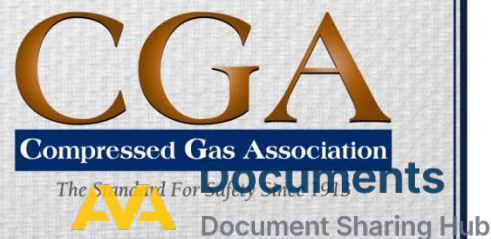


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CGA P-8.7—2016

**SAFE LOCATION OF OXYGEN
AND INERT GAS VENTS**

FIRST EDITION



PREFACE

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has issued [CGA P-8.7](#), *Safe Location of Oxygen and Inert Gas Vents*, jointly produced by members of the International Harmonization Council and originally published by the European Industrial Gases Association (EIGA) as EIGA Doc 154, *Safe Location of Oxygen and Inert Gas Vents*.

This publication is intended as an international harmonized standard for the worldwide use and application of all members of the Asia Industrial Gases Association (AIGA), Compressed Gas Association (CGA), European Industrial Gases Association (EIGA), and Japan Industrial and Medical Gases Association (JIMGA). Each association's technical content is identical, except for regional regulatory requirements and minor changes in formatting and spelling.

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Work Items 06-102 and 06-102a
Atmospheric Gases and Equipment Committee

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Contents	Page
1 Introduction.....	1
2 Scope and purpose	1
2.1 Scope	1
2.2 Purpose	1
3 Definitions.....	1
4 Hazards of oxygen-enriched or oxygen-deficient atmospheres	2
5 Factors for consideration in the location of vents	2
5.1 General considerations.....	2
5.2 Selection of concentration criteria for specific circumstances	3
5.3 Vent locations	4
5.4 Effect of weather and release conditions.....	5
5.5 Venting of cryogenic liquid.....	6
6 Calculations for the determination of safe vent locations	6
6.1 Introduction.....	6
6.2 Choice of software	7
6.3 Weather conditions.....	7
6.4 Release temperature	7
6.5 Release angle.....	8
6.6 Release velocities.....	8
6.7 Concentration limits	8
6.8 Ambient conditions	9
6.9 Interpretation of the tables.....	9
6.10 Limitations on the calculation methodology.....	10
7 Recommendations	10
8 References	13
Figures	
Figure 1—Example of warm oxygen vertical release with 23.5% oxygen concentration	11
Figure 2—Example of warm oxygen horizontal release with 23.5% oxygen concentration	11
Figure 3—Horizontal vent separations.....	12
Figure 4—Vertical vent separations	12
Figure 5—Angled vent separations.....	13
Appendices	
Appendix A—Warm high pressure oxygen	14
Appendix B—Cold high pressure oxygen	15
Appendix C—Warm high pressure nitrogen	16
Appendix D—Cold high pressure nitrogen	17
Appendix E—Warm high pressure argon	18
Appendix F—Cold high pressure argon	19
Appendix G—Equivalent release rates	20
Appendix H—Influence of release speed.....	24
Appendix I—Oxygen adjustment mathematics	25

