Safety advice.

Oxygen pressure regulators.

Properties

Properties of oxygen
Oxygen supports and accelerates combustion. It is slightly denser than air so a leak will collect in lower places.

Properties of materials in oxygen
Almost every material will burn in pure oxygen. Some metals burn relatively easily in oxygen, i.e. with low ignition source energy, whilst others burn less readily, i.e. they require higher levels of ignition source energy. Elastomers and other non-metallic components are more likely than metals to burn in oxygen.

Adiabatic compression
Adiabatic compression occurs when a gas is compressed rapidly without being able to dissipate heat. The direct consequence of this is that the gas temperature suddenly increases. For example, a compression from 1 bar to 200 bar causes a temperature increase from 20 °C to about 1000 °C. This may enable ignition of materials in an oxygen-enriched atmosphere.

Properties of gas containers
A compressed oxygen container stores the gas at high pressures, typically 200 to 300 bar. In this document, the term cylinder is used for both an individual cylinder and a cylinder bundle.

Properties of pressure regulators
A pressure regulator is a piece of equipment fitted to the cylinder valve which reduces the high pressure in the cylinder to a lower pressure suited to the application in question.

Note: some modern valves incorporate the pressure regulator within the design of the cylinder valve. This document describes separate pressure regulators.
The pressure regulating function is housed within the body of the regulator. It contains a pressure adjusting screw (sometimes also referred to as a handle or knob) for outlet pressure adjustment. It usually features two pressure gauges, one to indicate the pressure in the cylinder (the inlet pressure gauge) and one to indicate the pressure delivered to the application (the outlet pressure gauge). Once the outlet pressure has been set by the user, the regulator will maintain this pressure irrespective of the pressure in the cylinder.

The most common pressure regulator fire incidents are due to one of the following causes:

- Contamination – particulate inside the regulator (fuel)
- Contamination – hydrocarbon (oils or greases) inside the regulator or used on connections (fuel)
- Tightening components while trying to correct a leak during use (friction = ignition source)
- Incorrect use of spare parts, e.g. O-rings (fuel)
- Use of a regulator with damage that causes a leak (friction heat from high flow velocity leak = ignition source)
- Use of regulators which have not passed an adiabatic test (unsuitable materials = fuel; poor design = ignition source)
- Incorrect operation i.e. quick opening of the cylinder valve (adiabatic compression = ignition source)

National and international standards such as EN ISO 2503 define the design and test requirements for gas cylinder regulators and oxygen regulators.

Hazards

Fire
A fire will occur if three components are present: oxygen, combustible material (fuel) and an ignition source. In an oxygen regulator, oxygen is always present, so the objective is to minimise exposure to fuel and ignition sources.

Pressure release
When using regulators, the high pressures of gases stored in cylinders result in the following hazards:

- Leaks from the regulator itself or the connection to the cylinder can cause high pressure streams and damage the operator’s eyes or skin
- Mechanical failure of the regulator may cause parts or the cylinder to move, impacting or damaging people or equipment
Precautions

Taking into account the hazards described above, the following precautions apply when using oxygen regulators:

General
- Any pressure regulator used in oxygen service must be clearly specified and labelled for oxygen service (this ensures that the materials used in the regulator are oxygen-compatible and it has been cleaned and degreased for oxygen service)
- Never change gas service – the oxygen cleanliness inside the regulator may be compromised
- The regulator must be rated for the corresponding inlet pressure of the gas source, the required outlet pressure range and the required flow rates
- The operation and maintenance of oxygen pressure regulators must be carried out only by suitably qualified persons
- Keep the regulator and the cylinder valve connections free of flammable organic materials such as oils, greases, creams, etc.

Before use
- Never swap gauges or inlet fittings
- Before connecting a cylinder regulator to a gas cylinder valve, the valve outlet should be wiped with a clean cloth to remove any particles or other contaminants
- Before connecting the regulator, carefully check the integrity of the cylinder valve/pressure regulator connections, e.g.:
  - cleanliness and good mechanical condition of the mating surfaces
  - good condition and appropriate positioning of the gaskets or seals if fitted
- Check the connection of the regulator to the cylinder valve outlet with a suitable leak detector, approved for oxygen service
- For adjustable regulators, ensure that the regulator screw is in the “zero” position before opening the cylinder valve; then open the cylinder valve gradually. These steps will avoid adiabatic compression

Consider appropriate personal protective equipment, e.g. for eyes, in the risk assessments for activities involving the use of regulators

In use
- Users must be familiar with the correct operation and potential risks before first using a regulator; this information can be supplied with the operating instructions that come with the pressure regulator or through training provided by a competent person
- If an oxygen regulator is connected to a cutting or welding torch, a flashback arrestor must be installed to protect the regulator and the cylinder (by avoiding flashbacks)
- Always keep oxygen away from sources of ignition
- Do not operate the pressure regulator with dirty or greasy hands
- Never reverse flow through a regulator or rely upon it to act as a check valve
- Due to the hazard of pressure release, ensure that cylinders are suitable secured in a trolley or wall mount
- When opening the cylinder valve, position yourself behind the valve (opposite the pressure regulator) and open the valve gradually
- In the event of a leak on the high-pressure side, close the cylinder valve. Never try to retighten a defective connection under pressure

After use
- It is good practice to close off the control valve of the pressure regulator by turning back the adjusting screw immediately after use
- Before disconnecting the pressure regulator from the cylinder valve, make sure that the cylinder valve is closed and that the upstream pressure has dropped to atmospheric pressure
- Always disconnect the pressure regulator before transporting the cylinder

Personnel must be trained on the use of oxygen regulators, including the importance of backing the regulator off before connecting it and opening gas cylinder valves slowly to reduce the risk of excessive heat due to adiabatic compression.

Only use material, parts and substances approved for oxygen. Organic substances e.g. oils and grease are ignited extremely easily and can function as an ignition source for other more difficult to ignite materials.
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Storage and maintenance
- When not connected to a gas cylinder, oxygen regulators must be stored with inlet and outlet connections capped.
- In the event of an impact or a leak, remove the equipment from service and have it repaired by an authorised specialist.
- The regulator must be maintained and stored clean, avoiding any contamination particularly from hydrocarbons (oils and greases).
- It is recommended that regulators are maintained or replaced in accordance with the manufacturer’s instructions.

Emergency

Oxygen is an oxidiser and supports combustion. Fire will therefore be more intense in the presence of oxygen. Exposure to fire may cause containers to rupture/explode. Damaged containers must only be handled by authorised, specially trained personnel.

Leak
1. Keep combustibles (wood, paper, oil, etc.) away.
2. Stop the leak if possible – but only if safe to do so.
3. Isolate the leaking cylinder from other cylinders.
4. Oxygen is slightly denser than air, so prevent it collecting in low lying places e.g. entry into waterways, sewers, basements or confined areas.
5. Isolate the area until the gas has dispersed.

First aid
Inhalation: remove the victim to an uncontaminated area and fresh air. Ventilate clothing exposed to oxygen in the open air.

Fire
1. Use extinguishing medium suited to the type of fire.
2. Remove undamaged containers to a safe area, if safe to do so.
3. Cool containers with water from a protected position. Exposure to fire may cause containers to rupture or explode.
4. Advise the Fire Service of container locations and contents.

Refer to the oxygen Safety Data Sheet, to the Safety Advice about Oxygen Enrichment and to the manufacturer’s pressure regulator instructions for further information. Contact your local Linde supplier for any specific questions.