

June 28, 2021

**Brief on safety handling of gas cylinders at the University**

Explanations for the table: The concept PAC-2 defines the gas concentration that an unprotected individual can breathe without irreversible damage to his health for a given time.

Standard NFPA 704 defines four types of hazards, and for each type there are five levels from 0 [0=no hazard] to 4 [4=maximum hazard]. The four types are: F = fire hazards, H = health hazards such as toxic dangers, R = reactive or responsive or explosive, ~~W~~ = reaction with water [for the most part] whereas the intention is to prevent contact with water [or other common material].

These data are very important because they define the type of hazard, the level of hazard, and the level of respiratory hazard to an individual without a gas mask for periods of 10 minutes, 39 minutes, or 60 minutes.

The table of the hazardous gas cylinders in use at the University appears below.

List of some of the hazardous gases found at the University

Name of gas	Gas concentration	Definition of types of hazards according to NFPA 704: F, H, R, <del>W</del> [0 to 4]	PPM hazard PAC-2/10 min	PPM hazard PAC/30 2 min.	PPM hazard PAC-2 / 60 min.
Silane	0.1% in H <sub>2</sub>	4F, 1H, 3R: highly flammable, reactive	170	170	130
Phosphine	% in H <sub>2</sub>	4F, 4H, 2R: flammable and highly toxic	4	4	2
Germane	Pure & in H <sub>2</sub>	4F, 4H, 3R, <del>2W</del> : very hazardous	0.3	0.21	0.17
Diborane	% in H <sub>2</sub>	4F, 4H, 3R: very hazardous	2	2	1
Ammonia	Pure	1F, 2H, 0R: toxic, very flammable	220	220	160
Nitrous oxide N <sub>2</sub> O	Pure	Not flammable, oxidant			10,000
Carbon monoxide	Pure	4F, 2H, 0R: highly flammable, toxic	420	150	83
Hydrogen	Pure	4F, 0H, 0R: highly flammable and explosive			230,000
Fluorine	Pure	0F, 4H, 4R, <del>W</del> : toxic and highly reactive	20	11	5
Acetylene	Up to 35 %	4F, 0H, 3R: flammable and highly explosive			2,500
Propylene	Pure	4F, 1H, 1R: highly flammable			10,000
Butene , Butylene	Pure	Flammable gas			ND
Ethylene	Pure	4F, 2H, 2R: highly flammable, toxic			1,500
Methane	Pure	4F, 2H, 0R: highly flammable			5,000
Ethane	Pure	4F, 1H, 0R: highly flammable			5,000

### **Receiving cylinders from the supplier**

1. The supplier must transport the hazardous cylinders in a vertical position.
2. The supplier must bring each cylinder of gas defined as hazardous directly to the location for connection of the gas for the lab that placed the order, while coordinating in advance with the PI or the lab manager.
3. The supplier will unload the cylinder/s using a designated cart until arriving at the lab, and in the presence of the PI, the lab manager, or someone on his behalf.
4. A situation in which a cylinder will not remain in a vertical position, even for a short time, is impermissible.
5. An employee of the lab and an employee of the supplier will place one or two cylinders in the designated cart for gas cylinders, and secure each cylinder separately with a chain attached to its upper third part.
6. At this stage, the lab employee must check the data written on the cylinder itself, and on the shipping certificate, in order to check that it corresponds with the order. He must also check that the date of the hydrostatic pressure test of the cylinder is still in effect.
7. The lab employee will transfer the cylinder to the designated place, unload it and secure it in place with a chain. When it has been secured in place, he will return to the door and to the supplier's employee to intake another cylinder, if there is a need for that.
8. If necessary to connect the cylinder to the system, it will be done by a worker who has had theoretical and practical training by the gas supplier.
9. Upon completing the unloading, the checks, transfer and affixing, the lab employee will sign the shipping certificate.

### **Storage of hazardous gas cylinders in labs**

1. The hazardous gas cylinders will only be stored outside the building in locations marked that they were approved in advance by the Safety Department, and they will be equipped with signs with the chemical name and UN numbers of the contents of the cylinders. Likewise, there will be signs for an empty cylinder and a full cylinder.
2. The storage places for each group of cylinders will be determined in consideration of the potential hazards, such as leakage of a given cylinder, in order to prevent interaction with neighboring cylinders. For example: a hydrochloric acid cylinder will not be installed next to a cylinder of ammonia, and a butylene cylinder will not be installed next to an oxygen cylinder.
3. On the wall next to each group of hazardous cylinders, a full printout of the MSDS suited to the gas will be hung on the wall in a plastic wrapping open at the top, and it will be reprinted every 6 months. The language of the MSDS should be Hebrew, but if there is no MSDS for the material in Hebrew, the MSDS will be presented in English.
4. All activities with hazardous gas cylinders will be executed by only two skilled workers who have undergone training on the subject.
5. All of the cylinders will be fixed to the wall with chains arranged at a height of 2/3 of the height of the cylinder. Ropes, electric cables, or reinforced fabric strips for lifting are not to be used.
6. In every lab where toxic/flammable gas is used, there must be an emergency cupboard containing 2 full gas masks with ABEK-2-CO filters, and 2 pairs of long chemical gloves, and 2 pairs of thermal gloves.

