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CGA P-2—2019

**GUIDELINE FOR
CHARACTERISTICS AND SAFE
HANDLING OF MEDICAL GASES**

ELEVENTH EDITION

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NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendices A, B, C, D, E, F, and G (Informative) are for information only.

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1 Introduction

This publication provides information about and 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 or as otherwise defined in NFPA 99, *Health Care Facilities Code* [1].¹

2 Scope

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

This publication does not address the following:

- manufacture of, distribution to the customer location, or the administration of medical gases;
- oxygen 93% and nitrogen 97%, since these are health care facility manufactured or produced products; and
- oxygen concentrators or the containers filled by these devices that are used by individuals in health care facilities.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Container

Portable compressed gas cylinders and liquid containers made in accordance with the U.S. Department of Transportation (DOT) or Transport Canada (TC) specifications or liquid oxygen base reservoirs and portable vessels with service pressures under 40 psi (276 kPa).²

3.2.2 Distributor

Any person or firm who markets filled medical gas cylinders and who has not performed any manufacturing steps, such as filling, or relabeling.

3.2.3 Filling density

Percent ratio of the weight of gas in a container to the weight of water the container will hold at 60 °F (15.6 °C).

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section.

² kPa shall indicate gauge pressure unless otherwise noted as (kPa, abs) for absolute pressure or (kPa, differential) for differential pressure. All kPa values are rounded off per [CGA P-11, Guideline for Metric Practice in the Compressed Gas Industry](#) [2].

3.2.4 Manufacturer

Any person or firm who produces, fills, or relabels medical gas cylinders.

3.2.5 Transfilling

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)* [3]. Specific properties and additional information about most gases used in medical service are contained in Appendix A to Appendix F.

4.1.1 Nonliquefied compressed (oxygen, nitrogen, air, helium)

For cylinders charged with nonliquefied 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.

Specific properties and additional information, and cylinder content information can be found in the Appendices as follows:

Gas	Properties and other information	Cylinder content
Air	Appendix A	Table G-1
Helium	Appendix C	Table G-1
Nitrogen	Appendix D	Table G-1
Oxygen	Appendix F	Table G-1

4.1.2 Liquefied compressed (carbon dioxide, nitrous oxide)

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.

Specific properties and additional information, and cylinder content information can be found in the Appendices as follows:

Gas	Properties and other information	Cylinder content
Carbon dioxide	Appendix B	Table G-2
Nitrous oxide	Appendix E	Table G-2

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

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.

Specific properties and additional information, and container fill density and content information can be found in the Appendices as follows:

Gas	Properties and other information	Container content
Carbon dioxide	Appendix B	Table G-3
Nitrogen	Appendix D	Tables G-3 and G-6
Nitrous oxide	Appendix E	Table G-3
Oxygen	Appendix F	Table G-3

4.2 Multi-component medical gases

Multi-component medical gases are either drug gas mixtures or device gas mixtures, based on their use or the primary action that the gas has on the body.

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 other animals. A mixture may be considered a drug gas mixture even if it does not contain oxygen. Non-oxygen containing mixtures will typically be mixed with oxygen via a gas blender or mixer immediately prior to administration.

Device gas mixtures are typically used in conjunction with medical equipment, such as analyzers or lasers, or they achieve their primary action in or on the body by physical and not chemical means. These mixtures may contain oxygen but they are not intended for therapeutic use and are typically not inhaled. There are exceptions, such as device gas mixtures called lung diffusion mixtures.

4.2.1 Drug gases

A number of different mixtures of single component medical gases identified in 4.1 may be supplied as drug gases. These mixtures commonly include:

- oxygen in combination with nitrogen, carbon dioxide, nitrous oxide, or helium;
- oxygen in combination with both carbon dioxide and nitrogen; and
- oxygen in combination with both helium and nitrogen.

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

A number of different mixtures of medical gases are supplied as medical device mixtures. These mixtures most commonly include lung diffusion gas, blood gas, laser gases, aerobic, and anaerobic mixtures. These products are commonly provided in both high pressure reusable cylinders and nonrefillable single use cylinders.

