BELIZE:

STANDARDS (BELIZE STANDARD SPECIFICATION FOR MEDICAL GASES - GENERAL REQUIREMENTS) (DECLARATION AS A COMPULSORY STANDARD) ORDER, 2025

ARRANGEMENT OF PARAGRAPHS

BELIZE:

STATUTORY INSTRUMENT

No. 134 of 2025

ORDER made by the Minister responsible for the Bureau of Standards, on the recommendation of the Belize Bureau of Standards, in exercise of powers conferred upon him by section 9(2) of the Standards Act, Chapter 295 of the Substantive Laws of Belize, Revised Edition 2020, and all other powers thereunto him enabling.

(Gazetted 29th September, 2025).

WHEREAS, section 9(3) of the Standards Act, Chapter 295 of the Laws of Belize, provides that the Minister shall, by publication in the *Gazette,* give at least thirty days' notice of his intention to make an Order declaring a compulsory standard and shall thereby indicate the date on which it is intended that the compulsory standard shall come into force;

AND WHEREAS, a notice of intention to declare the BELIZE STANDARD SPECIFICATION FOR MEDICAL GASES - GENERAL REQUIREMENTS (BZS 30: 2025) to be a compulsory standard was published in the Belize Gazette dated 21st July 2025;

AND WHEREAS, no objections have been received to the making of the said Order;

NOW, THEREFORE, IT IS ORDERED as follows:–

1. This Order may be cited as the **Citation.**

STANDARDS (BELIZE STANDARD SPECIFICATION FOR MEDICAL GASES - GENERAL REQUIREMENTS) (DECLARATION AS A COMPULSORY STANDARD) ORDER, 2025.

Declaration of Compulsory Standard. Schedule.

2. The BELIZE STANDARD SPECIFICATION FOR MEDICAL GASES - GENERAL REQUIREMENTS (BZS 30: 2025), the full text of which appears in the Schedule hereto, is hereby declared to be a compulsory standard.

Purpose of Compulsory Standard.

3. The standard referred to in paragraph 2 is intended primarily to–

(a) protect the consumer or user against danger to health or safety;

(b) ensure quality in goods produced for home use or for export;

(c) prevent fraud or deception arising from misleading advertising or labelling;

(d) require adequate information to be given to the consumer or user; and

(e) ensure quality in any case where there is restriction in choice of source of supply.

Commencement.

4. This Order shall come into effect on the 1st day of October 2025.

SCHEDULE
[paragraph 2]

BELIZE STANDARD
SPECIFICATION FOR MEDICAL GASES – GENERAL REQUIREMENTS

0 FOREWORD

0.1 This standard provides guidance for the safe handling of compressed medical gases. It is intended to protect personnel in health care facilities, including hospitals, nursing homes, doctor and dental offices, and clinics.

0.2 In preparing this draft, assistance was received from the following documents:

a) CGA P-2 - Guidelines for Characteristics and Handling of Medical Gases

b) CGA C-9 - Standard Colour Marking of Compressed Gas Containers for Medical Use

c) CGA V-1 - Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections

d) CGA V-6 - Standard Bulk Refrigerated Liquid Transfer Connections

e) CGA P-1 - Standard for Safe Handling of Compressed Gases in Containers, describes general practices for handling compressed gases

f) CGA E-7 - Standard for Medical Gas Pressure Regulators, Flowmeters, and Orifice Flow Selectors

1 SCOPE

This standard describes the properties of common medical gases, medical gas containers, and safe practices and handling of these gases.

2 NORMATIVE REFERENCES

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

a) BZS 1: Part 8 - Belize Standard Specification for Labelling Part 8: Labelling and Marking of Medical Gas Cylinders
b) CGA P-2 - Guidelines for Characteristics and Handling of Medical Gases

c) CGA C-9 - Standard Colour Marking of Compressed Gas Containers for Medical Use

d) CGA V-1 - Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections

e) CGA V-6 - Standard Bulk Refrigerated Liquid Transfer Connections

f) CGA P-1 - Standard for Safe Handling of Compressed Gases in Containers, describes general practices for handling compressed gases

g) CGA E-7 - Standard for Medical Gas Pressure Regulators, Flowmeters, and Orifice Flow Selectors

3 DEFINITION OF TERMS

For the purpose of this standard, the following definitions of terms shall apply.

3.1 **Container** means a portable compressed gas cylinders and liquid containers made in accordance with the U.S. Department of Transportation (DOT) specifications or liquid oxygen base reservoirs and portable vessels with service pressures under 40 psi (276 kPa).

3.2 **Distributor** means a person or firm who markets filled medical gas cylinders.

3.3 **Manufacturer** means a person or firm who produces, fills or relabels medical gas cylinders.

3.4 **Transfilling** means a process of transferring compressed gas or refrigerated liquefied gas from one container to another.

4 GENERAL CHARACTERISTICS

4.1 Single component medical gases

Medical gases are prepared under carefully controlled conditions. Purity specifications for medical gases are prescribed in the United States Pharmacopeia and National Formulary (USP NF). Specific properties and additional information about most gases used in medical service are contained in Annex 2.

4.1.1 Non-liquified compressed (oxygen, nitrogen, air, helium)

a) For cylinders charged with non-liquefied compressed gas, container pressure is related to both the temperature and the amount of gas in the container. For gases such as oxygen, nitrogen, medical air, or helium, contained in compressed gas cylinders, cylinder content can be determined by pressure, e.g., at a given temperature the cylinder is approximately half full when the pressure is reduced to half, when full at the original pressure.

b) Specific properties and additional information in relation to non-liquified compressed medical gas cylinders are found in clause 5.

4.1.2 Liquified compressed (carbon dioxide, nitrous oxide)

a) For high pressure cylinders charged with liquefied compressed gas, the pressure is determined by the vapor pressure of the contained liquid in equilibrium with the vapor at the temperature of the contents. The pressure drops if vapor is used continuously due to cooling of the contents as the liquid is vaporized. If liquid remains when withdrawal stops, pressure will slowly rise in relation to the temperature of the contents. Because pressure is not an indicator of container content, weight or other suitable indicators shall be used.

b) Specific properties and additional information in relation to liquified compressed medical gas cylinders are included in clause 5.

4.1.3 **Cryogenic (oxygen, nitrogen) and refrigerated liquid (nitrous oxide, carbon dioxide)**

a) For containers charged with cryogenic or refrigerated liquefied gas, the pressure is determined by the vapor pressure of the contained liquid in equilibrium with the vapor at the temperature of the contents. The pressure drops if vapor is used continuously due to cooling of the contents as the liquid is vaporized. If liquid remains when withdrawal stops, pressure will slowly rise in relation to the temperature of the contents. Because pressure is not an indicator of container content, weight or other suitable indicators shall be used. Pressure can be maintained or raised using internal pressure building coils in some containers or an external vaporizer system as long as liquid remains in the container.

b) Specific properties and additional information in relation to cryogenic and refrigerated liquid compressed medical gas cylinders are found in clause 5.

4.2 **Multi-component medical gases**

Gases that are inhaled are typically drug gases because one or more components of the mixture have a chemical action in the body of humans or animals. Mixtures may contain oxygen or not. Non-oxygen mixtures are generally mixed with oxygen through a gas blender immediately prior to administration.

Medical gases are prepared under carefully controlled conditions. Purity specifications for medical gases are prescribed in the *United States Pharmacopeia* and *National Formulary* (*USP NF*). Specific properties and additional information about most gases used in medical service are contained in Annex 2.

4.2.1 **Drug gases**

a) Many different mixtures of single component medical gases identified in as single component medical gases may be supplied as drug gases. These mixtures commonly include:
   i. oxygen in combination with nitrogen, carbon dioxide, nitrous oxide, or helium;
   ii. oxygen in combination with both carbon dioxide and nitrogen; and
   iii. oxygen in combination with both helium and nitrogen.

b) Mixtures exist in a cylinder as nonliquefied, homogeneous gas that are usually charged to a pressure between 1600 psi and 2640 psi at 70 °F (11 030 kPa and 18 200 kPa at 21.1 °C) depending on the service pressure of the cylinder. At any given temperature, the pressure will decrease proportionately as the cylinder contents are withdrawn.

