Polytechnic University of Turin

Department of Applied Science and Technology

Guide to the use of cylinders

For compressed, dissolved, or liquefied gases

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Document for internal use

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Summary

1 Purpose

This guide provides general guidance on how to work with pressurized gas cylinders. It is addressed to all personnel working in the department's laboratories (students, fellows, PhD students, technicians and faculty).

2 Pressure vessels

A first existing distinction between pressure vessels is based on the physical state of the contained fluid; in fact, the gas may, due to high pressure, be liquefied (e.g., carbon dioxide) or dissolved in a solvent (e.g. acetylene in acetone); therefore, we speak of pressure vessels containing "compressed gases" if the critical temperature of the contained gas is below -10°C, "liquefied gases" if the critical temperature of the fluid is greater than or equal to -10°C, and "dissolved gases" if the gas is solubilized in a solvent. It should be noted that liquefied gases should be distinguished from "refrigerated liquefied gases," i.e., those that are liquid at cryogenic temperatures (e.g., liquid nitrogen), which require special vessels.

Current regulations classify vessels containing compressed, liquefied or dissolved gases on the basis of their capacity, expressed in liters, and on how they are constructed, that is, whether the vessel consists of a single piece or has welds. In fact, a cylinder is defined as a transportable receptacle intended to contain pressurized fluids constructed of steel (or light alloy) and consisting of a single piece having a capacity of between 5 and 150 liters, while in the presence of welds, the term "drum" is used. When the capacity of the vessel is between 3 and 5 liters, the term "small cylinder" is adopted, which becomes "small drum" in the presence of welds. When the capacity is less than 3 liters, the term "small canister" is used or, if the container has welds, "bottle."

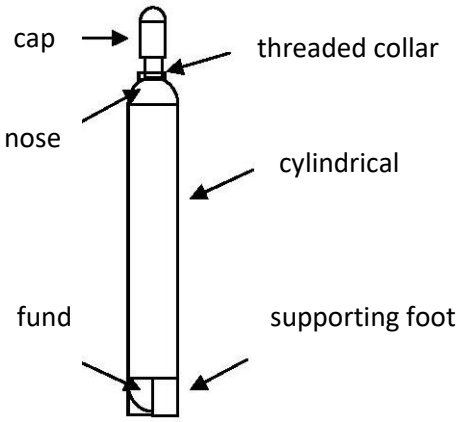
In this guide, the term "cylinder" will be used in a general sense to include all vessels containing compressed, liquefied or dissolved gases with a capacity between 3 and 150 liters regardless of whether or not they are welded: therefore, only canisters and bottles are excluded.

A cylinder normally consists of:

- An ogive (tapered top);
- A valve located above the ogive;
- A threaded collar (on the ogive);
- A screwable protective cap on the threaded collar;
- A cylindrical body;
- A fund;
- A support foot or hoof (surrounding the bottom).

The cylinder valve is the most delicate and vulnerable component to shocks; as a rule, this valve is handwheel operated to prevent its rapid opening. When the cylinder is not in use and, in particular, during its handling, the valve is protected from impact or tipping by the presence of a cap screwed onto the threaded collar. In some cases, for particularly hazardous gases, the cap is fixed, but it is usually removable. If the cap is of the fixed type, no attempt should ever be made to remove it by force; if it is removable, it should always remain screwed to the threaded collar when the vessel is not in use, that is, not connected to the gas distribution line. The cap has openings, aeration holes, which

are intended to allow a way to vent gas flow in case of gas leaks from the valve. The plinth**,** or support foot, allows the cylinder to be kept stable in an upright position; in addition, by raising its domed bottom off the ground it protects it from impact, rubbing, and, in the presence of moisture, corrosion.



2.1 Testing and Review

Cylinders, prior to their use, are tested; thereafter they are periodically overhauled. The duration of the overhaul depends on the dangerousness of the gas contained; generally it is ten years but, for example, in the case of hydrogen and carbon monoxide the duration is five years. The cylinder overhaul certificate is kept by the owner (supply company), the user is not required to have even a copy of it; however, the date of the last overhaul and the date of expiration are, however, available to the user as they are marked by stamping on the ogive of the cylinder. It should be borne in mind that, although the overhaul is the responsibility of the owner, the user has a duty to deliver cylinders with an expiring overhaul to the supplier company; in fact, he or she is legally responsible for the consequences that may result from the use and storage of cylinders without a valid overhaul.

