Compressed Breathing Air

1. Introduction

a. Atmosphere supplying respirators, including self-contained breathing apparatus (SCBA) and supplied-air (airline) respirators are the most complex types of respirators and require detailed respirator programs to support their use. One of most important elements of these respirator programs are procedures to ensure atmosphere supplying respirators provide high quality breathing air to the wearer.

b. There are several standards, regulations and instructions discussed in Section 2 that establish breathing air quality requirements and govern the use of atmosphere-supplying respirators.

2. Breathing Air Quality Standards

a. 29 CFR 1910.134
   (1) The Occupational Safety and Health Administration's Respiratory Protection Standard, Reference 1, requires procedures to ensure adequate quality, quantity and flow of breathing air for atmosphere-supplying respirators. Reference 1 requires compressed and liquid oxygen shall meet the United States Pharmacopoeia requirements for medical or breathing oxygen. Also, compressed breathing air shall meet at least the requirements for Grade D breathing air described in Reference 2. OSHA specifically states that the requirements for Grade D breathing air according to Reference 2 are an oxygen content (v/v) of 19.5-23.5%, a hydrocarbon (condensed) content of 5 milligrams per cubic meter of air or less, a carbon monoxide (CO) content of 10 parts per million (ppm) or less, a carbon dioxide content of 1,000 ppm or less, and a lack of noticeable odor. Per Reference 1, compressors used to supply breathing air to respirators must be constructed and situated to minimize moisture content so that the dew point at 1 atmosphere pressure is 10°F below the ambient temperature.
   (2) Per Reference 1, cylinders of purchased breathing air are required to have a certificate of analysis from the supplier stating that the breathing air meets the requirements for Grade D breathing air. The moisture content in the cylinder cannot exceed a dew point of -50°F (-45.6°C) at 1 atmosphere pressure.
   (3) Reference 1 also contains requirements for compressors used to supply breathing air. These requirements are detailed below.

b. OPNAVINST 5100.23 Series, Navy Safety and Occupational Health Program Manual
   (1) Reference 4 states breathing air must at least meet the minimum Grade D breathing air requirements of Reference 1, which are established by Reference 3. Reference 4

states that breathing air must be monitored quarterly and the results retained in the safety office for five years.

(a) A NOTE contained in Reference 4 states, "Monitoring does not apply to ambient air breathing apparatus." Ambient Air Breathing Apparatuses (AABAs) are exempt from the quarterly breathing air testing requirement.

(b) AABAs are defined as portable electrically or pneumatically-powered oil-less air pumps which supply breathing air to low pressure continuous flow respirators. Although AABAs do not generate oil mist, oil vapor or carbon monoxide, they also do not produce Grade D breathing air. The ambient air that is drawn through the inlet particulate filter is delivered to the respirator(s) without significant change to the air quality. Therefore, air inlets must be placed in contaminant-free environments.

(2) Reference 4 requires newly purchased compressors (except AABA) to be equipped with continuous carbon monoxide monitor and alarm systems. Existing compressors must have continuous carbon monoxide monitor and alarm systems installed when they are upgraded during major overhaul maintenance. This paragraph also requires that carbon monoxide monitor and alarm systems be calibrated according to manufacturers' instructions. More information on this issue is provided in Section 4, Standard Specific Compressor Requirements, below.

c. OPNAVINST 5100.19 Series, Navy Safety and Occupational Health Program Manual for Forces Afloat

(1) Reference 5 requires testing breathing air compressors quarterly to ensure Grade D air quality is met. Like Reference 4, there are carbon monoxide monitor and alarm requirements, which are discussed in Section 6 below.

(a) Ship's low pressure air is not suitable for use as breathing air unless specifically tested and certified to meet Grade D air criteria.

(b) AABA air quality testing is not required.

d. CGA G-7.1, Commodity Specification for Air

(1) The Compressed Gas Association, Inc. (CGA) published the seventh edition of CGA G-7.1 in 2018. American National Standards Institute (ANSI) jointly published the first three editions (1966, 1973, and 1989) of this standard as ANSI Z86.1. However, the 2011, 2004 and the 1997 editions were published solely by CGA.

(a) CGA G-7.1-1989 edition changes from 1973 edition:

1. Grades B, C, F and H gaseous air were discontinued because they no longer had major usage in industry.
2. Type II - Grade B liquid air was discontinued.
3. Established four new gaseous air classes - K, L, M and N.
4. Reduced the maximum allowable concentration of carbon monoxide in Grade D air from 20 ppm to 10 ppm.