4.3 Regulations and other standards

In the United States, medical gases shall comply with the Federal *Food, Drug and Cosmetic Act* and its supporting regulations [4]. The registration requirements specified by these regulations are found in Title 21 of the U.S. *Code of Federal Regulations* (21 CFR) Parts 207 and 807 [5]. Under the provisions of the *Food, Drug and Cosmetic Act*, certain medical gases shall conform to the standards of the United States Pharmacopeia and National Formulary (USP–NF) [3].

In Canada, medical gases shall comply with the regulations of Health Canada.

The United States Pharmacopeia publishes official pharmacopeial standards in the *USP–NF* [3]. The *USP–NF* contains a section or monograph on air, carbon dioxide, helium, nitrogen, nitrous oxide, and oxygen. Standards and methods of testing are prescribed in each monograph to ensure appropriate quality and purity.

5 Containers

5.1 Bulk storage systems

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.

5.1.1 Installation

Bulk storage systems at health care facilities shall be installed by qualified personnel in accordance with [CGA M-1](#), *Standard for Medical Gas Supply Systems at Health Care Facilities (an American National Standard)*, NFPA 99, NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, and local requirements [6, 1, 7].

5.1.2 Maintenance

In accordance with NFPA 99 a scheduled maintenance program shall be followed [1]. Health care facilities are responsible for performing periodic inspections (e.g., daily, monthly, annually, etc.) of their bulk storage and related systems to assure they are functioning properly and have not been tampered with or inappropriately modified. These inspections shall be performed in accordance with [CGA E-10](#), *Guideline for the Maintenance of Medical Gas and Vacuum Systems in Health Care Facilities* and any other requirements specified by the gas supplier [8].

5.1.3 Use

Bulk systems at health care facilities are typically designed to supply the health care facilities' gaseous product needs and in accordance with NFPA 99 shall not be used for liquid withdrawal. A separate dedicated system may be installed for that purpose. See also [CGA SB-23](#), *Liquid Oxygen USP Withdrawal from Health Care Facilities' Primary or Reserve Bulk Storage Tank Systems* [9].

5.2 High pressure cylinders and valves

5.2.1 High pressure cylinder styles and pressure ratings

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. These high pressure cylinders have standard styles having the dimensions and capacities shown in Appendix G, Tables G-1 and G-2. Most high pressure cylinders are refillable however, some device gas mixtures are provided in nonrefillable single use cylinders.

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.

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).

In the United States, the Department of Transportation (DOT) require high pressure cylinders to comply with the requirements specified in Title 49 of the U.S. *Code of Federal Regulations* (49 CFR) Parts 100-180 [10]. In Canada, Transport Canada (TC) requires high pressure cylinders to comply with the requirements specified in the *Transportation of Dangerous Goods Regulations* [11].

In accordance with DOT and TC regulations cylinders shall be marked with the specification that they were manufactured to along with their service pressure rating. They 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.

Cylinders that have been in a fire shall be removed from service until they are subjected to the prescribed reconditioning procedures. Aluminum alloy cylinders cannot be reconditioned and shall be condemned if they have been exposed to fire.

For additional information regarding high pressure cylinders, including the marking and inspection requirements, consult CGA publications; [C-6](#), *Standard for Visual Inspection of Steel Compressed Gas Cylinders*; [C-6.1](#), *Standard for Visual Inspection of High Pressure Aluminum Alloy Gas Cylinders*; [C-6.2](#), *Standard for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders*; and [P-15](#), *Standard for the Filling of Industrial and Medical Nonflammable Compressed Gas Cylinders* [12, 13, 14, 15].

5.2.2 Valves

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* [16]. 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.

Only standard valve outlet connections should 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.

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.

5.2.2.1 Threaded

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.

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.

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.

It is imperative that the user not rely on the connection to identify the gas. The user shall verify that the product label identifies the gas and then that the connection is consistent with that gas.

5.2.2.2 Pin-indexed

The Pin Index Safety System was designed to aid in the prevention of medical gas mix-ups. Details regarding the Pin Index Safety System can be found in [CGA V-1](#) [16]. 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.

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. Seals should be replaced per the

manufacturer's direction, also see [CGA TB-29](#), *Use of Gaskets in High Pressure Medical Oxygen Cylinder Service* [17].