Appendices tables

Table A-1—Warm high pressure oxygen venting horizontally at high velocity	14
Table A-2—Warm high pressure oxygen venting vertically at high velocity	14
Table A-3—Warm high pressure oxygen venting angled at high velocity	14
Table B-1—Cold high pressure oxygen venting horizontally at high velocity	15
Table B-2—Cold high pressure oxygen venting vertically at high velocity	15
Table B-3 Cold high pressure oxygen venting angled at high velocity	15
Table C-1—Warm high pressure nitrogen venting horizontally at high velocity	16
Table C-2—Warm high pressure nitrogen venting vertically at high velocity	16
Table C-3—Warm high pressure nitrogen venting angled at high velocity	16
Table D-1—Cold high pressure nitrogen venting horizontally at high velocity	17
Table D-2—Cold high pressure nitrogen venting vertically at high velocity	17
Table D-3—Cold high pressure nitrogen venting angled at high velocity	17
Table E-1—Warm high pressure argon venting horizontally at high velocity	18
Table E-2—Warm high pressure argon venting vertically at high velocity	18
Table E-3—Warm high pressure argon venting angled at high velocity	18
Table F-1—Cold high pressure argon venting horizontally at high velocity	19
Table F-2—Cold high pressure argon venting vertically at high velocity	19
Table F-3—Cold high pressure argon venting angled at high velocity	19
Table G-1—Equivalent release rates for oxygen at 10 °C, venting at 20m/s and 10m/s	20
Table G-2—Equivalent release rates for oxygen at –183 °C, venting at 20m/s and 10m/s	20
Table G-3—Equivalent release rates for oxygen at 10 °C, venting at 160m/s	21
Table G-4—Equivalent release rates for oxygen at –183 °C, venting at 90m/s	21
Table G-5—Equivalent release rates for nitrogen at 10 °C, venting at 20m/s and 10m/s	21
Table G-6—Equivalent release rates for nitrogen at –195 °C, venting at 20m/s and 10m/s	22
Table G-7—Equivalent release rates for nitrogen at 10 °C, venting at 170m/s	22
Table G-8—Equivalent release rates for nitrogen at –195 °C, venting at 90m/s	22
Table G-9—Equivalent release rates for argon at 10 °C, venting at 20m/s and 10m/s	23
Table G-10—Equivalent release rates for argon at –186 °C, venting at 20m/s and 10m/s	23
Table G-11—Equivalent release rates for argon at 10 °C, venting at 160m/s	23
Table G-12—Equivalent release rates for argon at –186 °C, venting at 85m/s	23

1 Introduction

This publication defines the criteria for the design of process vents to ensure the safe disposal of oxygen and inert gases.

Industrial gas producers are subject to more and more stringent demands from authorities to demonstrate that the operation of their plants is safe. A number of incidents have been reported where enriched or deficient atmospheres from venting operations have created operational safety issues [1, 2]. As air separation unit (ASU) capacity has increased, the risk of oxygen-enriched and oxygen-deficient atmospheres has become a significant safety concern.

2 Scope and purpose

2.1 Scope

This publication applies to air separation and cryogenic liquefaction plants in which the venting of oxygen, nitrogen, oxygen/nitrogen mixtures, argon, or air occurs.

Disposal of cryogenic liquid is not covered in this publication although the potential for vent releases to have some liquid present is included (see 5.5).

The recommendations contained in this publication for elevations and horizontal separation distances are not applicable to customer station tanks. Safety distances for such tanks are governed by the design criteria for plant layout or national regulations/codes of practice, whichever are more stringent [3, 4].

2.2 Purpose

This publication is designed to give a basis on which to determine the safe location of oxygen or nitrogen and argon gas vents for normal operating, upset, and emergency conditions. This determination can be made by calculation against the criteria specified or by use of the tables provided in the appendices as a guide.

The publication contains calculated safe separation distances for a range of vent sizes and orientations based on commonly encountered but specific design conditions. If these design criteria are not met particularly with regard to vents intended to operate over a large range of flows (for example, product vents having turndown flows), the tables may not be appropriate and detailed calculations should be carried out.

This publication should be used for new designs but can be used on existing plants to determine whether existing vents are safely located or whether modifications/temporary structures will interfere with the original design intent.

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 Inert gases

Gases that do not readily react with other materials under normal temperatures and pressures.

NOTE—Examples include argon, nitrogen, and helium.

3.2.2 Pressure

Bar indicates gauge pressure unless otherwise noted: bar, abs for absolute pressure and bar, dif for differential pressure.

4 Hazards of oxygen-enriched or oxygen-deficient atmospheres

Oxygen, which is essential to life, is not flammable but supports and accelerates combustion.

Oxygen reacts with most materials. As the oxygen concentration in air increases, the potential fire risk increases. The more vigorously the combustion reaction or fire takes place, the lower the ignition temperature and the ignition energy to get the combustion reaction started, and the higher the flame temperature and destructive capacity of the flame.

If the oxygen concentration in air decreases or if the concentration of inert gases increases, there is a risk of asphyxia. Lack of oxygen can cause vertigo and speech difficulties but the victim does not recognize these symptoms as asphyxiation. The asphyxiating effect of inert gases takes place without any preliminary physiological sign that could alert the victim. This action is very rapid: it only takes a few seconds to occur at very low oxygen concentrations.