(b) The CGA G-7.1-1997 standard discontinued three quality verification levels (Grades) from the 1989 edition, which included Grades K, G and M. OSHA was not aware of the 1997 edition of CGA G-7.1 when they promulgated their final Respirator Standard, 29 CFR 1910.134 on 8 January, 1998. The respirator standard

(Reference 1) required compressed breathing air to meet at least the requirements for "Type I - Grade D" breathing air described in CGA G-7.1- 1989. However, the Type I and II terminology for breathing air was discontinued after the 1989 edition of CGA G-7.1. OSHA corrected this error to specify "Grade D" instead of "Type I - Grade D" in the 23 April 1998 Federal Register.

(c) To prevent self-contained breathing apparatus (SCBA) valves from freezing, the 1997 and 2004 versions of CGA G-7.1 specified Grade L air for use with SCBA worn in extreme cold because of the Grade L air low moisture requirements of 24 ppm and -65° F dew point. However, the only other requirement for Grade L air was 19.5% to 23.5% oxygen content. Although the low moisture requirement made sense, it did not make sense for Grade L air to not require the same limiting characteristic requirements of Grade D air. This was corrected in the 2011 version of CGA G-7.1, in which Grade L and Grade D have the same limiting characteristics, except for the more stringent moisture requirements of Grade L air for use in SCBA worn in extreme cold. Table 2 of Reference 3 defines the typical, but not all inclusive, industrial uses for CGA grades of air. These uses are listed in Table 1.

Table 1-Grades of Compressed Air

CGA Grade	Industrial Uses
A	Industrial compressed air
L	Self-Contained Breathing Apparatus (SCBA) air
D	OSHA breathing air
E	Self-contained underwater breathing apparatus (SCUBA)
J	Specialty grade air, analytical applications
N	Medical air USP, food applications

(d) See Reference 3, Table 1 for maximum concentrations of the air constituents for each grade of compressed air. A blank box in the table indicates no maximum limiting characteristic. This does not mean that the substance is not present, but indicates that testing that component is not a requirement for compliance with the specification.

3. Grade D Air Limiting Characteristics

a. Oxygen - 19.5% to 23.5%

(1) Reference 1 does not allow the use of compressed oxygen in atmosphere-supplying respirators that have previously used compressed air. This is to prevent a flammability hazard from high pressure oxygen coming in contact with any oil introduced inside the airline hoses from compressed air operations. Reference 1 further requires that oxygen concentrations greater than 23.5% are used only in equipment designed for oxygen service or distribution (e.g., closed circuit respirators).

(2) It may seem counterintuitive that oxygen content in compressed breathing air even need be sampled because air intakes located outdoors should contain 20.9% oxygen since that is its concentration in ambient, atmospheric air. Unfortunately, there is no

guarantee that every employer will place air intakes in proper locations or properly maintain their air compressors.

(3) Although air intakes are required to be properly located in fresh outdoor atmospheres such as above roof level and away from ventilation exhausts, they are sometimes improperly located outdoors on loading docks and exposed to vehicle exhaust. Depending on the circumstances, there could also be a chance of oxygen depletion by the presence of other substances where air intakes are improperly located. Oxygen can also be consumed inside of oil-lubricated compressors running hot in the presence of hydrocarbons.

(4) Other factors that influence the oxygen concentration include moisture in the air and altitude. Moisture is the most variable component of the atmosphere. Water vapor in the atmosphere can range from 0% to 4%. In dry air (0% water vapor), the oxygen concentration is approximately 20.9%; however, atmospheres with 4% water vapor contain only 20.06% oxygen.

(5) At higher altitudes the percentage of oxygen remains the same as at sea level but the partial pressure of oxygen decreases, which effectively lowers the oxygen concentration available for respiration.

(a) Altitude affects the concentration of oxygen both in ambient air and in compressed breathing air. OSHA states in Reference 1 that all oxygen-deficient atmospheres (less than 19.5% O_2 by volume) shall be considered immediately dangerous to life or health (IDLH) and that personnel entering these atmospheres must wear either SCBA or combination airline/SCBA.

(b) There is an exception when the employer can demonstrate that under all foreseeable conditions, the oxygen concentration can be maintained within the ranges at the altitudes specified in Table II of the OSHA Respirator Standard (reproduced below). If so, then any atmosphere supplying respirator, including airline respirators may be used.