5.2.2.3 Valve integrated pressure regulators

VIPRs were developed by the industry based on customer desires to eliminate the need for assembling pressure regulators and cylinder valves using either threaded or pin index connections. VIPR specifications are found in [CGA E-18](#), *Medical Gas Valve Integrated Pressure Regulators* [18]. VIPRs utilizing a Diameter Index Safety System (DISS) connections for gas use outlet are unique for the gas service. See 7.1 for more information on DISS connections. VIPRs, utilizing a hose barb for gas use outlet, are not unique for gas service. The user shall follow the supplier's VIPR instructions and assure the proper gas service by verifying the product label.

5.2.3 Color codes

Color markings that aid in the identification of medical gas cylinders and containers have been adopted by the medical gas industry. [CGA C-9](#), *Standard Color Marking of Compressed Gas Containers for Medical Use*, describes the color markings and the proper application of the colors to various gas containers, see Table 1 [19].

NOTE—[CGA C-9](#) does not address color markings for device gases [19].

Table 1—Color marking of compressed gas containers for medical use ³

	United States Color ³⁾	Canada Color ¹⁾
Single gases		
Oxygen USP	Green	White ²⁾
Carbon dioxide USP	Gray	Gray
Nitrous oxide USP	Blue	Blue
Helium USP	Brown	Brown
Nitrogen NF	Black	Black
Medical air USP	Yellow ²⁾	Black and white quadrants
Gas mixtures of oxygen USP and nitrogen NF		
19.5% to 23.5% oxygen	Yellow ²⁾	Black and white quadrants
All other oxygen concentrations	Black and green	Pink
Other gas mixtures		
Oxygen USP and nitrous oxide USP: 47.5% to 52.5% oxygen USP, remainder nitrous oxide USP	Green and blue	White and blue quadrants
All other oxygen concentrations	Green and blue	Pink
Oxygen USP and carbon dioxide USP: ≥ 93% oxygen USP, remainder carbon dioxide USP	Green and gray	White and gray quadrants
All other oxygen concentrations	Green and gray	Pink
Carbon dioxide USP, oxygen USP, and nitrogen NF; or carbon dioxide USP, medical air USP	Gray, green, and black	Pink
Carbon dioxide USP and nitrogen NF	Gray and black	Pink
Carbon dioxide USP and helium USP	Gray and brown	Pink
Oxygen USP and helium USP: ≥ 20% oxygen USP, remainder helium USP	Green and brown	White and brown quadrants
All other oxygen concentrations	Green and brown	Pink
NOTE—The designation USP does not apply to containers filled using home fill oxygen systems.		
¹⁾ In Canada, the color pink shall be used for any other mixture not specified in Table 1.		
²⁾ Historically, white has been used in the United States and yellow has been used in Canada to identify vacuum systems. Therefore, white <i>shall not</i> be used in the United States, and yellow <i>shall not</i> be used in Canada to identify containers for use with any medical gas.		

³ Table 1 is an excerpt from Section 5.1 of [CGA C-9](#), *Standard Color Marking of Compressed Gas Containers for Medical Use*, Fifth Edition [19].

5.3 Large cryogenic containers and valves

5.3.1 Styles

Large cryogenic containers consist of two different types:

- 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 should contact their gas supplier if different gas pressures are required; and
- The second type typically known as liquid systems (LS) or vertical liquid (VL) are typically low pressure, liquid withdrawal only.

Appendix G, Table G-3 provides for typical sizes, the net contents in terms of pounds, cubic feet, and equivalent metric units. These values reflect contents when full. The user should expect normal evaporation through the primary relief valve influenced by ambient conditions, to occur anywhere between 1.4% and 2% per day.

5.3.2 Valves

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.

Cryogenic outlet connections are designed to prevent mix-ups. The following connections, listed in Table 2, are utilized with large portable cryogenic containers in accordance with [CGA V-1](#) [16].

Table 2—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

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 should not be used. Also see [CGA SB-26](#), *Cylinder Connections on Portable Liquid Cryogenic Cylinders* [20]. The user shall never adapt or change the valve outlet connections on these vessels.

5.4 Small cryogenic containers and portables

5.4.1 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. Appendix G, Tables G-4 and G-5 provide the net contents of typical oxygen home care base and portable vessels. These vessels utilize the oxygen DISS connection discussed in 7.1.

5.4.2 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.