The hazards from oxygen enrichment are explained in [CGA P-45, Fire Hazards of Oxygen and Oxygen-Enriched Atmospheres](#) [5]. The hazards of oxygen deficiency are explained in [CGA SB-2, Oxygen-Deficient Atmospheres](#) [6]. Acceptable safe oxygen concentrations in air are as follows:

- The maximum safe concentration for entry into a confined space is 23.5% oxygen by volume;
- The minimum safe oxygen concentration for entry into a confined space is 19.5% oxygen by volume; and
- The space should be ventilated sufficiently to obtain a value approaching 21% oxygen by volume (indistinguishable from atmospheric air).

Vents are distinguished separately on the basis of the acceptability of minimal risk.

The choice of concentration limits acceptable for vent location design is discussed in Section 5.

5 Factors for consideration in the location of vents

5.1 General considerations

The safe location of any vent to atmosphere is dependent on the venting conditions, the hazards associated with the gas at the vent conditions, the vent use frequency, and environmental considerations resulting from the gas being released. From these conditions will come decisions on vent height and orientation relative to surrounding equipment, personnel access areas, and prevailing wind direction. Consideration also has to be given to the effects of any release outside the plant boundary where the risks are affected by the nature of the surrounding area (industrial, commercial, urban, or rural conditions) as well as the numbers of people that could be subject to any release.

The following hazards are associated with vented atmospheric gases from industrial gas operations:

- asphyxiation (nitrogen and argon);

- enhanced fire risk (oxygen);
- cold and low visibility (cryogenic gases and liquids); and
- hot gases (for example, compressor interstage relief/discharge gas vents).

NOTE—Gases or mixtures containing flammable or toxic components such as hydrogen, carbon monoxide, or carbon dioxide can be discharged from operations involving atmospheric gas processing but venting of these is NOT covered by this publication.

Vent use frequency can be categorized in the following terms:

- continuous;
- intermittent in normal operation;
- commissioning/startup/shutdown;
- performance testing;
- emergency pressure relief; or
- emergency depressurization.

In general, only those vents that are either within the total control of the plant operation such as vents operated manually on an intermittent basis (for example, start up, shutdown, tanker fill), or those vents expected to be open for a short duration protection (for example, pressure relief devices, automatic dumps) can be assessed as being on a noncontinuous basis.

In addition, the influence of exit velocity is important where gases being vented at the warm end of an ASU can be vented at any flow rate between the nominal design capacity and zero. Such reduced venting flow rates are typically met during the adaptation period of the ASU after a sudden change of the client demand or when the nitrogen/oxygen ratio of the client demand does not match with the ASU production ratio. Therefore, the correct design of the vent stack of the separated gas streams exiting the warm end of an ASU shall take into account the potential reduced flow rates in normal operation when determining the vertical height of the vent. See 6.6 and Appendix H for further information.

Environmental protection considerations include:

- acceptable noise levels;
- visibility of emission; and
- local and national authority requirements.

In determining the disposal of vented gases, consideration should be given to whether the plant is unmanned because remedial action in the event of a gas release could be delayed. In general, the risks from venting from an unmanned plant should be no different from a fully attended facility because the periodic presence of people cannot be ignored.

The risk of damage to adjacent equipment or injury to people shall be determined taking the previous considerations into account.

The following subsections give more detailed consideration to the factors involved in safely locating atmospheric vents.

5.2 Selection of concentration criteria for specific circumstances

Vent locations shall be determined in relation to the hazards of oxygen or inert gas releases given in Section 4. On the basis of the risks from various gas concentrations summarized in Section 4, organizations may set their own concentration limits for the various vent types taking account the general considerations given in 5.1, and based on their own safety philosophy.

In principle, the general public should not be subject to any potential risk greater than that resulting from their normal activities, and so consideration shall be given to ensuring that all identifiable vent release cases do not result in oxygen concentrations outside the range of 19.5% to 23.5% oxygen by volume at ground level outside the plant boundary or at the height of buildings adjacent to the property line. These limits can also apply to adjacent industrial sites; however, for customer premises where the air separation plant products are being piped, it may be appropriate to treat the risks from gas vents as being the same as within the air separation plant boundary.