Table 2

Altitude (ft.)	Oxygen deficient Atmospheres (% 02) for which the employer may rely on any atmosphere-supplying respirator
Less than 3,001	16.0-19.5
3,001-4,000	16.4-19.5
4,001-5,000	17.1-19.5
5,001-6,000	17.8-19.5
6,001-7,000	18.5-19.5
7,001-8,000	19.3-19.5

(c) At high altitudes, References 1 and 6 require oxygen-enriched breathing air for atmosphere-supplying respirators.

(d) Per Reference 1, OSHA allows acclimated workers to perform their work without atmosphere-supplying or oxygen-supplying respirators, at altitudes up to 14,000 feet altitude, as long as the ambient oxygen content remains above 19.5%.

b. Carbon monoxide (CO) - 10 ppm
   (1) CGA G-7.1 -1973 listed the maximum limit for CO as 20 ppm. The limit for CO was changed in 1989 to 10 ppm. CO is the deadliest of the toxic gases commonly found in compressed air. Because CO is colorless and odorless, it is impossible for respirator wearers to detect. CO combines readily with hemoglobin in red blood cells and prevents the transfer of oxygen to the tissues, causing oxygen starvation or hypoxia.
   (2) Possible sources of CO include:
      (a) Motor exhaust drawn into compressor air intake.
      (b) Generated within compressors as combustion product of fuels, lubricants and overheated oils.
      (c) Generated within compressors from oxidation of overheated sorbent filters. CO accumulated on a filter can be released when there is a drop in operating pressure.

c. Oil - 5 mg/m^3 at normal temperature and pressure (NTP)
   (1) Oil was formerly called condensed hydrocarbons in the 1973 edition of CGA G-7.1. Large particles of condensed hydrocarbons or oil, can be removed by the body's clearance mechanisms (i.e., phagocytosis and mucociliary escalator). Smaller oil particles are retained and may be hazardous depending on the type and amount. Oil mist deposits in the alveoli can cause an intense inflammation, known as lipoid pneumonia.
   (2) Oil mist can also cause emphysema by dilating and rupturing the alveoli, thus decreasing the total surface area available for the transfer of oxygen and carbon dioxide. Possible oil sources include dust and pollen, motor exhaust pulled into the compressor air intake, and oil generated inside the compressor if lubricants escape through faulty piston rings.

d. Carbon dioxide (CO_2) - maximum 1000 ppm.
   (1) Carbon dioxide stimulates the respiratory center. A buildup of CO_2 in breathing air increases the breathing rate, which can deplete SCBA air supply more rapidly and increase inhalation of other contaminants.
   (2) High CO_2 levels can be indicative of compressor problems. Carbon monoxide is converted to CO_2 by hopcalite in the compressor CO filter. Therefore, high concentrations of CO_2 can result from the hopcalite catalyzing elevated concentrations of CO. Grade E air for SCUBA air was revised in the 1989 edition increasing the maximum allowable level for carbon dioxide from 500 ppm to 1,000 ppm.

e. Odor - Grade D air should have no pronounced odor. Odor is a subjective measurement.

f. Water
   (1) The lower the dew point, the lower the moisture content. If the ambient temperature falls below the dew point of compressed breathing air, any moisture present can condense and form liquid water. If the ambient temperature is freezing, then regulator and control valves can freeze. Adiabatic cooling further contributes to the problem of freezing. Adiabatic cooling occurs in atmosphere-supplying respirators as high pressure compressed air loses heat when its pressure is reduced. According to Reference 6, when ambient temperature, high pressure air (2000 to 4000 pounds per square inch

[psi] and about 70°- 85°F) is reduced by the regulator to 80 to 100 psi for airline respirator use the air temperature drops 25° to 40°F or more.

(2) Moisture content or dew point is expressed in ppm and °F at one atmosphere. Per OSHA, Reference 1, the dew point of compressed breathing air at one atmosphere must be 10° F below the ambient temperature. Reference 1 also requires that the moisture content in cylinders of breathing air purchased from suppliers does not exceed a dew point of -50°F (-45.6°C) at one atmosphere pressure.

(3) Several respirator documents detail moisture content in breathing air.

