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1ST EDITION

STANDARD FOR CARBON DIOXIDE MONITORING IN NEAR CONSUMER AND INDUSTRIAL APPLICATIONS

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Carbon Dioxide Committee

NOTE—Appendices A and B (Informative) are for information only.

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1 Introduction

This publication is designed to assist both national standards and code setting organizations and local code authorities in their creation of code requirements associated with carbon dioxide monitoring systems. This publication is also intended for carbon dioxide gas monitoring system designers and installers and can be of value to system users.

The primary focus of this publication is associated with assuring life safety. Although this publication addresses the requirements for an Occupational Safety and Health Administration (OSHA) 8-hour time-weighted average-permissible exposure limit (TWA–PEL) and other regulatory and code requirements, it is the responsibility of the user of the monitoring system to assure compliance with these requirements.

This publication is intended to inform the reader of the potential hazards and related safety concerns associated with carbon dioxide accumulation, concentration, and vapor and/or gas migration not only near the carbon dioxide storage container location but other areas where carbon dioxide can collect due to a leak in the system.

NOTE—Gaseous carbon dioxide can form a visible vapor. For purposes of simplicity, this publication will utilize the word gas when discussing either vapor or gaseous carbon dioxide.

2 Scope

This publication addresses:

- hazards of carbon dioxide in near consumer and industrial applications (the dangerous concentrations, where they can occur and accumulate);
- both fixed carbon dioxide monitoring systems and portable monitoring devices;
- required components of the system and their intended functionality;
- recommendations for installation including locations of the component parts of a carbon dioxide detection monitoring system; and
- proper maintenance and periodic system functional verification.

This publication addresses the general regulatory requirements as presented in existing codes and also addresses communications of carbon dioxide hazards.

Although this publication does not address in detail monitors that are used for other purposes outside of identification of carbon dioxide concentration hazards, Appendix A provides descriptions of these monitors, such as those used for fire suppression, indoor agriculture, and environmental air quality, that do not meet carbon dioxide monitoring system requirements that are the focus of this publication.

This publication does not include specific jurisdictional requirements and the reader is advised to determine the code requirements (e.g., National Fire Protection Association [NFPA], International Fire Code [IFC], National Board Inspection Code [NBIC]) including the specific yearly revision applicable to the jurisdiction where the facility is located.

This publication does not assign responsibilities for various activities that may be included in a contractual agreement or dictated by code or jurisdictional requirements. Although general installation and maintenance of the system is discussed, this publication does not cover the specifics of these activities that are defined by the manufacturer.

In certain applications, the identification and measurement of other gas types can be required (i.e., oxygen deficiency monitoring when nitrogen is used in beer applications). Monitoring for oxygen or other gases aside from carbon dioxide is outside the scope of this publication.

3 Definitions

For the purposes 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 Alarm

Audible or visible signal indicating an abnormal or potentially critical condition.

3.2.2 Calibration

Process of adjusting a device to match a known standard so that it indicates to within specified accuracy limits.

3.2.3 Carbon dioxide monitoring system

System including its components that detect carbon dioxide levels and communicates when hazardous levels have been reached.

3.2.4 Confined space

Space that 1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and (2) Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry.); and (3) Is not designed for continuous employee occupancy [1].¹

3.2.5 Detector

Device that includes a sensor designed to identify and measure a specific physical substance and conveys an electrical signal to another device that processes or displays the signal (audible, visual).

3.2.6 Enclosed space

Room, compartment, courtyard, or other area that restricts the dispersion of carbon dioxide and is outside the OSHA definition for confined space.

3.2.7 Immediately dangerous to life and health (IDLH)

Maximum concentration from which unprotected persons are able to escape within 30 minutes without escape-impairing symptoms or irreversible health effects.

3.2.8 Interstitial space

An intermediate space normally reserved for building utilities.

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

3.2.9 Permissible exposure limit (PEL)

Limit developed by the Occupational Safety and Health Administration (OSHA) for the maximum airborne concentration of a contaminant to which an employee may be exposed over the duration specified by the type of PEL assigned to that contaminant.

NOTE—PELs are set forth in Title 29 of the U.S. *Code of Federal Regulations* (29 CFR) 1910.1000 [1].

3.2.10 Recommended exposure limit—Short-term exposure limit (NIOSH REL—STEL)

15 minute Time-Weighted Average (TWA) occupational exposure that should not be exceeded at any time during a work day [2].

3.2.11 Time-weighted average—Permissible exposure limit (OSHA TWA—PEL)

Employee's average occupational exposure in any 8-hour work shift of a 40-hour work week, which shall not be exceeded [1].

3.2.12 Sensor

Component internal to the detector that identifies or measures a known gas.

3.2.13 Verification

Checking of an individual device or test apparatus by comparison with a given standard.

