■	●[3]	●[3]	●	●[3]	△			■	●[3]	●	△
Fluorine	F_2	△	■	△	■	△	△	●	■	■		■	■	△	△	■
Germane	GeH_4	●		●		●	●	●	●		△			●	●	△
Helium	He	●	●	●	●	●	●	●	●	◆	●	●	◆	●	●	●
Hydrogen	H_2	●	●	●	●	●	●	●	●	◆	●	●		●	●	●
Hydrogen bromide	HBr	■	■	△[1]	■	△[1]	△[3]	●	■	■		●	◆	●[3]	●	△
Hydrogen chloride	HCl	■		△[1]	■	△[1]	■	●[10]	●[3]	■		●	◆[3]	●[3]	●[11]	△
Hydrogen fluoride	HF	■		△[1]		△[1]	■	●[10]	△[1]	◆		●[7]	■	■	●[11]	●
Hydrogen selenide	HSe	■		■		●	■	●	■		△			●	●	△
Hydrogen sulfide	H_2S	●[3]	△	■[3]	●	△	△	●[10]	●	◆		△	△	●[3]	●[11]	
Krypton	Kr	●	●	●	●	●	●	●	●	◆	●	●	◆	●	●	●
Methane	CH_4	●	●	●	■	●	●	●	●	◆	●	●	◆	●	●	●
Methylamine	CH_3NH_2	△	△	■	△	●	■	●	●	△		●	◆	●	●	△
Methyl bromide	CH_3Br	■[2]	■	■	■	●[3]	■	●	●[3]	■		■	■	●[3]	●	
Methyl chloride	CH_3Cl	■[2]	■	■	■	●[3]	■	●	●[3]	■		■	■	●[3]	●	
Methyl fluoride	CH_3F	●	●	●		●	●	●	●	◆			◆	●	●	●
Methyl mercaptan	CH_3SH	■		■	△	△	■	●	■	△		●	◆	●	●	
Neon	Ne	●	●	●	●	●	●	●	●	◆	●	●	◆	●	●	●

Gas name	Chemical formula	Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polyethene	PVC	Stainless steel	Teflon®	Viton®
Nitric oxide	NO	●[3]		■	△	●[3]	■[3]	●	●	△		●	◆	●[3]	●	●
Nitrogen	N_2	●	●	●	●	●	●	●	●	◆	●	●	◆	●	●	●
Nitrogen dioxide	NO_2	●[3]		■		●[3]	■	△	●			△	■	●	●	■
Nitrogen trifluoride	NF_3					●[10]	●[12]	●	●[10]					●[10]	●	
Nitrous oxide	N_2O	■	△	●	●	△	●	●	●	△		●	◆	●	●	●
Octafluoropropane	C_3F_8	●		●		●	●	●	●			●	◆	●	●	
Oxygen	O_2	■		●	△	△	●	●	●	◆		■	■	●	●	●
Phosgene	$COCl_2$	■	●	△	●	△[1]	●[3]	●	●	◆		△	●[2]	●[3]	●	●
Phosphine	PH_3	■				●		●	■		△			●	●	
Propane	C_3H_8	●	●	●	■	●	●	●	●	△		■	◆	●	●	△
Propene	C_3H_6	●	■	●	■	●	●	●	●	△		△	◆	●	●	●
Propyne	C_3H_4	●		●		●	●	●	■	◆		●		●	●	
R 11 Trichlorofluoromethane	$CFCl_3$	●	●	●		●	●	△	●	■				●	●	△
R 12 Dichlorodifluoromethane	CF_2Cl_2	●	△	●	■	●	●	△	●	◆		△	◆	●	■	△
R 13 Chlorotrifluoromethane	CF_3Cl	●	●	●	●	●	●	△	●	◆	△		◆	●	●	
R 13 b1 Bromotrifluoromethane	CF_3Br	●	●	●	●	●	●	△	●	◆	△	■	△	●	●	
R 14 Tetrafluoromethane	CF_4	●		●	●	●	●	△	●	◆	△	●	◆	●	●	
R 21 Dichlorofluoromethane	$CHFCl_2$	●	■	●	■	●	●	△	●	■	●	●	◆	●	●	
R 22 Chlorodifluoromethane	CHF_2Cl	●	■	●	●	●	●	△	●	◆	■	△	△	●	■	■
R 23 Trifluoromethane	CHF_3	●		●	●	●	●	△	●	◆		●	◆	●	●	
R 114 1,2-Dichlorotetrafluoroethane	$C_2Cl_2F_4$	●	●	●	△	●	●	△	●	◆		●	◆	●	●	△
R 115 Chloropentafluoroethane	C_2ClF5	●	●	●	●	●	●	△	●	◆		●	◆	●	●	
R 116 Hexafluoroethane	C_2F6	●		●		●	●	△	●					●	●	
R 142b 1-Chloro-1,1-difluoroethane	$C_2H_3ClF_2$	●	●	●	●	●	●	△	●	◆		△	△	●	●	■
R 152a 1,1-Difluoroethane	$C_2H_4F_2$	●	△	●	●	●	●	△	●	△	●	●[7]	◆	●	●	
Silane	SiH_4	●		●		●	●	●	●	◆	△			●	●	△
Silicon tetrafluoride	SiF_4	■				△[9]	●[3]	●[10]	△[2]	◆		●[7]	■	■	●[11]	
Sulphur dioxide	SO_2	●[3]	■	△[3]	●	●[3]		●[10]	●[3]	■	■			●[3]	●[11]	
Sulphur hexafluoride	SF_6	●	●	●	●	●	●	●	●	◆	●	●	◆	●	●	●
Trimethylamine	$(CH_3)_3N$	■	■	■	△	●	■	●	■	△		●	◆	●	●	■
Tungsten hexafluoride	WF_6	●[12]				●[10]	●[12]	●	●[10]					●[10]	●	
Vinyl bromide	C_2H_3Br	△[1]		■	△	△	■	●	●	■	△	△	△	●	●	
Vinyl chloride	C_2H_3Cl	●[3]		●[3]	△	●[3]	●[3]	●	●[3]	◆	●	●		●[3]	●	●
Vinyl methyl ether	C_3H_6O	●		●	●	●	●	●	●	△		△	△	●	●	
Xenon	Xe	●	●	●	●	●	●	●	●	◆	●	●	◆	●	●	●