NOTE: Mixtures containing less than 19.5% oxygen might not support life.

c) Carbon dioxide used as a component in mixtures can cause injury or death depending on its concentrations and the length of exposure to the gas mixture.

4.2.2 **Device gas mixtures**

These mixtures commonly include lung diffusion gas, blood gas, laser gases, aerobic, and anaerobic mixtures. These products may be provided in both high pressure reusable cylinders and nonrefillable single use cylinders.

5 PROPERTIES OF MEDICAL GASES

Properties of medical gases namely for air; carbon dioxide; helium; nitrogen; nitrous oxide; and oxygen are specified in Annex 2: Tables 1 to 6 respectively.

6 CONTAINERS

6.1 Bulk storage systems

a) Bulk storage systems at health care facilities typically include liquid oxygen systems including backup systems. Some health care facilities may also have bulk storage systems for liquid nitrogen, nitrous oxide, and carbon dioxide.

b) A scheduled maintenance program shall be followed at health care facilities.

c) Large cryogenic containers consist of two different types:

i. The first type typically known as gas packs, also known as Portable Gas System (PGS) or Vertical Gas Liquid (VGL), are designed primarily for gas withdrawal but also capable of withdrawing liquid product. Gas packs have the capability of

building pressure through a pressure building coil internal to the container. Users shall not adjust the pressure building coil but shall contact their gas supplier if different gas pressures are required; and

ii. The second type typically known as Liquid Systems (LS) or Vertical Liquid (VL) are typically low pressure, liquid withdrawal only.

6.2 Small cryogenic containers and portables

6.2.1 Oxygen home care vessels

Oxygen home care vessels have been designed to be used at a place of residence or at a health care facility. Base units contain 10 L or more of liquid oxygen and mobile units contain 1.2 L or less of liquid oxygen. These vessels provide supplemental oxygen to patients at prescribed flow rates ranging from less than 1 L/min to 15 L/min.

6.2.2 Nitrogen dewars

Nitrogen dewars are used for multiple purposes in health care facilities. These are typically unpressurized, vacuum-insulated containers utilized for specimen preservation or transport, or minor surgical procedures. These vessels are typically filled locally (i.e., at the health care facility) by the supplier from a larger cryogenic container.

6.3 High pressure containers

6.3.1 High pressure cylinders

a) High pressure medical gases are supplied in steel, aluminum alloy, and composite (aluminum alloy core with a fiber reinforced material exterior for added strength) containers.

b) The gas pressure in a closed cylinder increases as the temperature rises. A cylinder charged with gas can reach dangerously high pressures at elevated temperatures. This is true whether the contents of the cylinder are in a gaseous or liquid state. In the liquid state, the contents may expand so much that excess hydrostatic pressure develops inside the cylinder. To prevent this from occurring, regulations limit the amount of gas that can be put into a cylinder.

c) Cylinder filling limits are set so pressure in the cylinder at 70 °F (21.1 °C) does not exceed the designed cylinder service pressure. Some cylinders containing nonliquefied, nonflammable gases, may be filled up to 110% of their marked service pressure at 70 °F (21.1 °C), e.g., a steel cylinder with a 2015 service pressure with a "+" marking may be filled to 2216 psi at 70 °F (15 279 kPa at 21.1 °C).

d) High pressure cylinders shall be periodically requalified and marked to attest that the cylinder has met the requalification requirements. Prior to fill all cylinders shall be appropriately inspected to assure that they are acceptable to fill.

e) These high-pressure cylinders have standard styles having the dimensions and capacities as shown in Annex 2 – Table 7.

6.3.2 **Valves**

a) CGA has developed standard outlet connections for medical gases to aid in the prevention of medical gas mix-ups. Large cylinders (e.g., Style M) are typically equipped with valves that have threaded outlet connections. Small medical cylinders (e.g., Style E) are typically equipped with flush-type (i.e., pin-indexed) valves that are used with yoke connections.

For details see CGA V-1, Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections.

b) For ease of use, some smaller cylinders are equipped with a Valve Integrated Pressure Regulator (VIPR) that uses a threaded connection for filling and a hose barb fitting to which a nasal cannula may be attached for use.

c) Only standard valve outlet connections shall be used. Cross product adapters that allow the incorrect connection of equipment or a system to a container with a CGA valve outlet connection shall not be used.

d) Cylinders may be supplied with a Residual Pressure Valve (RPV) in place. Cylinders with these valves will shut off at approximately 25 psi to 50 psi (172 kPa to 345 kPa) and not allow further withdrawal.

6.3.2.1 **Threaded**

a) Threaded valve outlets are designed to minimize the potential of connecting incompatible gases to gas utilization equipment. For example, the CGA oxygen valve outlet connection minimizes the ability to connect oxygen to a system adversely impacted by an oxidizing gas.

b) Threaded valve outlets vary by diameter, thread direction (right hand or left hand) and whether the thread is interior or exterior to the valve outlet.

c) Threaded valve outlets do not always identify the gas contained in the cylinder. For example, the oxygen connection does not differentiate between medical and industrial oxygen. In addition, nitrogen and helium share the same

valve outlet connection with several other inert gases.

d) It is imperative that the user not rely on the connection to identify the gas.

e) The user shall verify that the product label identifies the gas and then that the connection is consistent with that gas.

6.3.2.2 **Pin-indexed**

a) The Pin Index Safety System was designed to aid in the prevention of medical gas mix- ups. It consists of a combination of two pins projecting from the yoke assembly of the apparatus that match the size and location of holes in the cylinder valve. Medical gas users shall assure that the yoke assembly possesses the required pins. Assemblies without pins, missing pins, or misaligned pins shall not be used.

NOTE: A single pin is used for nitrous oxide-oxygen mixtures

b) Yoke-type connections require a durable seal or single use washer between the yoke inlet and the cylinder valve outlet, creating a leak-free, high-pressure seal. Using more than one seal can create a hazard and shall not be attempted. Seal material shall be compatible with the gas being used.

6.3.3 **Colour codes**

Aluminum cylinders might show aluminum metallic colour, and its identification will be conducted through the label as defined in Annex 2 – Table 9

which shows the colour codes for steel cylinders commonly used for medical purposes in Belize.

6.4 **Large cryogenic containers and valves**

6.4.1 **Styles**

a) Large cryogenic containers consist of two different types:

i. The first type typically known as gas packs, also known as Portable Gas System (PGS) or Vertical Gas Liquid (VGL), are designed primarily for gas withdrawal but also capable of withdrawing liquid product. Gas packs have the capability of building pressure through a pressure building coil internal to the container. Users shall not adjust the pressure building coil but shall contact their gas supplier if different gas pressures are required; and

ii. The second type typically known as Liquid Systems (LS) or Vertical Liquid (VL) are typically low pressure, liquid withdrawal only.

b) Annex 2 - Table 10 provides for typical sizes, the net contents in terms of pounds, cubic feet, and equivalent metric units in relation to liquid contents by weight and equivalent gaseous volume. These values reflect contents when full. The user shall expect normal evaporation through the primary relief valve influenced by ambient conditions, to occur anywhere between 1.4% and 2% per day.

6.4.2 **Valves**

a) Gas packs typically have a gas use, vent, and liquid fill/withdrawal connections with appropriate valves. In addition, a pressure building valve may be present. VLs will not have a gas use valve and may or may not have a pressure builder.

b) Cryogenic outlet connections are designed to prevent mix-ups. The following connections, listed in Annex 2 - Table 11, are utilized with large portable cryogenic containers in accordance with CGA V-1.

c) All medical large cryogenic containers will utilize tamper resistant connections or will have the connection soldered into the valve to prevent tampering. If a container does not utilize one of these systems the large cryogenic containers shall not be used.

d) The user shall never adapt or change the valve outlet connections on these vessels.

7 LABELLING

a) Each package containing compressed gas shall bear an appropriate identifying label, see Annex 2 - Table 12.

b) For additional information on marking and labelling, see Labelling Standard BZS 1: Part 8 Belize Standard Specification for Labelling Part 8: Labelling and Marking of Medical Gas Cylinders.