Within the plant boundary, a higher oxygen concentration from any vent may be acceptable at all normally accessible points within the facility provided that management controls of items such as unshielded flames, grinding or welding, and smoking are in force. The recommended value is a maximum expected concentration of 25% oxygen by volume for all identified vent cases.

Similarly, the risk from exposure to low oxygen concentrations (inert gas releases) can be controlled within a plant. For vent locations with known release conditions, it is recommended that a minimum expected oxygen concentration of 17% oxygen by volume be used as the design basis for all vents. Consideration may be given to increasing this limit to a higher value in order to provide safety margins for the effect of unknowns in the release cases or atmospheric conditions in making such an evaluation. The calculations described in Section 6 give inert gas dispersion limits to 18% oxygen by volume as a guide as well as 19.5% oxygen by volume and 17% oxygen by volume.

National or local regulations can specify different concentration limits for exposure, in which case these would supersede any previously recommended criteria.

The effects of variations in the release conditions are discussed in the following subsections.

5.3 Vent locations

In general, vents shall be orientated such that the discharge gases, warm or cold, cannot impinge directly on personnel, structures, working areas, or equipment.

The following is a summary of experience during engineering and operation of air separation plants:

- Ingress of vented gas into process air intakes, buildings, and air conditioning/ventilation systems shall be avoided;
- Vents from equipment situated inside totally enclosed rooms or buildings shall be piped to outside locations unless preventative measures against the hazards of oxygen-enriched or oxygen-deficient atmospheres are adopted;
- Vents shall be located so personnel on access platforms or walkways are not exposed to the hazards of oxygen-enriched or oxygen-deficient atmospheres unless controls are in place to manage the risk;
- Separation distances between oxygen vents and flammable gas vents shall be considered to avoid the risk from the effects of enhanced combustion;
- Separation distances between oxygen vents and flare systems of adjacent plants shall be defined to ensure the safety of the installation;
- Cold gas vents should be designed and located to manage fogging, ice formation, blockage due to precipitation, and cold embrittlement of structures and equipment;
- Even though the vertical release of a vent gives the best location in relation to height, it is often useful to install the vent outlet with an angle to give the gas stream a specific release direction, for example, away from a supporting structure such as a coldbox;
- If the vent outlets are located adjacent to or between taller structures such as buildings that are relatively close, the vent heights should be selected to mitigate the hazards of oxygen enrichment or deficiency. The influence of obstacles to unrestricted venting shall require a specific risk assessment;

- High pressure noncontinuous vents (for example, safety valves outlets) shall not be directed at platforms, ladders or other access points, and shall not blow directly onto equipment. This is to prevent injury to persons and damage to equipment from high velocities even if a hazard from an oxygen-enriched or oxygen-deficient atmosphere is not anticipated;
- Even if safely located with regards to dispersion, vent outlets (particularly at high pressure) can be a noise hazard. Vent position and orientation should account for both the environmental and occupational health effects of noisy releases; and
- Vents released at higher elevations can be exposed to a higher local wind speed than those released at lower elevations. Greater turbulence due to higher wind velocity at higher release elevation tends to cause releases at higher elevations to disperse more readily. Reduced separation distances may be justified for elevated platforms if the vent location is relatively high off the ground but it should be determined through a risk assessment.

NOTE—Dispersion calculations usually do not take into account vents that are located on or at the side of buildings in the area where flow patterns across roofs can give rise to downdrafts of air flow. The likelihood of downdraft flow patterns should be considered during the design phase and the location of vents should be selected to minimize or eliminate any adverse effects on the gas dispersion plume.

Care shall be taken in case of plant modifications, including erection of temporary structures to gain access to maintenance or modification work to ensure that changes in the plant do not make the locations of existing vents unsafe with regards to orientation. Existing vent locations need to be fully reassessed if the vent cases are likely to change as a result of modifications.

In any case where an oxygen-enriched or -deficient atmosphere is possible, a warning sign should be posted at the base of ladders and access points concerning possible oxygen-enriched or oxygen-deficient atmosphere. The location and arrangement of such vents and the disposition of warning signs should be the subject of a safety review. Portable air monitoring instruments should be worn during access to such areas.