(a) Note 7 from Table 1 of Reference 2 states that water content varies with intended use. SCBA breathing air must not have a dew point temperature exceeding -65°F (which corresponds to a moisture content of 24 ppm v/v) or the dew point temperature of the breathing air at one atmosphere must be 10°F lower than the coldest temperature expected in the atmosphere where the respirator will be worn. Water vapor will vary depending on relative humidity and dew point. Basically, there should be no liquid water in the breathing air to prevent freezing in atmosphere-supplying respirators. Table 3 of Reference 2 provides dew point temperatures ranging from -130° F to 0° F. This table covers the temperature range most likely found in the workplace where adiabatic cooling produced by SCBA and airline respirators could cause freezing. Moisture measurements taken during compressed breathing air quality testing can be compared to these table values to convert between dew point and moisture content.

(b) Table 3 of Reference 2 lists atmospheric dew point temperatures and their corresponding moisture contents; however, the “pressure dew point temperature” of compressed breathing air becomes a critical factor in evaluating air quality of breathing air use in extremely cold temperatures, such as occur in some geographic locations, such as in Canada and Alaska. The increased pressure of breathing air for atmosphere supplying respirator results in the “pressure dew point temperature” of the compressed air being considerably lower than the dew point of ambient air (at one atmosphere of pressure) with the same temperature.

(c) Per Reference 7, the dew point of breathing air used with airline respirators shall have a maximum dew point 10°F lower than the lowest ambient temperature to which any regulator or control valve on the respirator or air supply system may be exposed. Reference 7 also provides Table A.9-2 for use in determining the maximum water content for the pressure of the airline respirator system for the lowest temperature in which the airline respirator will be used.

(d) Table A.9-2 of Reference 7 takes into account pressure dew point temperatures at typical operating pressures of airline respirators and is used for determining the allowable moisture content to protect against valve freezing. To use Table A.9-2 of Reference 7, locate the operating pressure for the airline respirator and find the lowest temperature in which the respirator will be used, then read the maximum water content from the left column.

(e) Table A.9-3 of Reference 7 takes into account pressure dew point temperatures at typical operating pressures of SCBA and is used for determining the allowable moisture content to protect against valve freezing. To use Table A.9-4 of Reference

7, locate the operating pressure of the SCBA and find the lowest temperature in which the respirator will be used, then read the maximum water content from the left column.

(4) Other Contaminants - There are no limits for other contaminants (total hydrocarbon, nitrogen dioxide, nitric acid, sulfur dioxide, etc.) listed in Table 1 of Reference 3 for Grade D air. However, these should be tested if there is any reason to suspect a problem.

4. Testing Breathing Air

a. Per Reference 4, the Navy requires analyzing breathing air quality quarterly to ensure it meets Grade D criteria. A pressure reducer must be placed in line before the air is sampled. Test procedures are given in sections 5 and 6 of Reference 3, however, per Reference 8, "OSHA does not require the use of specific instrumentation to verify the compliance of air quality requirements prescribed in Compressed Gas Association Commodity Specification for Air, CGA G-7.1. Any measuring instrument which has an accuracy of ±25% at a 95% confidence limit is acceptable."

(1) Oxygen - Paramagnetic-type analyzer, electrochemical-type analyzer, thermal conductivity-type analyzer, volumetric gas analysis apparatus or a gas chromatograph. For more details, see section 6.2 of Reference 3.

(2) Water - Electrolytic hygrometer, dew point analyzer, metal oxide capacitor equipped analyzer, detector tube filled with a color-reactive material, infrared, tuneable diode laser or cavity ring down spectrometer or a piezoelectric oscillating quartz crystal hygrometer. For more details, see section 6.3 of Reference 3.

(a) Permanent dew point meters can be installed on sources of compressed breathing air to continuously monitor moisture content.

(b) These measurements can be used for quarterly air quality testing. Follow all manufacturer's instructions. Condensed oil - collect on glass-fiber filter and analyze gravimetrically, measure using a detector tube containing a color-reactive chemical for oil only, using a stainless steel mirror for inverted full cylinders, or a visual inspection of compressor oil and moisture removal systems using a stainless steel mirror or alternate wiping medium. For more details, see section 6.4 of Reference 3.

(3) Odor - sniff a moderate flow of air from the container being tested. Do not place your face directly in front of the valve. Cup your hand and waft a sample up to your nose. For more information, see section 6.5 of Reference 3.

(4) Carbon monoxide and carbon dioxide - gas cell equipped infrared analyzer, detector tube filled with a color-reactive material, catalytic methanator gas chromatograph or a gas chromatograph. An electorchemical fuel cell analyzer specific for carbon monoxide may also be used for carbon monoxide. For more information, see section 6.6 and 6.7 of Reference 3.

(a) Permanent CO meters and alarms can be installed on sources of compressed breathing air to continuously monitor CO concentration.