7.1 Drug gases

a) All medical drug gases shall be labelled to indicate the following:

i. Name and address of the person or firm who filled the cylinder (manufacturer) and/ or who distributed the cylinder (distributor). A name appearing without qualification shall be the manufacturer. If the distributor's name appears either alone or with the manufacturer's name, the distributor shall be identified with the words "distributed by".

ii. Name of the product or ingredients for mixtures;

iii. Lot number (may be part of the label or on a side sticker);

iv. Contents in units of measure commonly used (sometimes part of label);

v. Administration statements, warnings, cautions, and first aid statements.

vi. All drug labels shall indicate Rx only and "Keep out of reach of children" statement.

b) In addition, large cryogenic containers shall be labeled with 360-degree labeling that identifies the liquid's medical product contents. The label shall be marked continuously with the liquid product identification visible from all sides but not obstructed and placed just below the upper circumferential weld adhering to the container sidewall as follows:

i. for oxygen: medical oxygen or oxygen, USP;

ii. for nitrogen: medical nitrogen or nitrogen, NF;

iii. for nitrous oxide: medical nitrous oxide or nitrous oxide, USP; and

iv. for carbon dioxide: medical carbon dioxide or carbon dioxide, USP.

NOTE: No expiration dating is required.

c) If the owner of the container wishes to be identified, a "Property Of" sticker/side label may be used provided it is distinctly separate from the product label.

7.2 **Device gases**

a) In addition to many of the requirements for drug gas labels, all medical device gases shall be labelled to indicate the following:

i. statement of contents (name of product, e.g., laser gas, artificial atmosphere) or ingredients;

ii. statement of Intended use (i.e., "For calibration of ….", "For culture growth…", etc.)

b) To establish a difference between device gas mixture and drug gas mixtures, device gas mixtures shall indicate: "Not for Drug Use" or "For laboratory use only…"

8 SAFE PRACTICES AND HANDLING

8.1 **General practices**

8.1.1 Compressed medical gas cylinders, cylinder valves, cylinder regulators, other assemblies included with cylinders, or any other equipment used to supply compressed medical gases shall not be present in the same room as an MRI device unless proven nonmagnetic and/or tested and deemed suitable for this environment.

8.1.2 If there are any questions as to whether a piece of equipment is suitable for use in an MRI environment, the equipment manufacturer or supplier shall be contacted.

8.1.3 When handling compressed medical gases use the following safe practices:

1) ensure that connections to piping, regulators, and other equipment are tight to prevent leakage;

2) keep hoses in good condition;

3) prevent sparks or flame from coming in contact with containers and equipment;

4) open the cylinder valve completely when the cylinder is in use;

5) remove any paper wrapping before placing cylinders in service so the label is clearly visible;

6) identify the gas content by the label before use. If the container does not have a label or the label is not readable, return the unused cylinder to the supplier. If the label does not correctly identify the gas contained in a cylinder, return the unused cylinder to the supplier;

7) read and understand all warning and precautionary handling information on the labels; DO completely close the valve prior to disconnecting or replacing the cylinder;

8) return an empty cylinder with at least 25 psi (172 kPa) residual pressure, close the valve before returning and ensure that the valve protective cap and outlet caps or plugs, if used, are replaced before shipping;

9) ensure that repairs of or alterations to containers or pressure relief devices are performed by the supplier;

10) keep valves closed when the gas is not being used;

11) mark the cylinder and notify the gas supplier if a foreign substance may have entered the container or valve, providing the supplier with details of the occurrence and the cylinder serial number;

12) provide the gas supplier with complete details regarding any complaint with the container or product including the container lot and serial number, and then quarantine and isolate the container to prevent use;

13) ensure only experienced and properly instructed persons handle compressed gases;

14) use leak detection instruments or commercial leak detector solutions to detect gas leaks;

15) ensure that liquid oxygen transfilling into small base reservoir systems is performed on a noncombustible surface such as concrete either outside or inside in a properly constructed, ventilated area;

16) Review "Nitrous oxide facts" information presented in Annex 1.

17) only use liquefied gases such as carbon dioxide and nitrous oxide with the cylinder in the upright position unless equipped with a dip or eductor tube (and so labeled);

18) exclusively use nitrogen NF for health-related applications requiring nitrogen, for example, nitrogen used to power surgical instruments;

19) DO NOT let oil, grease, or other combustible materials come in contact with containers, valves, regulators, gauges, hoses, and fittings. Oil and certain gases such as oxygen or nitrous oxide may combine with explosive violence;

20) DO NOT lubricate valves, regulators, gauges, or fittings with oil or any other combustible substance;

21) DO NOT handle containers or apparatus with oily hands or gloves;

22) DO NOT use an open flame to detect gas leaks;

23) DO NOT interchange regulators or other appliances used with one gas with similar equipment intended for use with other gases;

24) DO NOT attempt to mix gases in containers. Mixtures shall be obtained already prepared from recognized suppliers;

25) DO NOT allow the filling of cryogenic containers from the bulk tank that supplies the health care facility's medical gas pipeline system;

26) DO NOT deface or remove any markings used to identify the contents of a container;

27) DO NOT subject any part of a compressed gas container to a temperature above 125 °F (51.7 °C);

28) DO NOT let a flame come in contact with any part of a compressed gas container;

29) DO NOT add adaptors to existing connections;

30) DO NOT modify or replace existing connections;

31) DO NOT change, modify, tamper with, or obstruct the discharge ports of pressure relief devices;

32) DO NOT use containers for any purpose other than to supply the contained gas as received from the supplier;

33) DO NOT place containers where they can become part of an electric circuit; and

34) DO NOT repaint containers. This shall only be done by suppliers.

8.2 **Moving**

Use the following safe practices when moving compressed medical gases:

a) use caps (if available) to protect valves when cylinders are moved;

b) move large cylinders using a suitable hand truck or cart and be sure the container retaining chain, strap, or hook is properly fastened in place;

c) move large cryogenic containers and small base reservoir systems using equipment specifically designed for that use;

d) DO NOT drop containers or let them strike each other violently;

CAUTION: Style E and smaller cylinders are not equipped with valve protection caps

and are vulnerable to valve damage if dropped in an inverted or near inverted position. Structural damage, especially if the valve stem is impacted, can result in valve malfunction or unsafe operation. Valves with bent or mushroomed stems shall be removed from service.

e) DO NOT lift the cylinder by the valve protection cap. Personal injury can result if the cap slips off.

8.3 **Storage**

8.3.1 There shall be adequate controls in place to ensure proper storage of medical gases.

8.3.2 Health Care Facilities that store and handle small liquid oxygen base and portable units shall comply with these storage guidelines.

8.3.3 Personnel responsible for storing medical gases shall be adequately trained and familiar with the applicable regulations and with the facility's cylinder storage policies and procedures:

a) store medical gases to allow for first in, first out (FIFO) access (i.e., the oldest inventory shall be used first);

b) ensure that storage rooms are dry, cool, and well ventilated;

c) ensure that storage areas are constructed of fire-resistant, noncombustible materials where practical;

d) store cylinders and containers away from heat sources such as radiators, heater vents, or other sources of heat;

e) keep combustible, flammable and/or corrosive materials away from cylinder storage areas;

f) keep refrigerated liquid CTC/DOT-4L and TC-4LM containers in an upright position;

g) protect cylinders and containers in storage from potential physical damage;

h) install valve protection caps on cylinders that are equipped with threaded collars;

i) DO NOT store cylinders and containers so that it prohibits access to electrical panels, fire extinguishers, or other emergency response equipment;

j) DO NOT use operating rooms or other patient areas for cylinder storage in excess of what may be required for backup;

k) DO NOT store containers near or expose to corrosive chemicals or fumes. The resulting corrosion will damage the containers and can cause the valve protection caps to stick; and

l) DO NOT store containers where they can come into contact with highly flammable materials or vapors including oil, gasoline, grease, or other combustible materials.

8.4 **Segregation**

a) Sound storage techniques require that cylinders be adequately segregated to prevent product mix-up.

b) All cylinder storage areas shall employ adequate signage to identify the status of the cylinders in storage, i.e.:

i. EMPTY CYLINDERS,

ii. FULL OXYGEN USP,

iii. FULL NITROGEN NF,

iv. QUARANTINE, etc.

8.4.1 **By gas**

a) As much as possible, full cylinders in storage shall be segregated by gas type to prevent product mix-up, i.e., oxygen USP from carbon dioxide USP, etc.

b) Segregation of gas types can be accomplished by employing the storage methods identified above. Segregation may be assisted by colour coding.

