



## CO2 Product Specifications

The following table summarizes the specifications for each of Linde's Co2 product grades:

- Frac
- USP - Aligns with CGA Medical/USP (Grade E)
- Commercial – Aligns with CGA Food (Grade H) and Commercial Grades (Grade G)
- Beverage - Aligns with ISBT guidelines and CGA Grade I

Constituent	Units	Frac	USP	Commercial	Beverage
Carbon Dioxide (CO2) Purity	%	95	99	99.5	99.9
Moisture (Water)	ppmv/°F	67/-50	200/-33	20/-68	20/-68
Non-Volatile Organic Residue (NVR)1	ppmw			10	10
Non-Volatile Organic Residue (NVOR)2	ppmw	5			5
Total Hydrocarbons (as Methane)	ppmv	50,000		50 <sup>7</sup>	50 ppmv*
Methanol (CH, OH)	ppmv				10
Oxygen (O2)	ppmv			50	30
Nitrogen (N2)	ppmv				120
Carbon Monoxide (CO)	ppmv		10	10	10
Oxides of Nitrogen (NO) (NO2)	ppmv		2.5 (each)	5 (total)	2.5 (each)
Phosphine (PH2)	ppmv				0.3
Sulfur Dioxide (SO2)	ppmv		5	5	1.0
Carbonyl Sulfide (COS)	ppmv			0.5	0.1

\*of which not more than 20 ppmv is non-methane hydrocarbons



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Hydrogen Sulfide (H <sub>2</sub> S)	ppmv	1	1	0.5	0.1
Total Sulfur (TS) as SO <sub>2</sub> <sup>3</sup>	ppbv	100 ppmv		500	100
Ammonia (NH <sub>3</sub> )	ppmv		25	25	2.5
Benzene (C <sub>6</sub> H <sub>6</sub> )	ppbv	1000 ppmv			20
Hydrogen Cyanide (HCN) <sup>5</sup>	ppmv				0.05
Chromium (Cr <sup>+6</sup> ) <sup>5</sup>	ppmw/v				0.06
Vinyl Chloride (CH <sub>2</sub> =CHCl) <sup>5</sup>	ppmv				0.05
Ethylene Oxide ((CH <sub>2</sub> ) <sub>2</sub> O) <sup>5</sup>	ppmv				0.2
Acetaldehyde (CH <sub>3</sub> CHO)	ppmv			0.5	0.2
Other Volatile Oxygenates <sup>6</sup>	ppmv				1.0
Foreign Taste				None	None
Foreign Odor				None	None
Appearance				None	None



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1. NVR is the total amount of residue including particulates as well as organic residue.
2. NVOR is also commonly referred to as Oil and Grease.
3. The total sulfur content is often expressed as a sulfur equivalent (S) and is proportional to the number of sulfur atoms in the molecule. The beverage grade specification for total sulfur is 100 ppbv so the sum of all sulfurs cannot exceed 100 ppbv with the exception of SO<sub>2</sub>, which is allowed to be up to 1 ppmv. If SO<sub>2</sub> cannot be measured separately, then the plant limit for total sulfur must be less than 90 ppbv.
4. The manufacturing specification for loading railcars is lower than that for loading trailers because of the potential concentration effect over the time while the product is in transport. Product loaded at the manufacturing limit in a railcar could exceed the product specification by the time it actually reaches the customer site. The rail manufacturing limit only applies to batch tests of product being loaded into railcars.
5. A specification limit exists for EO, HCN, Cr and VCI; however, any local test results that indicate the presence of these impurities must generate a non-conforming product investigation.
6. Target oxygenates include acetone, n-propanol, i-propanol, ethyl acetate, n-butanol, i-butanol, t-butanol, i-amyl acetate, propionaldehyde, methyl ethyl ether, methyl ether.
7. A test result that exceeds 50ppb benzene must be reported and investigated per Non-Conforming Product Procedures prior to release to any commercial customers.