2.2 Punching, labeling and coloring

Information about the cylinder and its contents is provided on the nosepiece by permanent marking (punching), affixing a label and coloring it depending on the type of gas it contains.

2.2.1 Punching

Current regulations require that a set of data be indicated by punching stamped on the ogive of the cylinder. In this context, the regulations by the term punching mean any permanent marking applied to cylinders by carbide stamping, engraving, casting or other similar methods. The mandatory data, which change depending on whether the fluid is compressed, liquefied, or dissolved, are all applied to one side of the nosepiece, known as the front side; additional data may be on the back side of the nosepiece. The most imported data are the trade name, the test agency stamp with the test date (month/year), and any additional test agency stamps with corresponding revision dates.

2.2.2 Labeling

A cylinder has a label that includes: the name, address and telephone number of the supplier; product identifiers (trade name, UN number, CAS number, etc.); hazard pictograms; warnings (one of the following words depending on the severity of the hazard: caution, danger); hazard statements (standard phrases describing the nature of the hazard); cautionary statements (standard phrases describing recommended prevention, response and storage measures); and a section for additional information, if any.

Because the cylinder fulfills the dual role of packaging for transport (subject to the regulations for the transport of dangerous goods) and a container for use (subject to the name for the use of dangerous products), its labeling differs from that commonly found on containers of chemicals found in laboratories. Specifically, as far as pictograms are concerned, those provided for transport are supplemented with those required by the regulations concerning use.

Regulations regarding packaging for the transportation of gases under pressure require the marking of possible hazards by the following pictograms:

N° 2.2

N° 2.1

N° 2.3

N° 5.1

N° 8

Environment

No. 2.2: Non-flammable and non-toxic gas

No. 2.1: Flammable gas

No. 2.3: Toxic gas

No. 5.1: Oxidizing material, complete label 2.2 or 2.3 for oxidizing gases

No. 8: Corrosive material, complete label 2.3 for toxic and/or corrosive gases

Environment: Material hazardous to the aquatic environment

The presence of hazards not covered by the Dangerous Goods Transport Regulations, but provided for in EU1272/2008 (CLP Regulation) requires the addition, when necessary, of the following pictograms:

be painted any color as long as this does not pose the danger of misinterpretation.

The current codification is shown in the table below.



GHS04 GHS08 GHS07

GHS04: Gas under pressure, in the absence of the label 2.2

GHS08: Gas hazardous to health : respiratory sensitization, mutagenicity or carcinogenicity or reproductive toxicity or specific toxicity to certain target organs

GHS07 Acute toxicity category 4 gas or source of skin irritation, eye irritation, or skin sensitization or toxic to certain target organs or respiratory tract irritant or narcotic effect

Example of a label

Company xxx - Street xxx - tel. xxx

A 1049 COMPRESSED HYDROGEN

DANGER

Contains gas under pressure; can explode if heated.

Highly flammable gas.

PREVENTION

Keep away from heat sources/sparks/open flames/heated surfaces. - Do not smoke.

CE NO.: 215-605-7

REACTION

In case of fire due to gas leakage, do not extinguish at

Unless the leak can be stopped safely.

Eliminate all ignition sources if there is no danger.

CONSERVATION

Store in a well-ventilated place.

ADDITIONAL INFORMATION

Close the valve after use.

2.2.3 Color code of the ogive

The nosepiece of a cylinder is painted with one or two colors (horizontal stripes) indicating the main hazards that can be associated with the gas contained. However, there are exceptions concerning more commonly used gases and gas mixtures, for which a particular coloring has been defined. The color coding applies only to the nosepiece of cylinders; the cylinder body can, in general, be painted any color as long as this does not pose a danger of misinterpretation.

The current codification is shown in the table below.

Table 2.1 - Color code of the ogive.