4 Carbon dioxide hazards

4.1 General hazards

The key hazards addressed in this publication are the accumulation of carbon dioxide gas leading to intoxication and asphyxiation. For other information on the hazards and physiological effects of carbon dioxide, see CGA G-6, *Carbon Dioxide* [3].

At lower concentrations, you will not see (colorless), smell (odorless), or taste carbon dioxide vapor. At higher concentrations, carbon dioxide vapor will combine with saliva to form low level carbonic acid and provide a sensation of smelling or tasting carbon dioxide.

4.2 Carbon dioxide accumulation

Gaseous carbon dioxide is 1.5 times heavier than air due to its molecular weight and; therefore, will collect at floor levels displacing the air. If a system leak exists, or installed equipment exhausts carbon dioxide in normal operations, these vapors will settle in the lowest levels first, and then will build concentration as time passes. Below grade areas are the highest risk, see 4.2.2 and 4.2.3. When designing a carbon dioxide monitoring system, consider where leaks of the equipment and associated piping can occur, and where the gas might spread, settle, and concentrate. Carbon dioxide gas will migrate from the initial leak location, therefore careful consideration to detector location(s) is imperative.

Carbon dioxide accumulation hazards can occur in three areas: confined spaces, enclosed spaces, and low lying spaces, and monitoring is especially critical for these areas.

All spaces where carbon dioxide can be released and accumulate shall be evaluated and considered for monitoring.

As an example, the potential danger from a single container might not be readily apparent. The danger from a small cylinder containing only 20 lb of carbon dioxide might appear to be minimal. However, the NIOSH Recommended exposure limit—Short-term exposure limit (REL—STEL) concentration can be reached within 15 minutes for an average person who is approximately 5 and a half feet tall, if that person was in an enclosed room with an area less than 1040 ft² (e.g., a 33 ft x 33 ft room), and the contents of that cylinder leaked out. This should not be interpreted that a room of this dimension/size does not require monitoring.

For service technicians and first responders: it should not be assumed that currently installed fixed carbon dioxide gas monitoring equipment is always fully functional. If arriving on-site in response for assistance, observe the potential for hazardous levels of carbon dioxide accumulation, particularly in below grade usage, and exercise

caution. Portable carbon dioxide monitors, either wearable or non-wearable, are safety equipment for additional protection that should be considered. If in doubt, do not enter an area until a safe atmosphere can be assured.

4.2.1 Confined space

Many workplaces contain areas that are considered confined spaces because while they are not necessarily designed for people, they are large enough for workers to enter and perform certain jobs. Prior to starting any activities that require entering a confined space, determine OSHA or Canadian Centre for Occupational Health and Safety requirements [1, 4]. Any additional local jurisdictional requirements and corporate policies shall be reviewed prior to starting activity. All gases should be considered prior to entrance to a confined space.

Confined spaces include, but are not limited to, tanks, vessels, silos, storage bins, hoppers, vaults, pits, man-holes, tunnels, equipment housings, ductwork, pipelines, etc.

OSHA uses the term "permit-required confined space" (permit space) to describe a confined space that has one or more of the following characteristics:

- contains or has the potential to contain a hazardous atmosphere;
- contains material that has the potential to engulf an entrant;
- has walls that converge inward or floors that slope downward and taper into a smaller area that could trap or asphyxiate an entrant; or
- contains any other recognized safety or health hazard [1].

Gas detection is not required for confined spaces that are too small for human entry.

4.2.2 Enclosed space

Indoor areas, rooms, or enclosed outdoor locations where carbon dioxide systems are filled and/or used shall be provided with a monitoring system unless either natural or mechanical ventilation meeting specific code exemptions is present (e.g., NFPA 55) [1]. Gas monitoring is strongly recommended in any situation, whether there is ventilation or not.

To be considered unenclosed, carbon dioxide storage equipment and distribution would have to be outdoors and above grade. Additionally, there can be no more than three sides of the perimeter with supports and walls obstructed. At least 25% of the perimeter area as calculated from the maximum height of the storage container shall be open to atmosphere and openings shall be in direct conveyance with the ground.

See CGA P-41, *Standard for Locating Bulk Liquid Storage Systems in Courts*, for additional information on outdoor installations in courtyards [5].

Examples of potential enclosed areas include an entire building, closets, storage rooms, walk-in coolers and freezers, basements, open-air walled outdoor storage areas, outdoor storage buildings, rooms that can be adjacent to carbon dioxide container storage areas, and rooms below or containing gas distribution lines. Gas detection should be considered in these areas. This should include areas not controlled by the user of the carbon dioxide, such as adjoining offices, restaurants, other businesses, etc.

4.2.3 Low lying spaces

Examples of low lying spaces include basements, stairwells, building floor elevations below installed equipment or where distribution lines are installed. Outside areas that are at lower elevations are at risk especially in calm wind conditions.

4.2.4 Other considerations

In addition, the equipment can malfunction or otherwise not detect significant levels of carbon dioxide therefore one should be cautious before entering any potential hazard area.