8.4.2 **Full/empty**

a) In storage, full cylinders shall be separated from empty cylinders. This can be accomplished in a variety of ways such as:

   i. storing full and empty cylinders in separate storage rooms; or
   ii. storing empty cylinders at opposite ends of the storage area from the full cylinders, or in areas specifically designated for full cylinders and empty cylinders, such as bins, painted areas, or areas separated by physical barriers or dividers.

b) Empty cylinders do not have to be segregated by gas type.

8.4.3 **Quarantine**

a) Each cylinder storage area shall have an area designated for quarantine and used specifically to store non-conforming products and materials. Quarantine areas can be a separate bin, an area separated by physical barrier, or an area that is painted and identified as QUARANTINE.

b) Any nonconforming product identified prior to, during, or after use shall be adequately marked or tagged with a brief description of the nonconformance and placed in the designated quarantine area to prevent use.

c) Non-conforming cylinder products should never be placed in the empty storage area.

8.5 **Security**

8.5.1 In the current atmosphere of terrorist threats and increased criminal activity, security has become an integral part of the compressed gas industry culture. Like safety measures, security measures protect facilities, employees, and the community by reducing the risk of a wide range of threats and mitigating the effects of incidents like vandalism, sabotage, workplace violence, theft/misuse of product, and terrorism. Security measures can enhance the goals of risk management and personnel safety.

8.5.2 To prevent the theft or diversion of medical gas cylinders, storage areas shall be secured and accessible to authorized personnel only.

8.5.3 Health care facilities need to especially safeguard against theft of nitrous oxide cylinders due to their abuse for recreational purposes.

8.5.4 The abuse of nitrous oxide is dangerous, and it is recommended that the government enacts legislation making the recreational use of nitrous oxide illegal.

8.5.5 Based on a concern for the misuse and/or intentional contamination of compressed gas products and systems used in medical applications, companies shall review their security requirements.

8.5.6 Security includes, but is not limited to, the following:

a) Security for containers and systems:

i. Store full and empty containers in a secured area

NOTE: Empty containers may contain residual product and require security precautions.

ii. Avoid leaving a delivery truck open and unattended

iii. Limit access to authorized personnel only

iv. Maintain a product inventory Investigate any discrepancies

v. Report any incidents involving thefts, misuse, or inventory shortages to law enforcement and the supplier;

b) Security for bulk systems:

i. Provide perimeter security having a minimum height of 6 ft (1.8 m) and lockable gates

ii. Use bollards or barriers to prevent unauthorized vehicle intrusion, e.g., crash protection from vehicular accidents

iii. Provide area lighting to reduce dark zones surrounding the installation, which enhances security and facilitates nighttime deliveries and maintenance.

8.6 **Product withdrawal**

8.6.1 Pressure-reducing regulators shall always be used when withdrawing the contents from a medical gas container. These devices deliver a constant, safe working pressure. Needle valves or similar devices without pressure-regulating mechanisms shall not be used in place of pressure-reducing regulators because excessive pressures can develop downstream of such devices, resulting in damage to equipment or injury to personnel.

CAUTION: The release of high-pressure gas can be hazardous. Provide adequate means for reducing the gas pressure to usable levels and for controlling the gas flow.

8.6.2 Use the following safe practices when withdrawing compressed medical gases from cylinders:

a) ensure that if containers are connected to a manifold, the manifold is of proper design and is equipped with one or more pressure regulators;

b) slightly open the valve for an instant to clear the opening of possible dust and dirt after removing the valve protection cap;

NOTE: This shall not be done with a cylinder containing flammable gas.

c) point the outlet away from you when opening a valve;

d) use wrenches or tools provided by or approved by the gas supplier to open a cylinder valve;

e) ensure that the threads on regulator-to-cylinder-valve connections or the pin-indexing devices on yoke-to-cylinder-valve connections are properly mated;

f) keep refrigerated cryogenic containers in the upright and vertical position;

g) close the container valve before the regulating device is disconnected;

h) Keep valves closed unless gas is actually being dispensed;

i) DO NOT force connections that do not fit;

j) DO NOT use adapters or attempt to change the product withdrawal connections on a container while trying to connect to a product distribution system;

k) DO NOT remove the valve protection cap until ready to withdraw contents or connect to a manifold;

l) DO NOT hammer the valve wheel when attempting to open or to close the valve;

m) DO NOT use gas-specific pressure regulators, pressure gauges, and manifolds with any gas other than the specified gas(es);

n) DO NOT use medical gases if the container can become contaminated by the feedback of other gases or foreign material unless the container is protected by suitable traps or check valves;

o) DO NOT allow oxygen equipment to be carried under clothing; and

p) DO NOT let gas enter the regulating device suddenly; open the container valve slowly.

8.7 **Additional requirements for liquefied compressed gases**

a) Liquefied compressed gases such as nitrous oxide and carbon dioxide present unique handling issues regarding product withdrawal depending on whether the cylinder does or does not utilize a dip tube (also known as an eductor tube or syphon tube) attached to the cylinder valve.

b) If the cylinder utilizes a dip tube, the valve shall be stamped with the letters D.T., E.T., or S.T or a cylinder label indicating the same.

c) A cylinder that is equipped with a dip tube and is in the upright position will allow liquid product to exit the valve when the valve is opened. A cylinder, that is not equipped with a dip tube and is in the upright position, will allow gas product to exit the valve when the valve is opened. If the user is unsure if a dip tube is or is not present, it is imperative to verify its presence or lack of presence prior to administering or using the gas. Serious injury or death could result from improper administration.

d) If the gas phase is rapidly withdrawn from a liquefied compressed gas container, the liquid remaining in the cylinder can become solidified. The user shall wait until the container warms sufficiently to allow the solid product to again become a liquid before withdrawing additional product. Do not use external heat sources to speed up this process.

8.8 **Cryogenic Liquids**

8.8.1 **Liquid withdrawal**

a) Cryogenic liquids present an extreme cold hazard as well as an expansion hazard.

b) The following precautions and safe practices shall be adhered to:

i. Never allow cryogenic liquids or their frosted components to come in contact with your skin;

ii. Wear heavily insulated gloves.

iii. Never use gloves contaminated with oil around liquid oxygen;

iv. Wear a protective face shield;

v. Wear a long-sleeved shirt with natural fibers such as wool or cotton buttoned at the cuff. Synthetic materials such as Rayon or polyester shall not be worn;

vi. Wear long pants without cuffs. Do not tuck pants inside of boots. Cryogenic liquids may get trapped and cause serious burns;

vii. Wipe or blow off moisture from quick connect valves between fills to prevent poppets from freezing open;

viii. Use phase separators with cryogenic transfer lines and a phase separator at low pressure (22 psi [152 kPa]) when

transferring liquid nitrogen to open lab type dewars;

ix. Keep cryogenic containers upright at all times;

x. Never leave transfilling systems unattended;

xi. Cryogenic liquids expand rapidly when vaporizing into a gas. For example, liquid oxygen expands 860:1 at atmospheric pressure and ambient temperature; Extreme high pressure can rupture transfer lines, containers, and plumbing components with explosive force without properly sized or functioning relief valves; and

xii. Withdraw all cryogenics in well-ventilated areas.

xiii. Use oxygen monitors in designated filling areas to prevent fire hazards while withdrawing liquid oxygen and to prevent asphyxiation while withdrawing other cryogens.

8.8.2 **Gas withdrawal**

The following are precautions and safe practices as they apply to facilities and to personnel involved in withdrawing gas from cryogenic containers:

a) Do not withdraw gas at flow rates exceeding the maximum specified flow values. Excessively high flow rates can cause extremely low gas temperatures that can cause damage to components and equipment and potentially

present health hazards. Excessively high flow rates under certain conditions can even cause cryogenic liquid to be withdrawn; and

b) Withdrawing gas from cryogenic containers at high flow rates for long periods of time can cause excessive frost condensation and water, which can damage facilities or present safety hazards.

