Bulletin ID: SYPB2213
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Date: October 10, 2022
Title: **Recommended CO_2 Grades for use as a refrigerant in a CO_2 Booster system**

Due to global supply chain challenges, there has been a shortage of Carbon Dioxide (CO_2) available for refrigerant grade CO_2 as well as for gas cylinders. This bulletin is designed to provide Dover Food Retail's recommendations and guidelines for using the appropriate grade of CO_2 (R744) as a natural refrigerant.

CO_2 is produced as a byproduct of several manufacturing processes such as the formation of hydrocarbons or various distillation and fermentation processes. After CO_2 gas has been isolated it is purified into various levels, removing impurities, moisture, and non-condensable gases resulting in different grades of CO_2 for various applications.

Examples of various grades of CO_2 are shown below:

Common Grades of CO_2

Industrial Grade	99.5%
Bone-Dry Grade	99.8%
Anaerobic Grade	99.9%
Coleman (Instrument) Grade	**99.99%**
Research Grade	99.999%
Ultra-Pure Grade	99.9999%

Coleman (Instrument) Grade CO_2 contains less than 0.01% non-condensable gases and moisture (99.99% pure) is the recommended grade of CO_2 for commercial refrigeration systems.

Key factors to note:

- CO_2 used in commercial refrigeration systems must be of a purity level high enough to prevent the introduction of non-condensable gases into the system.
- A build-up of these gases can block the heat transfer surface and cause inefficient operation or malfunction of the system.
- Non-condensable gases that may be trapped in the system can be removed by using an available access valve in the system to vent off the non-condensable gases.

The table below shows typical Coleman (Instrument) Grade impurities:

Specifications of Coleman Grade CO_2 impurities

Minimum Purity of CO_2	99.99%
Nitrogen N_2	< 50 ppm
Oxygen O_2	< 20 ppm
Water H_2O	< 10 ppm

The introduction of a lower-grade CO_2 (99.99%) with purity levels less than those of the Coleman Grade is not recommended and should only be done in emergencies. The use of a lower-grade CO_2 may result in decreased system performance and require specific procedures to purge non-condensable gases from the system.

In emergency or shortage situations CO_2 grades of lower purity levels such as "Industrial Grade" and "Bone Dry Grade" should take the following precautions:

1) Include a filter drier in the line as part of the charging process

2) Thoroughly check for non-condensable gases, which may get charged into the system, and execute specific procedures to purge non-condensable gases from the system

The use of Carbon Dioxide of a higher level than Coleman Grade CO_2 (99.99%) is acceptable through typically not cost-effective nor readily available in the quantities needed for charging an entire system.

To ensure that the refrigeration system operates properly the purity of the CO_2 (R-744) utilized in the R-744 refrigeration system must meet certain standards as specified below:

The table below is copied from 2019 AHRI Standard 700, Page 11, Table 1C

Carbon Dioxide Refrigerant Characteristics and Allowable Levels of Contaminants		
	Reporting Units	R-744
Characteristics		
Sublimation Point	^{o}C at 101 kPa	-78.4
Sublimation Point Range	K	± 0.3
VAPOR PHASE		
Air and other non-condensable gases, maximum	% by Volume at 10^{o}C below the critical temperature and measure non-condensable gases directly	1.5
LIQUID PHASE		
Water, Maximum	ppm by weight	10
High Boiling Residue, Maximum	% by weight	0.0005
Particulates/Solids	Pass or Fail	Visually Clean
Minimum Purity	% by weight	99.9

Notes:
1. Sublimation Point, sublimation point range, although not required, is provided for informational purposes. Refrigerant data compiled from Refprop 9.1.
2. Sample taken from the vapor phase.
3. Sample vaporized from the liquid phase

Warning: Some CO_2 gas suppliers offer a “cap-charge” of helium or other gases for liquid cylinders which increases tank pressure to speed the charging process – DO NOT accept any cylinder with this cap-charge – use only cylinders that are PURE CO_2. The use of cylinders with a cap charge is likely to introduce large amounts of non-condensable gases, render the system inoperable, and require purging, evacuation, and recharging of the entire system.

To determine if a cylinder has a cap-charge, measure the tank pressure using a regulator and compare this with the saturation pressure at the approximate storage temperature of the tanks – tanks with a cap-charge will have a pressure significantly higher (>200 psig) than the corresponding saturation pressure.

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CO_2 Refrigeration Grade FAQs

Q: Why is there a shortage of Refrigeration Grade CO_2?
A: Supply chain challenges resulting from the COVID pandemic coupled with contamination at a naturally occurring CO_2 site have had a lingering impact on CO_2 gas production and thus availability.

Q: What is the recommended grade of CO_2 to use in refrigeration systems?
A: Dover Food Retail recommends Coleman (Instrument) Grade or Refrigerant grade CO_2, which is 99.99% pure with only 0.01% impurities and non-condensable gas. Lower-grade CO_2 can be used in emergencies only.

Q: With the limited availability of refrigeration system grade CO_2 what other grades are acceptable?
A: In emergencies lower grade CO_2 can be used (Anaerobic, Bone-Dry, etc.) if the necessary precautions are put in place.

Q: What precautions or preparations are required when using lower than Coleman-grade CO_2?
A: In emergency or shortage situations CO_2 grades of lower purity levels such as "Industrial Grade" and "Bone Dry Grade" should take the following precautions:

1) Include a filter drier in the line as part of the charging process
2) Thoroughly check for non-condensable gases, which may get charged into the system and require available means for removing these from the system.

Q: Where can I purchase CO_2 gas for my system?
A: Any Industrial Gas supplier will be able to supply various grades of CO_2

Q: Will my system have any detrimental effects if I use lower than Coleman-grade CO_2?
A: If precautions and preparations are not executed as listed above this could lead to excessive water content causing ice to form in the EEV; impurities in the CO_2 will cause poor operational performance, i.e. increase the compressor operating pressures.