Gas type	Ogive color	RAL Code
Toxic and/or corrosive	Yellow	RAL 1018
Flammable	Red	RAL 3000
Oxidant	Light blue	RAL 5012
Inert	Bright green	RAL 6018
Specific gases:		
Acetylene	Reddish brown	RAL 3009
Oxygen	White	RAL 9010
Nitrous oxide	Blue	RAL 5010
Inert gases for medical use:		
Argon	Dark green	RAL 6001
Nitrogen	Black	RAL 9005
Carbon dioxide	Gray	RAL 7037
Helium	Brown	RAL 8008
Mixtures for medical and respiratory use		
Air or synthetic air	Black and white	
Helium/oxygen	White and Brown	
Oxygen/carbon dioxide	White and gray	
Oxygen/nitrous oxide	White and blue	

3 Pressure reducers

A pressure reducer is a device used to reduce the pressure of a gas and regulate its delivery. It is a precision instrument and must be treated as such; it must be protected from accidental shock and contact with dust, oil and other impurities; it is never to be used if it malfunctions.

A typical cylinder reducer consists of an inlet fitting, a central body, and an outlet fitting. The inlet fitting can be connected directly to the cylinder valve (the type of fitting depends on the type of gas). The central body has connected two pressure gauges, one indicating the pressure in the cylinder and the other the pressure downstream of the reducer, and a handwheel to adjust the outlet pressure and consequently the gas supply. Finally, the outlet connection is connected to a needle valve and thus to a pipeline for gas distribution.

4 Dangers from cylinders

The main cause of danger common to all cylinders is the high compressive energy of the gas contained in them, which if released due to impacts, falls, or upon failure of the container material can cause damage to property or persons. Consequently, cylinders are constructed to be very strong; however, as a consequence we have the fact that their weight is often high, so even if the container withstands impact, there is still a danger that an operator hit by a cylinder could suffer significant damage. Additional sources of danger are due to the inherent properties of the gas contained; in fact, in the event of accidental release, the gas can generate flammable, explosive, toxic, or asphyxiating atmospheres.

Bumps and falls must be avoided at all costs. Cylinders must always be stably anchored both during transport (performed on special trolleys equipped with chains) and in use or storage depots; since the most vulnerable point of a cylinder is its valve, it must always be protected by a cap screwed to the threaded collar of the nosepiece when not connected to a gas distribution line. When handling a cylinder, operators should wear gloves and safety shoes; gloves provide a good grip on the cylinders and prevent leaving traces of grease (we mean that which is naturally present on the skin), which becomes particularly dangerous in the case of oxidizing gases; safety shoes reduce the possibility of operators slipping and protect the toes from being crushed, which, in the case of heavy cylinders, can have permanent consequences.

In addition to bumps or falls, possible damage to cylinders can be caused by corrosion and exposure to high or low temperatures. To avoid corrosive phenomena, cylinders should be placed in ventilated and non-humid locations. Regarding the effect of temperature, a cylinder is usually designed to operate at a maximum temperature of 50°C and, if it is made of steel, at a minimum temperature of -20°C (lower temperatures require the use of special alloys). Thus, one has that high temperatures can cause leakage problems (ogive valve connection) and, in extreme cases, vessel failure. Fires, in particular, can cause a cylinder to explode due to overheating; this event is particularly feared by firefighters. Cylinders can be protected from overheating due to fire by placing them in special insulated cabinets. In general, cylinders should be protected from sunlight and other heat sources such as radiators (radiators), furnaces etc. Regarding low temperatures, these cause embrittlement of the container, which facilitates its rupture. Particularly in the case of liquefied gases, it should be borne in mind that if a cylinder feeds a distribution line with very high flow rates, low temperatures can be reached due to evaporation-induced cooling of the fluid.

The danger from accidental gas leaks makes it preferable to place cylinders in ventilated places (outdoor storage or ventilated cabinets); the use of gas detection systems equipped with an alarm signals emergency situations.

5 Cylinder storage and cabinets.

The ideal location for a cylinder is in a dry, well-ventilated, cool outdoor storage area (protected from solar radiation or other heat sources). For some types of cylinders, this is the only permissible placement: toxic gas cylinders and explosive gas (acetylene) cylinders should not be in laboratories or other enclosed places at all. Other cylinders may be placed either in outdoor storage or in laboratories; however, those that can be placed inside laboratories must still comply with a number of restrictions; in particular, air and inert gas cylinders must be anchored to a wall or other stable support; and flammable, oxidizing and noxious gas cylinders must be placed in G90-type cylinder cabinets that comply with European standard EN 14470-2. Flammable, oxidizing, toxic and noxious gases require a detection system equipped with specific sensors in the laboratory; in the case of inert gases, oxygen sensors are required in case of danger of under-oxygenation.

