



Sanford

Underground Research Facility

South Dakota Science and Technology Authority

Compressed Gasses Standard

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Revision History

Rev	Date	Section	Paragraph	Summary of Change	Authorized by
01	10/4/2023	NA	NA	Initial Release	CCR 835

1.0 Purpose

It is the purpose of this standard that all risk associated with compressed gas hazards shall be managed to prevent harm to personnel. This standard documents processes, systems, and tools to mitigate risk associated with related hazards.

South Dakota Science and Technology Authority (SDSTA) complies with the following to fulfill this standard:

- Occupational Safety and Health Administration (OSHA) General Industry Standards, Compressed Gases 1910.101, Subpart H
- OSHA General Industry Standards, Permissible Exposure Limits
- OSHA General Industry Standards, Hazard Communication
- OSHA General Industry Standards, Occupational Exposure to Hazardous Chemicals in Laboratories
- ESH-(11000-S)-73328 Oxygen Deficiency Hazards Standard
- ESH-(11000-S)-73326 Cryogenic System Standard

2.0 Scope

This standard applies to all personnel using compressed gases contained in cylinders at Sanford Underground Research Facility (SURF).

3.0 Definitions

Check Valve – Equipment in piping systems to prevent the reverse flow of gas or liquids.

Compressed Gas – Gas that is stored and used at pressures greater than nominal atmospheric pressure (15 pounds per square inch absolute). Compressed gas is supplied in cylinders, compressors, portable tanks or through piping systems.

Compressed Gas Cylinder – A pressure vessel used to store gases above atmospheric pressure.

Corrosive – A substance that can cause visible destruction of, or irreversible alterations in, living tissue such as skin, eyes, and lungs by chemical action at the site of contact.

Excess Flow Control – A fail-safe system designed to shut off flow due to a rupture in pressurized piping systems.

Exhausted Enclosure – A non-combustible enclosure, such as a gas cabinet, laboratory hood, or enclosed compartment, which consists of at least a top, back, and two sides and is connected to an approved exhaust ventilation system.

Flammable Gas – a gas having a flammable range with air at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi).

Gas Cabinet – A fully enclosed, non-combustible exhausted enclosure used to store or use gas cylinders. Meets the following criteria:

- Operates at negative pressure in relation to surrounding area.
- Provided with self-closing limited access points to give access to equipment controls.
- Connected to an exhaust ventilation system.
- Provided with self-closing doors.
- Constructed on not less than 0.097 inches (12 gauge) steel.

Incompatible Gases – Gases that, when in contact with each other, have the potential to react in a manner that generates heat, fumes, gases, or byproducts that are hazardous to life or property.

Local Exhaust Ventilation (LEV) – Ventilation provided to remove contaminated air directly from its source.

Lower Explosion Limit (LEL) – The minimum concentration of a combustible gas or vapor in air that will ignite if an ignition source is present.

Maximum Allowable Working Pressure (MAWP) – The maximum pressure at which a vessel or system is designed to operate safely. This is the maximum setting for the primary pressure relief device or secondary regulator.

Oxygen Deficiency – Any condition under which the concentration of atmospheric oxygen is less than 19.5% by volume.

Physical Hazard – A chemical for which there is scientifically valid evidence that it is a combustible liquid, compressed gas, explosive, flammable, organic peroxide, oxidizer, pyrophoric, unstable/reactive, or water reactive.

Pounds Per Square Inch Gauge (psig) – Measures pressure difference from local atmospheric pressure.

Pressure Relief System – A system designed to relieve excess internal pressure from a pressurized system. Includes pressure relief devices, such as safety valves, relief valves, and rupture disks, and piping or tubing to an approved release point.

Pyrophoric – A substance that may spontaneously ignite in air at a temperature of 130 degrees Fahrenheit (54 degrees Celsius) or below. Specific gases, such as silane, may not ignite in these circumstances or may explosively decompose.

Storage Area – A building, portion of a building, or exterior area used for the storage of compressed gases.