By design, continuous, large capacity process vents such as oxygen, waste, and low pressure nitrogen can be grouped in one general area to make use of a common support structure. Normal vent location selection criteria would not generally account for several or all of these vents operating at the same time. Special consideration may be required for such arrangements.

5.4 Effect of weather and release conditions

The following weather factors can have a detrimental effect upon the dilution of the vented gas:

- high ambient temperatures in relation to the vented gas;
- moderately stable atmospheric conditions; and
- low wind speed.

Calculations are usually carried out over the normal reported range of weather conditions to determine the worst-case effect but extremes in the previous factors can have significant impact on estimated plume distances especially if the vent release conditions are a plume (low velocity) rather than a gas jet (high velocity).

In order to minimize the weather effects and achieve the best possible dilution, it is recommended that the outlet design velocity of a vent be set as high as possible within the realms of process possibility (for example, pressure loss, noise, etc.).

The prevailing wind at a plant site should be taken into account, but it has to be considered that the wind can come from any direction. For higher release velocities, horizontal or angled releases will negate much or all of any wind direction effect, although most computer modelling cannot take appropriate account of any crosswind condition except for truly vertical releases.

5.5 Venting of cryogenic liquid

To minimize exposure of, and injury to personnel and damage to equipment, intentional venting of cryogenic liquids directly to atmosphere should be prohibited. Cryogenic liquids that are released in quantity, either during routine operations or predicted upset conditions, should be directed to a disposal system designed for this purpose. However, care shall be taken in the design of common headered liquid and vapor disposal systems to avoid the possibility of liquid backflow into gas vent headers, and to avoid risk of plugging of cryogenic relief valve discharges with ice from water accumulating in the header.

Some small liquid venting systems may be directed to a safe location without the need to pass through a disposal system:

- Vents from cryogenic thermal relief valves that could discharge cryogenic liquid in upset conditions may be vented at grade because of the small orifice size and short duration of any liquid release. However, there should be consideration of any consequence of releasing a significant inventory of liquid in the event that the discharging relief valve fails to completely reseal after venting off the excess pressure; and
- Small vents, drains, and trycocks from liquid fill lines, pump cooldown lines, or similar systems can be directed to catch trays or local spillage areas having adequate natural ventilation.

6 Calculations for the determination of safe vent locations

6.1 Introduction

Factors to be considered as the basis for specifying safe locations for oxygen or asphyxiant atmospheric gas vents are given in Section 5, which also gives accepted concentration criteria that can be used for detailed dispersion calculations. Following generally available textbook methods such as Chapter 2 in *Guidelines for Consequence Analysis of Chemical Releases* or using equivalent computer programs, it is possible to model predicted safe separation distances for vent designs when all the appropriate release data are available [7]. The calculations are case specific but can result in separation distances optimized to minimize risk without requiring excessive safety margins. However, for a large majority of atmospheric gas vents in an air separation plant, detailed calculations are either not practical because of insufficient information or because of the number of possible vents involved. In these circumstances the use of previous designs or look-up tables or graphs may be sufficient providing the assumptions made for the previous designs or tables or graphs are met by the specific vent designs under review.

Expert opinion has been gathered and calculations carried out to prepare look-up tables that cover a variety of common vent designs cases so detailed calculations are not required. It should always be noted that the preparation of look-up tables will always involve compromises on the presentation of results, and as a consequence the separation distances presented in this publication may be conservative. In the event that use of these or other look-up tables indicates that an identified vent location is too close to people or other equipment, the option to revert to carrying out detailed calculations for that specific case is always available.

The following paragraphs provide the basis on which the vent elevations and separation distances in this publication have been determined. It is important to recognize when unusual conditions exist that could vary significantly from those assumed for the calculations. In this event, the user shall review the available data and judge whether a separate assessment is necessary.

When a gas is released, the resulting vapor cloud will be diluted by air entrainment. The rate of dilution is controlled by several factors that include gas properties, the release flow and velocity, meteorological conditions, and terrain. There are also the various release scenarios to be considered, such as continuous releases, high momentum releases from the opening of a relief valve, or low momentum releases from conservation vents (pressure or flow control). For these reasons, there is generally no universal dispersion model that can handle all types of releases. The appropriate model shall be chosen for the particular release. Some computer programs can combine various models to allow automatic selection for the vent case under consideration.