Legend

● Good
△ Fair
■ Avoid
Data missing

1 Avoid in presence of moisture
2 <65% Cu
3 Avoid in presence of oxygen
4 Up to 100 bar (1,450 psi)
5 In absence of oxygen
6 Possible forming of spontaneously flammable compounds
7 <50 °C (120 °F)
8 <100 °C (210 °F)
9 <150 °C (300 °F)
10 <180 °C (360 °F)
11 <250 °C (480 °F)
12 <400 °C (750 °F)

Regulators for High purity systems

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S 201/R HiQ®

I 40X HiQ®

A 208/R HiQ®

W 40B HiQ®

Materials for High purity systems

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V 200 HiQ®

V 50 HiQ®

V 1315 HiQ®

Swagelok compression fittings

Materials and regulators for Ultra-High purity & aggressive / toxic gas systems

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Connections for orbital welding

Welded and VCR connectors

Compression fittings only for purge

High purity gas delivery system
Location

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Ultra-High purity & aggressive / toxic gas systems
Location

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Cabinets for cylinders storage
Ultra-High purity & aggressive / toxic gas systems

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Cabinets for cylinders storage

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Simple cabinet for outdoor cylinders storage.

Openings for ventilation

Cylinders' brackets

Painting to protect from outdoor environment

Lockable doors

Available in different sizes:

OD600 600x596x1997 mm	1 - 2 (50l)
OD1200 1200x596x1997 mm	1 - 4 (50l)

Cabinets for cylinders storage

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For internal cylinders storage according to DIN EW 14 470-2

- Compulsory ventilation
- Gas detectors
- Electromechanical safety valves
- Cylinders' brackets
- Not for outdoor use

Cabinets for cylinders storage
Ultra-High purity & aggressive / toxic gas systems

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Tailor made cabinet for semiconductor gases

- Designed for particular customer
- Technical support
- In-house quality control
- Clean rooms assembly
- Full functional test before dispatch (hardware and software)
- Corresponds to ATEX
- Configurable

Containers for cylinders storage

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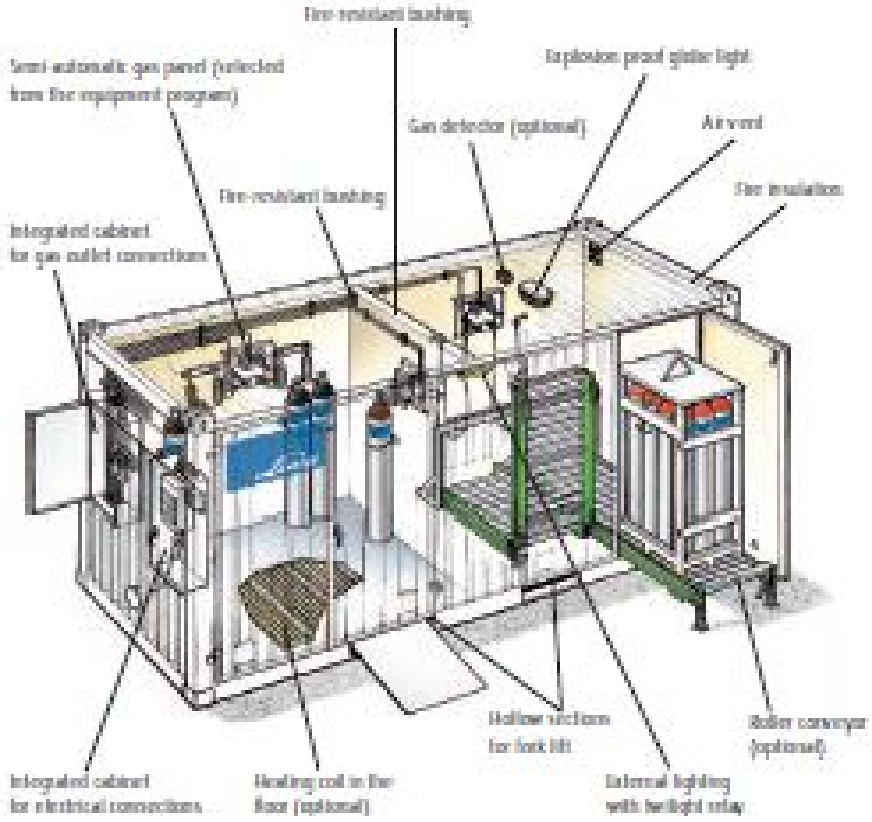
Container 20” (6000x2400x2600)



Technical service and maintenance – Safety and Quality

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Regular technical service:

- Leak tests;
- Pressure tests;
- Exchange of filters;
- Calibration of detectors, etc.

Local regulation:

- annual verification of manometers;
- annual tests of liquid tanks, etc.

Emergency service visits:

- Safety;
- Economy, etc.

Service and maintenance should be performed by appropriate trained specialists (internal or external). Involvement of technicians with inadequate experience and knowledge can cause serious safety and economical risks.

THANK YOU!