(b) These measurements may be used for quarterly air quality testing if the apparatus is maintained and calibrated per manufacturer's instructions.

1. Compressors equipped with color-change CO and moisture indicators do not meet the OSHA requirements for CO alarms. Reference 9 states the following about CO indicators:
The color change in color-change indicators which detect the presence of CO in breathing air is a warning of the presence of moisture in the breathing air that is trapped in the filter. Moisture can render the filter ineffective. Thus, the color-change indicator cannot be used to detect the presence of carbon monoxide.

b. Commercially available air test kits may also be used. Air quality testing can also be contracted.

c. Locations to Test Breathing Air Sources.
(1) Quarterly air quality samples should be taken at specified locations in the distribution system that are representative of the whole system.
(2) When specifying sample locations, consideration must be given to the parts of the air distribution system with dead legs and low volume usage. Therefore, collect samples at risers that have a potential for use.
(3) When a breathing air station is required to be connected to the raiser, first blow out the pipes in the air distribution system at the riser to ensure that:
(a) all valves leading to the riser are open;
(b) there is sufficient air volume;
(c) sediment in the air distribution lines is removed.
After the system blow down, connect breathing air distribution lines and portable filtration boxes for supplied air respirators.

5. Compressor Requirements

a. Oil-Lubricated Compressors - Reciprocating compressors (piston compressors) are the workhorses of the workplace. Most are oil-lubricated to extend service life. When oil is in the crankcase, it will predictably be discharged into the compression chamber. Compressors are either oil-lubricated or non-oil-lubricated. Most non-oil-lubricated compressors use Teflon® parts.

b. Oil-Less Compressors - Oil-less is another name for non-oil-lubricated compressors because they have no oil in the crankcase. Oil-less reciprocating compressors use sealed bearings and the piston rings are made from self-lubricating Teflon®. The Teflon® rings seal the cylinder bore and reduce friction. To further reduce heat, "force-compensated piston ring" design is used in which the Teflon® rings ride on a cushion of air, sealing during compression stroke and releasing during intake stroke, which reduces friction and pressure forces on the rings. Teflon® thermally decomposes at 752° F. However, compressor manufacturers set their high temperature alarms to shut off the compressors well before this temperature is ever reached. Particles of Teflon® (median size 1.1 micron) will be produced especially during the early use of new compressors, but these are filtered out by the mechanical filtration system required on the compressors. Residual heat from

compression and friction is removed by forced-air cooling, usually by a blower wheel mounted on the end of the motor shaft directing air over the pistons, cylinders and bearings to cool them. Oil-less piston air compressors are available with 1/12 to 15 horsepower and with pressure rating up to 220 psi.

(1) Other oil-less compressors include carbon vane compressors and diaphragm compressors, which are limited to maximum operating pressures of 15 psi and 100 psi, respectively. Carbon vanes are self-lubricating on cast iron in the presence of humidity in the atmosphere.

(2) Diaphragm compressors are oil-less because the diaphragm completely isolates the crankcase from the compression chamber.

c. Oil-Free Compressors - The term oil-free compressor is misleading. These compressors actually have oil in the crankcase but are sealed such that oil cannot contaminate the compression chamber until the seals eventually wear or break.

6. Standard Specific Compressor Requirements

a. Per OSHA in Reference 1, compressors supplying breathing air to respirators must be constructed and situated to prevent entry of contaminated air into the air-supply system. For example, air intakes must not be located on a loading dock because carbon monoxide may be present. Suitable in-line air-purifying sorbent beds and filters are required to further ensure breathing air quality. Sorbent beds and filters must be maintained and replaced or refurbished periodically following the manufacturer's instructions. Examples of sorbents include molecular sieves, charcoal, desiccants and hopcalite. OSHA also requires that sorbents be periodically maintained following the manufacturer’s instructions and further states: "Have a tag containing the most recent [sorbent] change date and the signature of the person authorized by the employer to perform the change. The tag shall be maintained at the compressor."

(1) If an air receiver is used to supply breathing air it must be maintained according to *29 CFR 1910.169, Compressed Gas and Compressed Air Equipment, Air Receivers.*

(2) Reference 1 requires that oil-lubricated compressors must be equipped with high-temperature or carbon monoxide alarms, or both, to monitor carbon monoxide levels. If only high-temperature alarms are used, the air supply shall be monitored at intervals sufficient to prevent carbon monoxide in the breathing air from exceeding 10 ppm. Manufacturers of air compressors state in their equipment manuals what the maximum allowable temperature is for their compressors.