The **Laboratory Manager** in agreement with the **Managers of the Teaching and Research Activities** who use the gases, determines the quantity and type of cylinders that are allowed in the laboratory and outside storage rooms. The gases that are allowed must be marked at both the laboratory and depot entrances.

In general, the following criteria must be met:

- In all laboratories, cabinets and storage facilities, cylinders should always be **stably anchored in an upright position** and **protected from sunlight or other heat sources**.
- Cylinders should never be placed in environments (laboratories, cabinets, storage rooms) that would expose them **to excessive moisture or corrosive chemicals**. Rust damages the vessel shell and causes the cap to become blocked.
- Cylinders containing **gases that are incompatible with each other** should always be placed in separate cabinets or in different storage rooms or, in the case of the same storage room, in separate compartments so as to avoid dangerous reactions such as explosions or fires (e.g., oxygen-hydrogen, oxygen-ammonia, chlorine-hydrogen should be separated). In particular, flammable gases (hydrogen, methane, etc.) should therefore be kept separate from oxidizing gases (oxygen, nitrous oxide, etc.), and again, ammonia should be separated from acid gases (hydrogen chloride, etc.).
- Cylinders containing **explosive gases**, such as acetylene cylinders, cannot be placed in laboratories, they must necessarily be placed in appropriate outside storage facilities. The laboratory served must have a gas leak detection system equipped with an optical-acoustic alarm and automatic flow interception in case of an emergency. The interception must be outside the building.
- Cylinders containing **flammable gases** can be placed in an outside storage area or in a laboratory; in the latter case, they must be placed inside a ventilated cylinder cabinet with 10 changes/hour. The interior of the cabinet and the extraction system must meet the regulations for explosive atmospheres (ATEX). There must be a gas detection system in the laboratory with optical-

acoustic alarm and automatic flow interception in case of emergency. The shutoff valve must be placed inside the cabinet or outside the building in case a storage facility located outdoors is used.

- Cylinders containing **oxidizing gases** may be placed in an outside storage room or in a laboratory; in the latter case they must be placed inside a ventilated cylinder cabinet with 10 changes/hour. The laboratory must have a gas detection system with an optical-acoustic alarm and automatic flow interception in case of emergency. The shutoff valve must be placed inside the cabinet or outside the building in the case of using storage located outdoors.
- Cylinders containing **toxic gases, e.g.,** carbon monoxide **gas,** cannot be placed in laboratories; they must necessarily be placed in appropriate external storage facilities. The laboratory served must have a gas leak detection system equipped with an optical-acoustic alarm and automatic flow interception in case of an emergency. The interception must be outside the building.
- Cylinders containing **noxious gases** may be placed in an outside storage area or in a laboratory; in the latter case, they must be placed inside a ventilated cylinder cabinet with 120 changes/hour. The laboratory must have a gas detection system with an optical-acoustic alarm. The shutoff valve, which may be manual, must be placed inside the cabinet or outside the building in the case of using a storage facility located outdoors.
- Cylinders containing **inert gases** can be placed in an outside storage area or in a laboratory anchored to a wall or other stable support. If the gas is carbon dioxide, the laboratory must have an optical-acoustic alarm detection system with sensors for this specific gas. For other inert gases, an oxygen detection system equipped with an optical-acoustic alarm is required only if there is a danger of asphyxiation. Emergency shut-off may be manual. If the storage facility is outdoors, the shutoff valve should be outside the building.
- Cylinders containing **air** can be placed in an outdoor storage room or in a laboratory anchored to a wall or other stable support.