Threshold Limit Value (TLV) – A guideline value to establish the airborne concentration of a substance to which healthy working adults may be repeatedly exposed day after day over a working lifetime without adverse health effects.

4.0 Responsibilities

4.1. SDSTA Executive Director

- 4.1.1. Ensures accountability of the requirements of this document with direct reports.

4.2. Environment, Safety and Health (ESH) Department

- 4.2.1. Provides support in preparation of required WPC documents.
- 4.2.2. Determine and validate courses specific to pressure safety training for required personnel.
- 4.2.3. Provide technical assistance as needed or required.

4.3. SDSTA Department Directors

- 4.3.1. Ensures that direct reports who are or may potentially be exposed to compressed gases are trained to handle, use, and respond.
- 4.3.2. Ensures accountability of the requirements of this document with direct reports.

4.4. Science Director

- 4.4.1. Ensure that Experiment Planning Statements that include compressed gases are evaluated prior to installation or use.
- 4.4.2. Ensure Authority to Proceed review is followed to control compressor gas hazards.
- 4.4.3. Coordinate with the Engineering Department on the hazard assessment.

4.5. Engineering Department

- 4.5.1. Reviews and approves the design, fabrication, installation and testing of research pressure systems.
- 4.5.2. Reviews and approves pressure system-related formal work authorizations, which are written to ensure that pressure system use is within the design limitations of such systems.
- 4.5.3. Approves safety notes pertaining to research systems.
- 4.5.4. Assures that documentation, traceability, and accountability for each unique custom-built research pressure vessel or system are maintained, including description of design, pressure conditions, testing, inspection, operation, repair and maintenance.

4.6. Emergency Response Team Supervisor

- 4.6.1. Be aware of all compressed gas hazards on site.
- 4.6.2. Ensures that the team is trained to respond to compressed gases hazards/emergencies on site.

4.7. Supervisors

- 4.7.1. Ensures that direct reports who handle, use, or may potentially be exposed to compressed gases, are trained.
- 4.7.2. Verify that all required inspections are completed, and any corrective actions are taken.
- 4.7.3. Ensure all labeling is in place and legible.
- 4.7.4. Ensure WPC documents are completed prior to work beginning.

4.8. Project Managers

- 4.8.1. Ensure that contractors/subcontractors comply with the work practices described in this standard.
- 4.8.2. Ensure that Safety Data Sheets (SDS) are provided before being brought on site.
- 4.8.3. Be aware of the entire compressed gas cylinder lifecycle (e.g. disposal costs) when planning.

4.9. Procurement Department

- 4.9.1.** Strive to purchase cylinders that can be returned to the provider when empty or no longer needed.
 - For gases that cannot be purchased in returnable containers, it must be verified in advance with the ESH Department that arrangements can be made for proper disposal.
 - If the product only comes in non-returnable or disposable cylinders, arrangements must be made for its final disposal as a condition of its purchase.
- 4.9.2.** Ensure equipment manuals are provided so that maintenance and repair information is available.

4.10. Infrastructure Technicians

- 4.10.1.** Install and maintain all required gas labeling inside the shaft itself.
- 4.10.2.** Review appropriate WPC documents.

4.11. Workers

- 4.11.1.** Complete required training for handling, use or exposure to compressed gases as presented in this standard.
- 4.11.2.** Use and maintain pressure systems, including re-evaluation and/or re-testing of pressure system components in accordance with the requirements of applicable formal work authorization documents.

5.0 Instructions

Proper management of compressed gas and compressed gas cylinders is critical because of the unusual and often dangerous characteristics some of them possess e.g., stored under pressure, flammability and many toxic gases don't have distinguishable odor or color. Improper handling, storage and use could lead to catastrophic events like:

- Oxygen depleted atmosphere
- Fires
- Adverse health effects or even death

The immediate and uncontrolled release of gas from a leaking/damaged compressed gas cylinder can result in the cylinder becoming a projectile with the potential to penetrate through walls, causing structural damage, severe injury, and even fatality.