8.9 **Transfilling**

8.9.1 **Gas**

a) There are serious hazards associated with transfilling. Only properly trained and qualified personnel using appropriate equipment and working under carefully controlled conditions shall perform the transfilling process.

b) Filling capacities can vary for containers even though their sizes appear to be the same. Overfilling can result in container rupture and damage. The danger of overfilling small containers may be greater when inexperienced operators do the charging because they may not have adequate knowledge of proper filling procedures and the properties of the gas being handled.

c) Pressure relief devices, valves, and all other parts shall be inspected at frequent intervals to ensure safe operation, and repairs or replacements shall be made if defects are found. Manufacturers regularly engaged in the production of gases are qualified to perform this essential maintenance work.

d) Because all transfilling operations require experienced supervision and superior equipment maintenance to avoid personal injury and property damage, containers shall always be returned to charging plants for refilling.

e) Manufacturers report that each year supposedly empty containers are returned to them containing a gas other than the gas originally shipped. Some of these contaminating gases are flammable. Intermixture of flammable and oxidizing gases can cause an explosion.

f) Containers that have been used for one type of gas can inadvertently or intentionally be recharged with a gas other than that originally or last contained in the cylinder by inexperienced or improperly trained operators. This practice will cause contamination and can introduce a serious explosion or health hazard.

WARNING: Unless proper precautions are taken, a dangerous mixture of gases can occur when charging one container from another.

g) Manufacturers have established specific procedures for detecting contaminating gases and for preparing medical gas containers before they are recharged. They also have developed special equipment for thorough cleaning.

h) The importance of the purity of medical gases cannot be overemphasized. Inexperienced persons transfilling medical gases may adversely affect purity. The sale and distribution of gases that are adulterated or may be a health hazard is prohibited.

i)Medical gas manufacturers are required to supply compressed gases labelled in accordance with the requirements

8.9.2 **Liquid**

a) Transfilling of cryogenic liquids presents a number of serious potential hazards and shall only be conducted by properly trained and qualified personnel using appropriate equipment and facilities. The same safety precautions and practices discussed under liquid withdrawal apply here as well.

b) The following are some basic precautions and safe practices as they apply to facilities and to personnel involved in transfilling cryogenic liquids:

i. Never leave transfilling systems unattended;

ii. Do not disconnect cryogenic transfer lines until all valves are closed;

iii. Close the liquid valve on the supply vessel prior to closing the vent and liquid valves on the receiving tank when terminating a fill, to prevent overfilling.

iv. For medical oxygen portables, disengage the portable from the base reservoir prior to closing the vent valve.

v. Never change the connectors of a cryogenic container. Connections shall conform to CGA V-1 and CGA V-6. These connections are dedicated to the

service to prevent mixing or mix-ups of liquids and gases that can cause death or serious injury.

vi. In the case of liquid oxygen home units, manufacturers may use noninterchangeable quick disconnect valves that are specific to liquid oxygen.

9 EQUIPMENT

9.1 Supply systems

a) Piping and manifold systems for medical gases from the bulk storage source valve shall be properly constructed and maintained.

b) It is important to differentiate medical air supply systems from non-medical air systems, e.g., instrument air.

9.2 Pressure regulators

a) A regulator reduces the pressure of the gas from the cylinder pressure to the required working pressure. CGA E-7, Standard for Medical Gas Pressure Regulators, Flowmeters, and Orifice Flow Selectors, describes regulators and flowmeters for medical use.

b) The user shall assure that the system will be able to supply adequate pressure and flow for the full range of the intended use. Information to assure adequate supply may be obtained from the equipment manufacturer.

c) Some pressure regulators are equipped with two pressure gauges. The first gauge indicates the pressure at the regulator inlet and corresponds to the pressure in the cylinder or other supply source when connected to that source. The second gauge indicates the pressure at the

regulator outlet and may increase when connected to utilization equipment depending on application.

d) Flow gauge regulators are calibrated to indicate flow rather than pressure as displayed on the second gauge by incorporating an orifice downstream of the second gauge.

e) Flowmeter regulators combine fixed delivery pressure regulators with an adjustable flowmeter to provide user adjustable variable flow rates based on application requirements.

f) Click style regulators combine fixed delivery pressure regulators with an orifice flow selector to provide discrete user adjustable flow rates based on user application requirements.

g) The inlet pressure to a regulator can impact pressure and flow based on its design. Flowmeters are designed and calibrated for specific gases and cannot be interchanged while still providing accurate flow information. There are several ways to adjust the flow and pressure of gas from a regulator; consult the manufacturer's instructions for proper operation and limitations.

h) Regulators, flowmeters, and regulator/flowmeter combinations shall be inspected and tested at a minimum of 5-year intervals and more frequently, if necessary, to ensure safety.

Annex 1 (Informative): Nitrous Oxide Facts

A.1 What is nitrous oxide?

Nitrous oxide (N2O) is a clear, colourless, oxidizing liquefied gas with a slightly sweet odor. The product is stable at room temperature. While classified by the U. S. Department of Transportation (DOT) as a nonflammable gas, nitrous oxide will support combustion and can detonate at temperatures in excess of 650 °C (1202 °F). Contact your supplier to obtain a nitrous oxide Safety Data Sheet (SDS) for information on the safe handling and security of this product.

A.2 What are the principal applications of nitrous oxide?

A.2.1 Nitrous oxide finds beneficial use in a number of legitimate applications such as:

a) Medical/dental anesthesia and analgesia
b) Food processing propellant
c) Semiconductor manufacturing
d) Analytical chemistry
e) Chemical manufacturing
f) Auto racing engine injection

A.2.2 Nitrous oxide is blended with oxygen when used in anesthesia applications. Pure nitrous oxide will cause asphyxiation, resulting ultimately in respiratory arrest. Nitrous oxide in auto racing applications is denatured to deter inhalation.

A.2.3 Nitrous oxide, used in food propellant applications, is typically supplied to commercial packagers of pressurized food dispensing containers.

A.3 Effects of nitrous oxide on the human body

A.3.1 Nitrous oxide’s painkilling and numbing qualities begin to take effect when the gas is inhaled at concentrations of 10 percent. At increasingly higher concentrations, a sense of well-being, or “high,” is experienced. A person experiencing a nitrous oxide high could:

a) Have slurred speech
b) Have difficulty in maintaining his or her balance or walking
c) Be slow to respond to questions
d) Be immune to any stimulus such as pain, loud noises, and speech
e) Lapse into unconsciousness

A.3.2 Nitrous oxide that is inhaled over a long period of time can lead to a vitamin B12 deficiency. When the level of vitamin B12 in the body is reduced, the red blood cell count is lowered, anemia results, and nerves degenerate. A vitamin B12 deficiency causes a person to have painful sensations in the arms or legs; have an unsteady walk or gait; become unbalanced and tend to fall over; feel or appear to be irritable; suffer intellectual deterioration.

A.4 What are the dangers?

A.4.1 Nitrous Oxide readily displaces air, causing asphyxiation. A person who is rendered unconscious by nitrous oxide is likely to stop breathing within a few seconds as a result of a depressed central nervous system–brain, brain stem, and spinal cord. Depression is caused by a combination of the effects of nitrous oxide and the lowered oxygen content that occurs as pure nitrous oxide displaces oxygen from the lungs with each succeeding inhalation of the gas; i.e., the person is asphyxiated.

A.4.2 Tragedy can occur very quickly. Long-term exposure (several minutes) is not necessary before death occurs. Sudden, prolonged exposure to high levels of nitrous oxide, or a series of inhalations (without breathing clean air between inhalations) can result in death. The length of this action can be measured in seconds. Since the narcotic effect of nitrous oxide is very brief (several seconds) abusers tend to follow this repetitive action pattern.

A.4.3 If a person remains conscious and stops breathing the nitrous oxide, recovery (full consciousness and alertness) can occur within minutes. A person who loses consciousness, however, and continues to inhale a pure gas is most likely to

die. Death usually occurs when abusers, in their attempt to achieve a higher state of euphoria, breathe pure nitrous oxide in a confined space — in a small room, inside an automobile or other vehicle cab, or by placing their head inside a plastic bag.

A.4.4 If death does not occur, the person who suffers from these symptoms may recover from all of them. The debilitating process is reversible, although some persons have experienced permanent loss of balance.

A.4.5 Abuse of nitrous oxide as an inhalant is on the rise, as is evidenced by the increased media attention to the subject. Its abuse has grown significantly at concert venues and on college campuses. Dealers will typically fill balloons with nitrous oxide and sell them. Police and other enforcement officials have found empty and/or discarded cylinders at the end of concerts. In some cases, dealers have removed required labels that identify cylinder contents and that provide information about safe use.