6 Handling of cylinders

When moving cylinders, the following precautions should be taken:

- **Use gloves**. The operator must wear gloves during handling operations. Cylinders **should not be handled with hands or gloves greasy with oil or** grease-this rule is especially important when handling containers of **oxidizing gases (e.g.,** oxygen or nitrous oxide).
- **Use safety shoes** to protect your feet...
- **Use trolley**. Handling should be done even for short distances only by a suitable trolley that allows the cylinder to be arranged vertically, securing it firmly, usually by means of a chain, to prevent falling and toppling over.
- **Always screw on the protective cap.** The purpose of the cap is to protect the cylinder dispensing valve from mechanical shocks so it is a good idea to make sure that cylinders are fitted with the cap before handling them.
- **Avoid shocks and falls**. Cylinders should be handled with care by avoiding violent shocks, falls or mechanical stresses that may compromise their integrity and strength.
- **Do not lift cylinders off the canopy**. Cylinders should not be lifted from the cap, dragged, rolled or slid on the floor.

- **Do not leave cylinders** near freight elevators, or in places where heavy moving objects can bump into them and cause them to fall.

7 Placement of cylinders

- **Place cylinders only in laboratories, cabinets and storage rooms where they are allowed**: comply with signs and restrictions on the number and type of gases. If in doubt, contact the **Laboratory Manager** or the **Head of Teaching and Research Activities**.
- The only cylinders allowed in the laboratories are those **in use** (i.e., connected to the distribution network), and those for **ready replacement** (reserve cylinders for one quickly available to replace those in use). Only one spare cylinder is allowed for each cylinder in use; **no other cylinders are allowed to be stored in the laboratories**.
- Cylinders should always be **secured by chain** or to another solid support. **Only after securing them can the protective cap be removed**.
- Cylinders must always be placed **upright (nosepiece on top) in an upright position**. It is forbidden to use cylinders in a horizontal or upside-down position. In fact, in the case of liquefied or adsorbed gases (e.g., acetylene) the liquid part could come in contact with the inside of the valve and result in large spills.
- Cylinders should be placed in such a way that they are **protected from any object that could cause them to be cut or other abrasion** on the metal surface.
- Cylinders must be placed so that they can never become **part of an electrical circuit.**

8 Precautions in use

- Carefully read the **safety data sheet of** the gas you intend to use.
- To be familiar with the operating and emergency procedures prepared by the **Laboratory Manager** in consultation with the **Heads of Teaching and Research Activities.**
- Equip yourself with the required **Personal Protective Equipment** as listed in the MSDS (e.g., individual gas detectors, gas masks, etc.).
- Verify that the use of gas is permitted in the laboratory in which you intend to work; in particular, **verify the presence of the required gas detection systems**.
- Check the cylinder's expiration date. Never use **cylinders with expired revision period**.
- **Use cylinders only to contain the gas for which they were built and tested**; do not use the cylinder in its own way (e.g., as a roller, anvil, or support) and avoid transferring from one cylinder to another.
- **Never lubricate cylinder valves**, this operation is not necessary can be dangerous. **It is absolutely forbidden to use oil, grease or other combustible lubricants** on the valves of cylinders containing oxygen and other oxidizing gases.

8.1 Limits on cylinder temperature

- **Cylinders cannot be heated to temperatures above 50°C**.
- **Cylinders should not be cooled at very low temperatures**. Many types of steel lose ductility and embrittlement at low temperature. The temperature limit for steel cylinders is -20°C.
- In the case of high flows from cylinders with **liquefied gases** consider that there may be an **abrupt drop in cylinder temperature** that may compromise the strength of the material.

8.2 Content verification

Before opening the dispensing valve, make sure of the gas contained. The gas can be identified by the cylinder label and the trade name stamped on the nosepiece. Information on the type of gas is also provided by the coloring of the ogive and the type of connection of the cylinder handwheel valve. The user **must not erase or make illegible the** markings, or remove the labels, decals, tags attached to the receptacles by the supplier for identification of the gas contained.