### **Transport and issuing hazardous cylinders**

1. No hazmat cylinder should be turned or lifted in a horizontal position. The manual cart must be attached below it when it is still secured to the wall with the chain, and release it only when it is standing on the platform of the cart, and then secure it to the cart with its chain. Then, the cart can begin to move the cylinder to the place where it is needed.
2. The cylinder should be unloaded and fixed to its location, secured in place with the chain intended for positioning it.

### **Handling a cylinder that falls during transport or a cylinder leaking in its storage place or from where it feeds into the lab**

1. The workers will be equipped in advance with full gas masks with a standard filter, suited to the type of gas or the universal ABEK-2 type, in order that they will be prepared to act in the event that a gas cylinder falls from the cart.
2. A fallen cylinder is not to be approached to check for leakage.
3. First, the Security Department should be notified at telephone 03-6405555 and they will alert the Safety Department and other parties.
4. The workers must distance all people from the place until the arrival of the security people from the University.
5. The security and safety people will come urgently to the site and will be equipped with standard gas masks and gloves for chemicals.
6. If it is ascertained that there is no leakage, everything will resume operating as it had been beforehand.
7. If it turns out that there is leakage, the instructions of the person who oversees chemical safety at the University will be followed. For example: distancing people, closing windows in nearby buildings, and even evacuation of employees.
8. In the event of a fire that cannot be controlled, the fire and rescue services should be alerted, at telephone 102, and provided with a detailed description of the incident.
9. Until the experts arrive, the safety people must evacuate the public in accordance with the distances required by the PAC-2 coefficient which enables a person without respiratory protection to remain for up to an hour, in order to enable a person to flee while still standing in the direction of the wind.

### **Regulation for detaching and connecting a gas cylinder**

1. A cylinder will only be replaced by skilled workers who have had theoretical and practical training by an expert in the field or by the gas supplier.
2. A gas cylinder should never be replaced alone. There must always be two people present.

### **Replacing flammable/toxic gas**

1. With every replacement of flammable and/or toxic gas, two sets of personal protection equipment (PPE) for handling the situation must be brought close to the site. The PPE should include a gas mask with suitable filter that has not expired, protective glasses and gloves. In the event that the MSDS requires open breathing systems, then there must be an opening breathing system and a suit that is impermeable to gases.
2. Attend to transferring the full cylinder to the location where it is needed, using a suitable cart.

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3. Attend to transport of the full cylinder, using an appropriate cart.
4. The lines of the "empty" cylinder should be rinsed several times with nitrogen, purging it, using the automatic panel, and according to the manufacturer's instructions.
5. After the rinsing, shut the main valve of the cylinder and check for leakage.
6. Exercise extreme caution when opening the connection to the cylinder, while you check for leaks using a detector or a leak locating kit. Wait a few seconds after the initial opening, and then continue releasing the connection. Check leaks!
7. In the event that no gas leakage is discovered, take the cylinder out of the closet and place the full cylinder in its place.
8. Move the "empty" cylinder to the cart in order to remove it.
9. Close the connection securely, and vacuum and rinse the lines, following the manufacturer's instruction.
10. Adapters are not to be used – every gas has its own screwing mechanism, as well as its own pressure regulator which it is absolutely, positively forbidden to replace with another.
11. Cautiously begin opening the cylinder, the valves, and the hoses step by step. At every stage, there should be a check for leaks.

### **Replacing inert gas**

1. Securely close the "empty" gas cylinder and release the gas trapped in the hose, only if it is inert gas.
2. Wear mechanical gloves and protective safety glasses, and release the pressure by slowly opening the connection after the valves. Make sure there is another person in the area.
3. Disconnect the gas from the point where it is secured, move it, and install the new cylinder in its place and secure it tightly with the chain.
4. Screw the new cylinder in place.
5. Adapters are not to be used – every gas has its own screwing mechanism, as well as its own pressure regulator which it is absolutely, positively forbidden to replace with another.
6. Load the "empty" cylinder on the cart and transfer it to the appropriate place.

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