A.4.6 While most of the publicity regarding nitrous oxide abuse focuses on its occurrence at concerts, nitrous oxide abuse for recreational purposes is equally prevalent among individuals and small groups in settings far removed from the concert hall.

A.4.7 Theft of cylinders has made nitrous oxide available to people who are seeking the euphoric qualities of the gas, but who are unaware of the hazards of abusing nitrous oxide. People typically steal the cylinders from distributors or legitimate users or falsely represent themselves as legitimate users.

A.5 Guidelines to prevent nitrous oxide theft

A.5.1 CGA recommends the following guidelines for nitrous oxide sales and security. These guidelines are intended to help implement principles of product stewardship and to identify sufficiently responsible control measures that will minimize the theft of nitrous oxide and deter its abuse.

A.5.2 These guidelines are established for the following groups:

A.5.2.1 **Producers**

a) Producers are anyone who produces nitrous oxide and then purifies, compresses, and liquefies this product for storage, shipment, and sale to a second party.

b) It is recommended that producers:

i. Establish a written sales policy that identifies legitimate applications for nitrous oxide, that may include but is not limited to medical, industrial, and food-based uses;

ii. Restrict sale of nitrous oxide to those who can substantiate the legitimate use of nitrous oxide, as enumerated above;

iii. Establish a written policy that clearly defines conditions for cash sales of nitrous oxide (e.g., all cash sales must be accompanied by a driver's license and a certified document that identifies the company or medical practice that will use the product);

iv. Provide customers with a current SDS and any additional instructions for proper use and safe handling practices;

v. Provide this nitrous oxide fact sheet to customers;

vi. Alert employees and customers to the dangers of nitrous oxide abuse.

vii. Non-Bulk producers shall keep an inventory of both full and empty

cylinders and investigate any discrepancies.

viii. Bulk producers (having large non-portable storage containers) shall have a policy to investigate any tampering or vandalism of their bulk storage container.

A.5.2.2 **Commercial Carriers**

a) Commercial carriers are anyone who transports for hire nitrous oxide by road, rail, sea, or air.

b) It is recommended that commercial carriers:

i. Take appropriate steps to prevent the theft of nitrous oxide cylinders, both full and empty, since empty cylinders may contain residual product;

ii. Keep cylinders in a secure area when on company premises;

iii. Do not leave a delivery vehicle unattended without limiting access to nitrous oxide cylinders;

iv. Keep an inventory of both full and empty cylinders and investigate any discrepancies;

v. Report any thefts promptly to the police and the shipper;

vi. Alert employees to the dangers of nitrous oxide abuse and train them on the special security measures they shall take to prevent its theft.

A.5.2.3 **Container fillers of distributors**

a) Container fillers and distributors are anyone who transfers nitrous oxide from a bulk vessel to cylinders, and anyone who sells nitrous oxide to medical, industrial, food, and other legitimate users.

b) It is recommended that container fillers or distributors:

i. Establish a written sales policy that identifies legitimate applications for nitrous oxide, that may include but is not limited to medical, industrial and food-based uses;

ii. Restrict sale of nitrous oxide to those who can substantiate the legitimate use of nitrous oxide, as enumerated above;

iii. Establish a written policy that clearly defines conditions for cash sales of nitrous oxide (e.g., all cash sales must be accompanied by a driver's license and a certified document that identifies the company or medical practice that will use the product);

iv. Sell denatured (e.g., rendered unfit for human consumption) nitrous oxide for enhancing performance of internal combustion engines, so as to deter abuse;

v. Screen existing nitrous oxide accounts to assure that all are legitimate users of nitrous oxide and for unexpected changes in ordering patterns, cylinder balances, or other indications of

increased consumption beyond their normal order pattern;

vi. Provide customers with a current SDS and any additional instructions for proper use and safe handling practices;

vii. Provide this nitrous oxide fact sheet to customers;

viii. Take the following steps to prevent the theft of nitrous oxide cylinders, both full and empty, since empty cylinders may also contain residual product:

ix. Keep cylinders in a secure area when on company premises;

x. Do not leave a delivery vehicle unattended without limiting access to nitrous oxide cylinders;

xi. Keep an inventory of both full and empty cylinders and investigate any discrepancies;

xii. Report any thefts promptly to the police and the supplier;

xiii. Alert employees and customers to the dangers of nitrous oxide abuse and train them on the special security measures they shall take to prevent its theft.

A.5.2.4 **Legitimate Users**

a) Legitimate users are anyone who can substantiate a medical, industrial, food, or other legitimate use for nitrous oxide.

b) It is recommended that legitimate users:

i. Minimize theft and indiscriminate use of nitrous oxide by storing containers and utilization equipment in a secured area subject to removal by authorized personnel only;

ii. Keep an inventory of bulk product and/or containers (both full and empty) and investigate any discrepancies;

iii. Report any thefts promptly to the police and the shipper;

iv. Use denatured (e.g., rendered unfit for human consumption) nitrous oxide, if required, for enhancing performance of internal combustion engines, so as to deter abuse;

v. Alert employees to the dangers of nitrous oxide abuse and train them on the special security measures they shall take to prevent its theft;

vi. Provide employees with a current SDS and any additional instructions for proper use and safe handling practices.

c) Contact your supplier to obtain a nitrous oxide Safety Data Sheet (SDS) for information on the safe handling and security of this product.

Annex 2 (Normative): Properties of Medical Gases

Table 1: Properties of Medical Air

Chemical formula	Mixture of nitrogen and oxygen with oxygen content between 19.5% and 23.5%
Molecular weight	28.975
Colour	Colourless
Odor	Odorless
Life support capability	Will support life. Medical air is the quality verification level (QVL) for medical use.
Physical state in full cylinder	Nonliquefied gas in conventional compressed gas cylinders such as DOT-3A or 3AA.
Approximate number of liters in 1 kg at 70 °F (21.1 °C) and 1 atm	833
Approximate number of liters in 1 oz at 70 °F (21.1 °C) and 1 atm	24
Approximate density at 70 °F (21.1 °C) and 1 atm	0.0749 lb/ft^3 (1.20 kg/m^3)
Combustion characteristics	Nonflammable; supports combustion.
Usual method of manufacture	Compressed from surrounding air then purified and dried; or by mixing medical oxygen and medical nitrogen **NOTE:** Where oxygen and nitrogen are mixed to make medical air, the filling agency shallverify the oxygen content of each cylinder.
Normal cylinder filling limit at 70 °F (21.1 °C)	Nonliquefied gas—1900 psi to 2640 psi (13 100 kPa to 18 200 kPa) pressure, depending upon the type of cylinder.
Pressure in normally charged cylinders	Nonliquefied gas—Pressure in cylinders of air will vary as described in 4.1. At any given temperature, the pressure will decrease proportionately as the cylinder contents are withdrawn.

Table 2: Properties of Medical Carbon Dioxide

Chemical Formula	CO2
Molecular Weight	44.010
Colour	Colourless
Odor	Pungent
Life support capability	Will not support life. Forms acid with body fluids.
Physical state in full cylinder	Liquefied gas below 87.9 °F (31.1 °C) and nonliquefied gas at 88 °F (31.1 °C) and higher in conventional compressed gas cylinders such as DOT-3A or 3AA. Refrigerated liquefied gas in DOT containers.
Number of liters in 1 kg at 70 °F (21.1 °C) and 1 atm	545
Number of liters in 1 oz at 70 °F (21.1 °C) and 1 atm	15.45
Specific gravity of gas compared to air at 70 °F (21.1 ºC) and 1 atm (air = 1)	1.522
Density at 70 °F (21.1 °C) and 1 atm	0.1144 lb/ft3 (1.833 kg/m3)
Combustion characteristics	Nonflammable; does not support combustion.
Usual methods of manufacture	• Adsorption and recovery from product of combustion of various carbonaceous materials. • From natural sources such as springs or water. • Containing the gas in solution. • By thermal decomposition of carbonate. • By action of acid on carbonate. • As a by-product in fermentation processes.
Normal cylinder filling limit	Liquefied gas—68% of the weight of water that cylinder will hold. (Normal industry practice has

	been to fill carbon dioxide cylinders to 50 lb).
Pressure in normally charged cylinders	Refrigerated liquefied gas—approved percentage of water capacity based upon liquid density at relief valve setting, e.g., 97% at 350 psi (2413 kPa). Pressure in cylinders of carbon dioxide charged to a filling density of 68% will vary with temperature. At temperatures be-low 88 °F (31.1 °C), the pressure will drop with continuous withdrawal of gas. However, if liquid remains when withdrawal stops, cylinder pressure will slowly return to the pressure corresponding to the temperature of the contents. At temperatures of 88 °F (31.1 °C) or higher, the pressure at a given temperature will decrease proportionately as the contents are withdrawn.

