

User guide for Laboratorio di Ateneo

PoliFAB

Building 30, via G. Colombo 81, 20133 - Milano

Gas and high pressure

General description

In PoliFAB high pressure systems and several gas lines which serve different cleanroom facilities are installed. Gas lines have been fabricated and installed according to the law and the best technical practices. The lab has a large number of technical gas lines (compressed air, vacuum and nitrogen 5.0) placed on the cleanroom walls. **Any connection or modification to these parts have to be performed by and discussed with the cleanroom Staff. Special care has to be taken during opening and closing the gas supply.** All gas bottles are placed outside of the cleanroom in two dedicated bunker gas, except a C_4F_8 bottle (backside of RIE) and other small bottles with low amount of product. **Connection and modification of the gas lines can only be performed by the Staff.**

The gases present at PoliFAB can be divided into 3 families: inert, oxidant, toxic and explosive. The latter comprehends ammonia and silane only, which will be described in a separated section below.

Inert and oxidant gases

In the following table we list the process gases belonging to the first two families. The list specifies the hazards (H) connected to each gas. Common to all gases is the hazard “H280: contains gas at high pressure; can explode if heated”.

Inert	Hazard H	Oxidant	Hazard H	Hazard H	Hazard description
N_2	280	O_2	270 - 280	270	Can cause or worsen a fire; Oxidant
He	280	N_2O	270 - 280	280	Contains gas at high pressure; Can explode if heated
Ar	280				
CO_2	280				
CF_4	280				
C_4F_8	280				
CHF_3	280				
SF_6	280				

For all gases the risk of asphyxiation is present, as rooms filled with an inert gas may have a too low residual percentage of oxygen (< 20%). Symptoms may include a reduced mobility or faint and exposed humans may not recognize them. Low concentration of inert gases may act as narcotics or lead to dizziness, headache, nausea, reduced movements. Fresh air can be used to establish the normal condition. If the use of a rebreather is necessary to enter a specific ambient or to help an injured person, the Staff will take care of this operation. The air treatment unit of the cleanroom ensure that the volume of air in each cleanroom area is completely changed 5 times per hour, therefore the risk of asphyxiation is rather low; However extreme care has to be taken by every user when using the gas lines. **Any leakage of gas has to be reported to the Staff immediately by the users.**

Oxidants (O_2 , e NO_2) are dangerous because can cause or worsen a fire even in absence of air. The most popular oxidant is surely oxygen, but other oxygen compound are also oxidant, like N_2O , NO_2 and NO . Other substances are considered oxidants, like F_2 and Cl_2 , as by decomposition, they can produce oxidants. Oxygen is in particular extremely dangerous as the probability of fire

increases with the percentage of oxygen in the atmosphere. The risk becomes very high for concentrations higher than 30%. In presence of a flammable gas:

- The flammability range widens as the flammability superior limit increases (e.g. for methane it increases from 15% to 61%).
- Fire propagation speed increases (for methane it increases from 0.4 m/s to 40 m/s).
- The fire activation energy decreases (for methane is 100 times lower).
- The combustion temperature increases (for methane 2000 °C fino a 3000 °C).
- The self-activation temperature decreases.

Nearly all substances burn under atmosphere of pure oxygen, therefore its presence in the ambient can dramatically change the probability of fire. Users who operate system which utilize an oxidant gas have to carefully follow the user manual and in particular:

- Substitution of pumps or mechanical parts in contact with oxidant with other oils which are not suited for this operation is forbidden
- Follow the limit of pressure and flux suggested for each process, as reported by the manuals or recommended by the cleanroom Staff

Almost any material can burn in a pure oxygen atmosphere and therefore the oxygen concentration can change the classification of a material from non-flammable to flammable. Human bodies burn rapidly in pure oxygen. Users that work with oxidants must follow the safety rules of every machine and carefully follow the pressure and flux limits reported in the machine manuals. Only the Staff can perform hardware modification taking care of the technical requirements of the systems and of the safety related to the use of oxidants (e.g. vacuum pumps operated with FOMBLIN).