(a) High temperature alarms are for the protection of the compressor, while carbon monoxide monitor and alarm systems are for the protection of the worker. High temperature alarms will not detect carbon monoxide entering the compressor at the air inlet or produced inside the compressor. The locations of high temperature alarms on compressors vary. When the alarm sounds depends on the location of the alarm sensor. The respirator wearer could already be breathing carbon monoxide by the time the high temperate alarm signals.

(b) To help emphasize the importance of controlling CO to safe levels in compressed breathing air, Reference 10 is a National Institute for Occupational Safety and

Health (NIOSH) report of a worker's death caused by breathing excess CO from their airline respirator.

(3) Reference 1 states that the breathing air produced by non-oil lubricated compressors must not contain carbon monoxide levels exceeding 10 ppm. This requirement can be met by several different methods (or combination of methods) including the use of the following:
   (a) Continuous carbon monoxide monitors and alarm systems;
   (b) Carbon monoxide filters;
   (c) Proper air intake location in an area free of contaminants; or
   (d) The use of high-temperature alarms and automatic shutoff devices, as appropriate.

(4) Per Reference 9, electrochemical sensors used for periodic and continuous monitoring of breathing air must be calibrated periodically, usually monthly, to perform accurately. The measurement error for most electrochemical sensors is 5%. Color change indicators cannot be used to detect the presence of carbon monoxide in breathing air. The color change in the indicator is a warning of the presence of moisture in the breathing air that is trapped in the filter, which can render the CO hopcalite filter ineffective.

b. OPNAVINST 5100.23 Series - In addition to quarterly air quality monitoring to ensure Grade D breathing air, Reference 4 requires compressor systems to be equipped with either-high temperature or continuous carbon monoxide monitor and alarm systems or both to monitor carbon monoxide levels. If only high-temperature alarms are used, the air supply shall be monitored at intervals sufficient to prevent carbon monoxide in the breathing air from exceeding 10 ppm. Furthermore, all new and/or upgraded air compressor systems must be equipped with continuous carbon monoxide monitor and alarm systems. Another requirement of this paragraph is to calibrate monitor and alarm systems on compressors used for supplying breathing air according to the manufacturer's instructions.

c. OPNAVINST 5100.19 Series - Per Reference 5, the compressor requirements include quarterly testing to ensure Grade D quality before use and locating air intakes in clean air. It states, "Ships shall equip compressor systems with either high-temperature or carbon monoxide monitor and alarm systems or both, to control carbon monoxide levels. High-temperature cut-off switches on fixed compressors, which shut down the compressor at a temperature below which the lubricating oil breaks down (i.e., thermal degradation point), meet the requirement for high-temperature alarms, provided that quarterly monitoring meets the requirements for Grade D breathing air. Ships shall equip all new and/or upgraded FIXED breathing air compressor systems with high-temperature cut-off switches. New and upgraded portable breathing air compressor systems will be equipped or operated with carbon monoxide monitor and alarm systems during SCBA air cylinder charging operations. Calibrate monitor and alarm systems on compressors used for supplying breathing air according to the manufacturer's instructions."

7. Breathing Air Couplings

a. Reference 1 requires that airline couplings be incompatible with outlets for other gas systems. This prevents inadvertent servicing of airline respirators with non-respirable gases or oxygen.

b. This paragraph also states that no asphyxiating substance shall be introduced into the breathing air lines. For example, nitrogen cannot be used to blow the lines out.

8. Point Of Contact

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9. References

1. 29 CFR 1910.134, OSHA Respiratory Protection Standard
2. CGA G7.1-1989, ANSI/Compressed Gas Association Commodity Specification for Air.
3. CGA G-7.1-2018, Commodity Specification for Air. Seventh Edition.
4. OPNAVINST 5100.23 Series, Navy Safety and Occupational Health Program Manual
5. OPNAVINST 5100.19 Series, Navy Safety and Occupational Health Program Manual for Forces Afloat
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7. ANSI/ASSE Z88.2-2015, Practices for Respiratory Protection.
8. 29 CFR 1910.134, OSHA Standard Interpretations
9. Occupational Safety and Health Administration, Questions and Answers on the Respiratory Protection Standard.
10. National Institute for Occupational Safety and Health, Fatality Assessment and Control Evaluation (FACE). Face 9131, Laborer Dies of Carbon Monoxide Poisoning During Sandblasting Operations in Virginia.