Table 3: Properties of Medical Helium

Chemical formula	He
Molecular weight	4.00
Colour	Colourless
Odor	Odorless
Life support capability	Will not support life.
Physical state in cylinder	Nonliquefied gas in conventional compressed gas cylinder such as DOT-3A or -3AA.
Number of liters in 1 kg at 70 °F (21.1 °C) and 1 atm	6037
Number of liters in 1 oz at 70 °F (21.1 °C) and 1 atm	171.15
Specific gravity of gas compared to air at 70 °F (21.1 °C) and 1 atm (air = 1)	0.1380
Density at 70 °F (21.1 °C) and 1 atm	0.0103 lb/ft^3 (0.165 kg/m^3)
Combustion characteristics	Nonflammable; does not support combustion.
Usual method of manufacture	From natural gas through a process of liquefaction and purification.

Normal cylinder filling limit at 70 °F (21.1 °C)	Nonliquefied gas—1600 psi to 2640 psi (11 030 kPa to 18 200 kPa) depending upon the type of cylinder and method of filling.
Pressure in normally charged cylinders	Nonliquefied gas—Pressure in cylinder of helium will vary At any given temperature, the pressure will decrease proportionately as the cylinder contents are withdrawn.

Table 4: Properties of Medical Nitrogen

Chemical formula	N2
Molecular weight	28.01
Colour	Colourless
Odor	Odorless
Life support capability	Will not support life.
Physical state in full cylinder	Nonliquefied gas in conventional compressed gas cylinders such as DOT-3A or 3AA. Refrigerated liquid in CTC/DOT-4L containers.
Number of liters in 1 kg at 70 °F (21.1 °C) and 1 atm	861
Number of liters in 1 oz at 70 °F (21.1 °C) and 1 atm	24.42
Specific gravity of gas compared to air at 70 °F (21.1 °C) and 1 atm (air = 1)	0.967
Density at 70 °F (21.1 °C) and 1 atm	0.072 lb/ft^3 (1.153 kg/m^3)
Combustion characteristics	Nonflammable; does not support combustion.
Usual method of manufacture	Separation from air.
Normal cylinder filling limit at 70 °F (21.1 °C)	Nonliquefied gas—1900 psi to 2640 psi (13 100 kPa to 18 200 kPa) pressure depending upon the type of cylinder.

	Refrigerated liquid; approved percentage of water capacity based upon liquid density at relief valve setting, e.g., 69% at 230 psi (1590 kPa)
Pressure in normally charged cylinders	Nonliquefied gas—Pressure in cylinders of nitrogen will vary. At any given temperature, the pressure will decrease proportionately as the cylinder contents are withdrawn. Refrigerated liquid up to 235 psi (1620 kPa) /DOT-4L containers—Pressure in container during normal operation is 75 psi (517 kPa). During nonusage, pressure will increase very slowly over a period of 3-5 days to 235 psi (1620 kPa), after which the container will vent gas at a rate of 2 ft3/hr to 5 ft3/hr (1 L/min to 2.5 L/min).

Table 5: Properties of Medical Nitrous Oxide

Chemical formula	N2O
Molecular weight	44.0128
Colour	Colourless
Odor	Odorless
Life support capability	Anesthetic. Will not support life.
Physical state in full cylinder	Liquefied gas below 98 °F (37 °C) and nonliquefied gas at 98 °F (37 °C) and higher in conventional compressed gas cylinders such as CTC/DOT-3A or 3AA. Refrigerated liquefied gas in DOT E-7638 containers.
Number of liters in 1 kg at 70 °F (21.1 °C) and 1 atm	545
Number of liters in 1 oz at 70 °F (21.1 °C) and 1 atm	15.444

Specific gravity of gas compared to air at 70 °F (21.1 ºC) and 1 atm (air = 1)	1.5297
Density at 70 °F (21.1 °C) and 1 atm	0.1146 lb/ft^3 (1.947 kg/m^3)
Combustion characteristics	Nonflammable; supports combustion.
Usual methods of manufacture	Thermal decomposition of ammonium nitrate or recovery of by-product from the nitric acid oxidation of cyclohexanone and cyclohexanol. Normal cylinder filling limit. Liquefied gas—68% of the weight of water that the cylinder will hold. Refrigerated liquefied gas—approved percentage of water capacity based on liquid density at relief valve setting, e.g., 94% at 350 psi (2410 kPa).
Normal cylinder filling limit	Liquefied gas—68% of the weight of water that the cylinder will hold. Refrigerated liquefied gas—approved percentage of water capacity based on liquid density at relief valve setting, e.g., 94% at 350 psi (2410 kPa).
Pressure in normally charged cylinder	Pressure in cylinders of nitrous oxide charged to a filling density of 68% will vary with temperature approximately as shown in Table E-2. In any cylinder of nitrous oxide at temperatures below 98 °F (37 °C), the pressure will drop with continuous withdrawal of gas. However, if liquid remains when withdrawal stops, the cylinder pressure will slowly return to the pressure

	corresponding to the temperature of the cylinder. At temperatures of 98 °F (37 °C) or higher, the pressure at a given temperature will decrease proportionately as the contents are withdrawn.

Table 6: Properties of Medical Oxygen

Chemical formula	O2
Molecular weight	31.9988
Colour	Colourless
Odor	Odorless
Life support capability	Will support life
Physical state in the cylinder	Nonliquefied gas in conventional compressed gas cylinders such as DOT-4L containers
Number of liters in 1 kg at 70 °F (21.1 °C) and 1 atm	754
Number of liters in 1 oz at 70 °F (21.1 °C) and 1 atm	21.4
Specific gravity of gas compared to air at 70 °F (21.1 ºC) and 1 atm (air = 1)	1.105
Density at 70 °F (21.1 °C) and 1 atm	0.08279 lb/ft^3 (1.326 kg/m^3)
Combustible characteristics	Nonflammable; supports combustion
Usual method of manufacture	Separation from air
Normal cylinder filling limit at 70 °F (21.1 °C)	Nonliquefied gas—Nonliquefied gas 1900 psi to 2640 psi (13 100 kPa to 18 200 kPa)

	depending on the type of cylinder Refrigerated Approved[1)] percentage of water capacity liquid based on liquid density at relief pressure valve setting, e.g., 98% at 230 psi (1590 kPa)
Pressure in normally charged cylinder	Nonliquefied gas—Pressures in cylinders of oxygen will vary At any given temperature, the pressure will decrease proportionately as the cylinder contents are withdrawn. Refrigerated liquid up to 235 psi (1620 kPa) in DOT-4L containers—Pressure in container during normal operation is 75 psi (517 kPa). During nonusage, pressure will increase very slowly over a period of 3 to 5 days to 235 psi (16 200 kPa) after which the container will vent gas at a rate of 2 ft^3/hr to 5 ft^3/hr (1 L/min to 2.5 L/min). Respiratory liquid oxygen base reservoirs—Refrigerated liquefied gases up to 50 psi (345 kPa) in liquid oxygen base reservoirs. Pressure in container will increase very slowly over a period of time to 20 psi to 50 psi after which the container will vent gas at a rate of 0.3 L/min to 0.5 L/min.
[1)] Reference Table in 49 CFR 173.316(c) (2) [10].	