5.1. Hazard Identification

- Follow ESH-(2000-S)-73320 Work Planning and Control Standard
 - o Emergency Preparedness
 - ◆ Specific emergency response procedures required for compressed gas, if any, must be included in WPC documents. See ESH-(7000-A)-209405 Leaks and Emergency for guidance in developing the WPC documents.
 - o Before ordering compressed gas cylinders:
 - ◆ Review the SDS for physical and health hazards.
 - ◆ All hazards (e.g., physical, chemical) of the gas itself and its system must be known so that necessary controls can be implemented for the entire time at SURF to include disposal.
 - ◆ If the gas is toxic, corrosive, flammable, or poisonous, etc., contact the ESH Department prior to ordering and receiving the gas. See ESH-(7000-A)-209406 Special Gases.

- ◆ Train the users on the hazards, pressure systems, regulators etc. per the WPC document requirements.

5.2. Receiving

- See ESH-(7000-WI)-209408 Receiving Compressed Gases (Before Use).
- Ensure proper labeling is present on the cylinder (see ESH-(7000-A)-186943 Labeling)

5.3. Transportation

- See ESH-(7000-WI)-209419 Transportation of Compressed Gas Cylinders.

5.4. Storage

- See ESH-(7000-WI)-209409 Storage of Compressed Gas Cylinders.
- Cylinder storage areas must be prominently posted with the names and hazard class of the gases being stored. See the ESH Department for assistance if needed.
- Compressed gas cylinder storage areas must be located away from emergency exits and must be kept well drained, well ventilated, cool, and protected from the weather.
- Any permanent underground storage of compressed gasses shall be approved by the ESH department.

5.5. Handling and Use

- See ESH-(7000-WI)-209407 Handling and Use of Compressed Gas Cylinders.

5.6. Personnel Protective Measures

- All personnel involved in the use or handling of compressed gas cylinders must wear the proper personal protective equipment (PPE), which includes, but are not limited to the following:
 - Eye protection – required any time compressed gases are used or handled to protect against eye injury.
 - Hand and body protection – required to protect against any hazard exposure depending on the type of gas handled.
 - Respiratory protection – may be required depending on the type of gas used.
 - Foot Protection – required to prevent injuries from cylinders slipping or falling.
 - See applicable WPC documents for specific guidance.

5.7. System Maintenance

- The following information applies to the use of system piping, regulators, manifolds, and other apparatuses:
 - Keep piping, regulators, and other apparatuses gas tight to prevent leaks.
 - Release pressure from systems before connections are tightened or loosened and before any repairs.
 - All redone connections shall be tested with a soapy water type solution.
 - The system shall be slowly and partially pressurized and leak-tested before fully pressurizing the system.
 - Fluorescent light can be used to check for grease or oil in regulators and valves.

- o Valve and Regulators:
 - ◆ Know the valve and regulator histories (e.g., repairs, damage, incompatible gases) before use.
 - ◆ Valves and regulators shall undergo periodic maintenance and repair per the manufacturer's guidance for users. Valves and regulators shall only be repaired by qualified person.
 - ◆ Perform a visual inspection before each use to detect any damage, cracks, corrosion, or other defects.
 - ◆ Long-term maintenance or replacement periods vary with the types of gases used, the length of use, and conditions of use. Consult the cylinder, regulator, or gas supplier for recommended valve and regulator maintenance schedules.

5.8. Central Gas Systems

- Central gas systems, such as house-systems or closed systems for scientific research must be designed and installed in accordance with applicable standards. See the ESH department for assistance.
- Appropriate WPC processes must be completed to identify the necessary controls to be incorporated in the system, which may include but is not limited to:
 - o Check valves
 - o Excess flow controls
 - o Exhausted enclosures
 - o Local exhaust ventilation
 - o MAWP
 - o Pressure relief systems

5.9. Quantity Limitations

- Quantity limitations are affected by the onsite hazard controls (refer to ESH-(7000-WI)-XXXX Storage of Compressed Gas Cylinders). Greater quantities are generally allowed in facilities equipped with automatic fire sprinklers and/or when exhausted enclosures or gas cabinets are provided. These controls will be addressed during pre-work planning activities related to compressed gases.