8.3 Pressure reducer connection

- **Always use pressure reducers**. Never check if there is pressure by directly opening the valve of a cylinder: if it is empty you will pollute it, if it is full you can cause serious damage.
- Ensure that the reducers are up to code and calibrated to **withstand a pressure 20% greater than the maximum cylinder pressure** (this information is stamped on the nosepiece).
- Before connecting a reducer to it, **check that the fitting is in good condition** and is free of dirt, oil etc.
- Do not fit pressure reducers, pressure gauges, hoses or other equipment designed for a particular gas or group of gases **to vessels containing gases with different and incompatible chemical properties.**
- Before and after use, check that the **reducer is adjusted for minimum flow**.
- If **backflow of gas** into the cylinder is possible (e.g., for low-pressure flows), a **check valve** must be installed **on the line**.
- **Any mechanical action or modification to the gearboxes is prohibited**.
- Shall not **change, modify, tamper with, plug any safety devices that may be present** and in case of gas leakage shall not make repairs on filled vessels and valves.
- **No part of the cylinder reducer or valve should be lubricated**. Lubricants in contact with oxidizing gases such as oxygen or nitrous oxide may result in combustion or explosion.

8.4 Valve opening and dispensing control

- Opening the valve of a cylinder is allowed **only after it has been anchored** and a **pressure reducer is** present.
- The **cylinder valve should be opened gradually and slowly** while remaining as far away from it as possible. Opening the valve too quickly can cause an abrupt rise in temperature inside the reducer resulting in **damage to internal parts** and, in the case of oxidizers, the **possibility of ignition of fire in non-metallic parts**.
- **Never use wrenches or other tools** to open or close valves equipped with handwheels. For valves that are hard to open or seized due to corrosion, or if the valve or fitting appears damaged contact the supplier for instructions. Forcing the opening can compromise the integrity of the valve and cause dangerous gas leaks.
- After opening the cylinder valve, **check for leaks** at the inlet connection, from the gauge connections, and from the pressure reducer safety valve. The tightness of the circuit should be checked with leak detectors or simply with soapy water, never with a flame.
- If there are no leaks, open the needle valve downstream of the reducer and adjust the gas supply by turning the hand wheel of the reducer.

- At the end of use, **close the cylinder valve and discharge the gas contained in the reducer** (the cylinder valve should remain open only when the gas is used**),** close the pressure reducer valve and finally the needle valve.

8.5 Depleted cylinders

- **Always leave a slight overpressure** inside the vessel so as to prevent changes in ambient temperature from causing air to enter when the cylinder without a reducer is opened (e.g., in the refilling stage performed by the supplier).
- When the **cylinder is exhausted, it is necessary to** make sure, before returning it, that **the cylinder valve is tightly closed**, then it is necessary to screw the blind cap, if any, on the valve nozzle and **put the protective cap back on**.
- Exhausted cylinders should be marked by writing the word **"EMPTY"** on the cylindrical body with chalk.
- Empty cylinders should always be placed clearly **separated from full cylinders**.
- Place empty cylinders containing **incompatible gases in separate storage facilities/compartments**.

Standards of conduct in cylinder handling

Handling of cylinders

- Use gloves and safety shoes.
- Using the trolley.
- Always screw on the protective cap.
- Avoid shocks and falls.
- Do not lift the cylinders from the cap.
- Never leave cylinders unattended.

Placement of cylinders in laboratories

- Place cylinders only in laboratories, cabinets, and storage rooms where they are allowed by complying with signs and restrictions on the number and type of gases.
- Secure cylinders by chain or to another solid support.
- Arrange the upright cylinders (ogive on top) in an upright position.
- Do not place cylinders in places where they could become part of an electrical circuit.

Precautions in use

- Never use cylinders with expired overhaul period.
- Always make sure of the gas in the cylinder before using it. Read the gas safety data sheet and equip yourself with the required Personal Protective Equipment.
- Connect a pressure reducer according to standards with a clean fitting in good condition. If necessary, install a check valve on the line.
- No part of the reducer or cylinder valve should be lubricated.
- The cylinder valve should be opened gradually and slowly. Never use wrenches or other tools to open or close valves equipped with handwheels.
- After opening the cylinder valve, check for leaks.
- Adjust the gas supply by turning the hand wheel of the reducer.
- At the end of use, close the cylinder valve, drain the gas contained in the pressure reducer, and finally close the pressure reducer valve.

Exhausted cylinders

- Consider the cylinder exhausted when there is slight overpressure inside the vessel. When you are in this condition, close the valve, remove the pressure reducer, put the protective cap back on, write EMPTY with chalk on the cylindrical body, and transport the cylinder to the storage room with a cart.
- Keep empty cylinders separate from full ones.
- Place empty cylinders containing mutually incompatible gases in separate storage facilities/compartments.