Toxic and explosive gases

In PoliFAB, Ammonia (NH₃) and Silane (SiH₄) are used as precursor gases for the Chemical Vapor Deposition (CVD) system, located at the Thin Films (operator side) area and at the Grey Corridor (machine side). Being those gases extremely dangerous (ammonia is mainly toxic and silane is explosive), the lab is equipped with sensors (2 for each gas) that are controlled by a dedicated control unit. **All users must know the access procedure and how to behave in case of emergency, even if their activity is not related to the CVD system. Each user also has to know the danger connected to those gases and the first aid measures explained in this document. In the following table we show the hazards for each of the two gases.**

Gas	Hazard H	Hazard description
Ammonia (NH ₃)	221	Flammable gas
	280	Contains gas at high pressure; Can explode if heated
	331	Toxic by inhalation
	314	Causes severe burns to skin and eye damage
	400	Very toxic to aquatic life
	EUH071	Corrosive to the respiratory tract
Silane (SiH ₄)	220	Extremely flammable gas
	280	Contains gas at high pressure; Can explode if heated

We stress that ammonia is extremely toxic and can cause, if inhaled, serious pulmonary edema. Ammonia is also flammable, although with a small flammability region; however Silane is extremely flammable, while it is not considered as toxic.

In order to ensure the user safety, gas sensors (2 for each gas) are installed close to the CVD machine and a gas control unit is located right before the cleanroom entrance, outside of the first air-lock. Sensors and control unit are equipped with an acoustic and visual alarm which shows the status of the system. Before entering the cleanroom users have to check the status of the control unit.

OPERATIVE INSTRUCTIONS: users are requested to check the status of the traffic light located on top of the control unit. It can display 3 different color lights: red, yellow, green.

RED LIGHT: this light is on only in case of detection of one (or both) gas in ambient and the acoustic alarm is also on. The system will also block the supply of oxidant gases (O_2 , N_2O). The cleanroom access is forbidden and users have to immediately evacuate from the cleanroom through the emergency exit of the lab and reach the collection point (gate towards via Pascoli). In case the emergency exit of the cleanroom is blocked or the access through it not possible, it is recommended to leave the cleanroom via the first air-lock, leaving its two doors open for the other users. The collection point can then be reached via the corridor outside of the cleanroom.

YELLOW LIGHT: the access to the cleanroom is possible, since no leak of NH_3 nor SiH_4 has been detected. However the supply of ammonia and silane is blocked either because the bottles are closed or because of a minor issue with the control system, with no danger for the safety. Any other gas, including oxidant, can still be used. In this configuration, evacuation from the laboratory is not necessary and no alarm will be present. Most of the times, for safety reasons the bottles of silane and ammonia are kept closed at the bunker gas, therefore the yellow light status is the most typical to observe.

GREEN LIGHT: no issue has been detected by the control unit and both bottles are open. Access to the cleanroom is possible. All gases, including the two dangerous are available.

Di seguito, riportiamo una tabella indicante il principio di funzionamento del sistema di gestione dei gas in base alla colorazione dei semafori con descrizione del rispettivo stato, possibilità di accesso, bloccaggio dell'erogazione di gas e necessità di evacuazione degli utenti presenti il laboratorio.

Light	Status	Access	Blocked gas	Evacuation
RED	Gas leakage	NO	NH_3 , SiH_4 , O_2 , N_2O	YES
YELLOW	Malfunction	YES	NH_3 , SiH_4	NO
GREEN	Working	YES	-	NO

Emergency

In case of accident during the operations the users have to behave maintaining the highest safety for themselves and the others. Even in case of accidents without consequences to people or instruments users have to report about it to the cleanroom Staff. Users also have to keep the Staff informed about situations that can be potentially harmful for users safety or that are in

disagreement with the instructions present in the present and in the other instruction and safety documents.

In case of dangerous gas leakage the visual and acoustic alarms will be on and all users have to immediately evacuate the cleanroom through the emergency exit of the lab and reach the collection point (gate towards via Pascoli). In case the emergency exit of the cleanroom is blocked or the access through it not possible, it is recommended to leave the cleanroom via the first air-lock, leaving its two doors open for the other users. The collection point can then be reached via the corridor outside of the cleanroom.

In case of health emergency, defined as any situation where one or more users show (even small) health problems, it is necessary to evaluate the danger. Only after a careful evaluation it is possible to proceed, helping the injured person(s). At the same time users have to inform the Staff. In the case of potential danger for other users, activate the fire alarm. If no Staff person is available it is possible to call Portineria Centrale of Politecnico (9300) and, only if also there nobody replies, call 118. Considering the nature of the two dangerous gases the access to the areas possibly contaminated by them is possible only to the Staff wearing a rebreather. However every user has to know about the first aid measure contained in the the safety documentation attached to this document.

In case of fire, activate the fire alarm by the dedicated button and inform the Staff. If the fire alarm is heard, immediately leave the working place, evacuate through the closest emergency exit and reach the collection point. In case the emergency exit of the cleanroom is blocked or the access through it not possible, it is recommended to leave the cleanroom via the first air-lock, leaving its two doors open for the other users.