Cylinder style	Dimensions[1] in (cm)	Service pressure psi (kPa)	Nominal water volume in^3 (L)	Pressure at 70 °F (15 °C) psi (kPa)	Air ft^3 (L)	Helium ft^3 (L)	Nitrogen ft^3 (L)	Oxygen ft^3 (L)
D	4.25 x 17 (10.8 x 43)	2015 (13 890)	180 (2.95)	1600 (11 030) 1900 (13 100) 2015 (13 890)	13.6 (380) 14.4 (400)	10.9 (300) 12.8 (350) 13.5 (370)	13.4 (370) 14.1 (390)	14.4 (400) 15.3 (420)
E		2015 (13 890)	293 (4.80)	1600 (11 030) 1900 (13 100) 2015 (13 890)	22.2 (620) 23.5 (650)	17.7 (490) 20.8 (580) 22.0 (610)	21.8 (600) 23.0 (640)	23.5 (650) 24.9 (690)
110 [2]	7 x 43 (17.8 x 109)	2015 (13 890)	1338 (21.90)	1600 (11 030) 1900 (13 100) 2015 (13 890) 2217 (15 290)	101 (2810) 107 (2970) 117 (3250)	81 (2240) 95 (2630) 100 (2780) 110 (3040)	100 (2760) 105 (2920) 115 (3190)	107 (2970) 114 (3160) 125 (3470)
200 [2]	8.5 x 51 (21.6 x 130)	2015 (13 890)	2370 (38.80)	1600 (11 030) 1900 (13 100) 2015 (13 890) 2217 (15 290)	179 (4980) 190 (5260) 208 (5760)	143 (3970) 168 (4660) 178 (4930) 194 (5380)	176 (4890) 186 (5160) 204 (5650)	190 (5270) 202 (5590) 222 (6150)
225 [2]	9.25 x 51 (23.5 x 130)	2015 (13 890)	2660 (43.60)	2015 (13 890) 2217 (15 290)	213 (5900) 233 (6460)	199 (5530) 218 (6040)	209 (5800) 229 (6340)	226 (6270) 249 (6900)
250 [2]	9.25 x 51 (23.5 x 130)	2265 (15 620)	2660 (43.60)	2265 (15 620) 2492 (17 180)	238 (6590) 259 (7190)	222 (6160) 242 (6720)	233 (6460) 254 (7030)	254 (7060) 280 (7760)
300 [2]	9.25 x 55 (23.5 x 140)	2400 (16 550)	3025 (49.60)	2400 (16 550) 2640 (18 200)	285 (7910) 311 (8620)	267 (7390) 291 (8070)	279 (7740) 304 (8420)	307 (8510) 337 (9340)

NOTE: Volume of contents is based on nominal cylinder volumes. Pressure or contents of mixes will vary with mix composition.

[1)] Outside diameter (O.D.) x height

[2)] Nominal ft^3 at service pressure. Check with supplier for letter designation.

Table 8: Contents of liquefied gases in uninsulated cylinders by weight and equivalent gas volume

Cylinder style	Dimensions [1)] in (cm)	Service pressure [2)] psi (kPa)	Nominal volume in^3 (L)	Carbon dioxide [3)] lb-oz, ft3 (kg, L)	Nitrous oxide [4)] lb-oz, ft3 (kg, L)
B	3.5 x 13 (8.89 x 33)	2 015 (13 890)	87 (1.43)	1-8, 13.1 (0.68, 370)	
D	4.25 x 17 (10.8 x 43)	2 015 (13 890)	180 (2.95)	3-13, 33.2 (1.73, 940)	3-13, 33.2 (1.73, 940)
E	4.25 x 26 (10.8 x 66)	2 015 (13 890)	293 (4.80)	6-7, 56.1 (2.92, 1 590)	6-7, 56.1 (2.92, 1 590)
30 [5)]	7 x 43 (17.8 x 109)	2 015 (13 890)	1 337 (21.9)	30-10, 267 (13.9, 7 570)	30-10, 267 (13.9, 7 570)
56 [5)]	8.25 x 51 (21.6 x 130)	2 015 (13 890)	2 370 (38.8)	56-0, 487 [6)] (25.4, 13 800)	56-0, 487 [6)] (25.4, 13 800)
4 5)	9.25 x 51 (23.5 x 130)	2 015 (13 890)	2 675 (43.8)	64-0, 558 (29.1, 15 800)	64-0, 558 (29.1, 15 800)

[1)] Outside diameter (O.D.) x height

[2)] Lower service pressures are permitted. Minimum service pressure for nitrous oxide and carbon dioxide is 1800 psi.

3) Carbon dioxide vapor pressure = 838 psi at 70 F (5780 kPa at 21.1 C).

4) Nitrous oxide vapor pressure = 745 psi at 70 F (5140 kPa at 21.1 C).

5) Nominal capacity in pounds at 68% filling density. Letter designations may vary from supplier to supplier.

6) 3A/3AA 1800 cylinders with similar O.D. dimensions to 3AA 2915 cylinders have a nominal water volume of 2160 in^3 and may only be filled to a maximum of 50 lb with carbon dioxide or nitrous oxide.

Table 9: Colour marking of high pressure steel cylinders for medical use

GAS TYPE	COLOUR
SINGLE GASES	
Medical Oxygen	Silver and green
Medical Carbon Dioxide	Gray
Medical Nitrous Oxide	Navy blue
Medical Helium	Mustard yellow and brown or only brown
Medical Nitrogen	Black
Medical Air	White
GAS MIXTURES	
Medical Oxygen 19.5% - 23.5% balance Medical Nitrogen	White
Other concentrations of mixtures of Medical Oxygen and Medical Nitrogen	Silver and White
Medical Oxygen and Medical Nitrous Oxide	Silver and Navy Blue
Medical Oxygen and Medical Carbon Dioxide	Silver and Gray
Medical Carbon Dioxide and Medical Air (Oxygen and Nitrogen)	Gray and White
Medical Carbon Dioxide and Medical Nitrogen	Gray and Black
Medical Carbon Dioxide and Medical Helium	Gray and Brown
Medical Oxygen and Medical Helium	Silver and Brown

Table 10: Liquid contents by weight and equivalent gaseous volume [1)]

Container capacity [2)] ft^3 (L)	**Carbon dioxide [3)]** lb, ft^3 (kg, L)	**Nitrogen [4)]** lb, ft^3 (kg, L)	**Nitrous oxide [5)]** lb, ft^3 (kg, L)	**Oxygen [6)]** lb, ft^3 (kg, L)

80 (85)		129, 1 560 (59, 43 200)		183, 2 210 (83, 61 400)
160 (176)	376, 3 280 (171, 91 000)	267, 3 230 (121, 89 500)	364, 3 180 (165, 88 100)	379, 4 580 (172, 127 100)
180 (196)	418, 3 650 (190, 101 300)	298, 3 590 (135, 99 600)	405, 3 540 (184, 98 100)	423, 5 100 (192, 141 500)
190 (209)	446, 3 900 (202, 108 000)	317, 3 830 (144, 106 200)	432, 3 770 (196, 104 600)	451, 5 440 (205, 150 900)
230 (239)		363, 4 380 (165, 121 500)		515, 6 220 (234, 172 600)
265 (276)		419, 5 060 (190, 140 300)		595, 7 190 (270, 199 300)

1) Relief valve settings vary and are selected based on application requirements and service pressure of the container. Other relief valve settings will alter the permitted contents. Gaseous equivalents will vary with the filling density.

2) Container size is expressed as water volume. Actual water volumes vary from manufacturer to manufacturer. Consult manufacturer's literature for capacity information.

3) Maximum DOT fill density of 97% with pressure control valve setting of 350 psi.

4) Maximum DOT fill density of 69% with pressure control valve setting of 230 psi.

5) Maximum DOT fill density of 94% with pressure control valve setting of 350 psi.

6) Maximum DOT fill density of 98% with pressure control valve setting of 230 psi.

Table 11: Cryogenic outlet connections

Product	Liquid fill withdrawal	Vent	Gas use
Cryogenic oxygen	CGA 440	CGA 440	CGA 540
Cryogenic nitrogen	CGA 295	CGA 295	CGA 580
Carbon dioxide	CGA 320	CGA 320	CGA 622
Nitrous oxide	CGA 326	CGA 326	CGA 624

Table 12: Requirements for compressed gas container labels

Gas	Label requirement
Oxygen	nonflammable gas label (green) and oxidizer label (yellow) [1)]
Other nonflammable gases	nonflammable gas label (green)
Flammable gases	flammable gas label (red)

END OF DOCUMENT

MADE by the Minister responsible for the Bureau of Standards this 29 day of September, 2025.

(HON. JOSE ABELARDO MAI)
Minister of Agriculture, Food Security and Enterprise
(Minister responsible for the Bureau of Standards

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