5.10. Ventilation

- Dedicated ventilation systems may be required for storage and/or use of compressed gases based on the controls identified during WPC activities. The ventilation requirements may include, but are not limited to, exhausted enclosures (including laboratory hoods), gas cabinets, and local exhaust ventilation (surface). Ventilation systems may be used as an engineering control to address the hazards of:
 - o Ambient atmospheres potentially containing less than 19.5% oxygen (i.e., oxygen deficient or higher than 23.4% oxygen rich environments).
 - o Corrosive, toxic or highly toxic atmospheres potentially exceeding the TLV or some other recognized hazard criteria.
 - o Flammable atmospheres potentially exceeding 10% of the LEL of the gas (es) used or stored.

- Basic requirements for dedicated ventilation systems include:
 - Mechanical ventilation must be provided.
 - The exhausted area (e.g., gas cabinet, hood) must be at negative pressure in relation to the surrounding area.
 - Exhaust must be discharged to an acceptable area that is approved by the ESH Department.

5.11. Continuous Gas Detection

- Continuous gas detection may be required for storage and/or use of compressed gases based on the controls identified during WPC activities, Oxygen Deficiency Hazard (ODH) assessments, cryogen use, or professional judgement. Compressed gas hazards that may require continuous detection could include:
 - Highly toxic in quantities >1 ft³.
 - Pyrophoric if quantities > 1 ft³ and concentration >1%.
 - Flammable gases where it is determined that a leak will result in concentrations greater than 10% of the LEL.
 - Corrosive gases if quantities >1 ft³ and that have physiological warning properties at a higher level than the TLV.
 - Gases that if accidentally released may create an oxygen deficient atmosphere (<19.5% or higher than 23.4% oxygen rich environments).

5.12. Oxygen Monitoring

- Shall be placed in areas that are poorly ventilated, have potential for ODH conditions or where confined spaces allow the build-up of asphyxiating gases to reach dangerous levels.
- Compressed gases or cryogenic liquids shall not be stored, used, or dispensed in any surface location that does not have proper ventilation. Underground dispensing shall be covered in WPC documents.

5.13. Training

- Hazard communication training is required for workers who handle, use, or may potentially be exposed to compressed gases.
- Additional training may be required and documented in the WPC documents based on the specific hazards presented by the storage and/or use of compressed gases.

5.14. Disposal

- Proper identification of the contents of all cylinders is required prior to disposal.
- Refillable cylinders shall be returned to the vendor. Return cylinders with at least 30 pounds of pressure to reduce the risk of foreign materials entering the empty vessel.
- If a refillable cylinder is encountered that does not have a manufacturer label, contact the vendor or ESH.
- Disposal fees of an unknown cylinder are a user expense. See contract or MOU for details.

6.0 Documented Information/Related Documents

- 6.1.** ESH-(11000-S)-73328 Oxygen Deficiency Hazards Standard
- 6.2.** ESH-(11000-S)-73326 Cryogenic System Standard
- 6.3.** ESH-(7000-A)-209405 Leaks and Emergency
- 6.4.** ESH-(7000-A)-186943 Labeling
- 6.5.** ESH-(7000-A)-209406 Special Gases
- 6.6.** ESH-(7000-WI)-209407 Handling and Use of Compressed Gas Cylinders
- 6.7.** ESH-(7000-WI)-209409 Storage of Compressed Gas Cylinders
- 6.8.** ESH-(7000-WI)-209410 Transportation of Compressed Gas Cylinders
- 6.9.** ESH-(7000-WI)-209408 Receiving Compressed Gases (Before Use)
- 6.10.** Occupational Safety and Health Administration (OSHA) General Industry Standards, Compressed Gases 1910.101, Subpart H
- 6.11.** OSHA General Industry Standards, Permissible Exposure Limits
- 6.12.** OSHA General Industry Standards, Hazard Communication
- 6.13.** OSHA General Industry Standards, Occupational Exposure to Hazardous Chemicals in Laboratories