Airborne Labs International

CO_2 Analyzer System Products

Getting the Facts

Fact 1: There are several technological approaches to performing bev-grade CO_2 analysis. They range from the simple & inexpensive – to the highly automated & complex. There is "no" perfect technology that will fit all needs. Like any tool in a toolbox, each analytical tool has its set of advantages & limitations that should be considered for your quality assurance demands & budgets.

Fact 2: The optimal system for you will involve the following issues, all of which define the level of risk you face concerning the impact of a CO_2 quality upset. These include: Your plant size & **daily production capacity**, your **location**, your **staff resources**, your **Feed Gas source(s)**, your **budget** & your **vendor's expertise & back-up support** capability.

Fact 3: : Like any tool, sometimes they break or do not work the way they should. What effect would an out-of-service or errant analyzer have on **your** production, brand name, reputation, customer relations & potential loss of revenue – **when** this analyzer tool doesn't work right? **How long** can you afford to stop production or risk "**running blind**"?

Fact 4: There will be a set of key impurities that you should monitor based upon the **risks** from your **Feed Gas source**, manufacturing process, customer or regulatory requirements. You need to precisely define "**the hit list**". **ISBT Guidelines** should be used as a resource for desired measurement performance. Use expert vendor resources that can see the "entire picture" of your CO_2 application – not **just** the hardware.

Typical Technologies Employed for Bev-Grade CO_2 Applications
(CO_2 Suppliers & Bottling Plants)

I) Detector Tubes: *Ex. Benzene, TSC, SO_2, H_2S, Acetaldehyde (AA), H_2O, Methanol, Ethanol, NO_x, NO_2, NH_3, HCN, CO, Vinyl Chloride, Phosphine (PH_3), and others*

II) Specific Impurity or Impurity Class Analyzers: *Ex. Trace O_2, H_2O, Total Hydrocarbon (THC), Total Sulfur (TSC), NOx / NO_2*

III) Multi-Component Analyzers: *Ex. High Resolution, Industrial Gas Chromatographs (GC), Rapid Mass Spectrometric Analyzers (ex. SIS), Ultra-violet / Infra-red (UV / IR) Spectrometers*

Based upon our extensive experience as an **ISO 17025** accredited, **Pepsico & Coca-Cola** approved, independent Analytical Chemistry Laboratory with an intimate knowledge of **all types** of CO_2 Feed Gas sources, ISBT leadership, **world-wide**, **highly diverse** customer base, our pioneering R&D experience in developing detector tubes, specific analyzers, GC / MS / UV / IR methodologies – (**many adapted by ISBT**) we have compiled a useful "**Advantages & Limitations**" list concerning these technologies as an educational guide to help you pick the best analytical tools for **your** CO_2 quality testing needs.

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Typical Technologies Employed for Bev-Grade CO_2 Applications

Explained

I) Detector Tubes

Advantages: Versatile, simple to use, low cost, *low* staff training needs, ISBT accepted, great for fast ***confirmation*** **of continuous analyzer data or** ***emergency use*** when a continuous analyzer is "out-of-service". Ideal for low frequency, periodic "batch testing" apps & use in small –mid size plants in remote areas. Multi-Channel DT analyzers are easy to use, rapid, highly sensitive, non-labor intensive. **No calibration gases needed**. DT shelf life typically 2 yrs, low gas sample volume required. Can use 1L sample cylinders. Very low maintenance needs. Passivated hardware used.

Limitations: Not cost effective nor meant for continuous or high frequency monitoring of many impurities, most DT models cannot be re-used. DTs require refrigeration.

II) Specific Analyzers (ex. TSC, THC, Trace O_2, H_2O, NOx / NO_2)

Advantages: **Continuous** measurements, easily calibrated, low calibration / verification frequency, low – medium staff training needs, ISBT accepted methods, field ruggedness. Good for either "batch" **or** continuous measurement, easily automated / conc alarms / autocal features often offered, service contracts optional. Low maintenance – plug & play typical. Good for use in most remote locations. Can use 1L sample cylinders. Low sample & cal gas flow / volume requirements (LT 1 LPM). Passivated hardware std.

Limitations: Span & zero cal gases required, some support gases (ex. zero grade air / H_2) needed from cylinder or small generators, periodic (ex. yearly) sensor recalibration or replacements, periodic filter change outs. Some units require programming & associated operator training. Expense low - mid-range.

III) Multi-Component Analyzers: (Industrial GC & MS [SIS] types)

Advantages: Semi-Continuous measurements, rapid 1 – 10 min / measurement cycle, easily calibrated & verified (visible peaks), **low calibration / verification frequency**, med - high staff training needs, ISBT accepted methods, field ruggedness. GC good for batch or semi-continuous measurements (this includes **TSC capability for GC**), easily automated / conc. alarms / autocal features available, service contracts optional (but recommended), low maintenance – plug & play replacement parts typical, GC **good for use** in most **remote** locations, **low** sample & cal gas flow / volume requirements (ex. **can use 1L cylinder samples**), low support gas needs. MS is programmable for multiple components (use of 1 **INCAL** std reduces cal std costs), high resolution / tuned GC columns with PID show **very low susceptibility to interference errors from non-ISBT listed impurities – therefore good for use on ANY CO_2 feed gas sourced final product. Low** sample & cal gas flow requirements (ex. 0.1- 0.2 LPM. MS methods feature computer-based spectral subtraction based on **INCAL** std use. For industrial GC's, long history, **method of choice** for **majority of CO_2 gas producers** around the world. TSC by GC or MS use rugged, thermo-catalytic reductive converters. **Modular** configuration (GC) analyzers (all eggs are **not** in 1 basket). Passivated hardware std.

III) Multi-Component Analyzers: (Industrial GC & MS [SIS] types) – CONT.

Limitations: Combination Span & zero cal gases required (ex. 1 – 2), some support gases (ex. zero grade air / H_2 or N_2, [or Hg, Xe / Kr for SIS]) needed from cylinders or small generators, periodic (ex. 8 mo. or yearly) PID sensor lamp or filament (MS-SIS) replacements, periodic filter change-outs. Some units require programming & associated operator training.). Expense mid-range (GC) to high (MS-SIS). THC by target analyte addition not ISBT accepted.

III) Multi-Component Analyzers - Continued: (UV / IR types)

Advantages: Semi-Continuous measurements, typically 15 min / measurement cycle. Programmable list of up to 16+ analytes. TSC capability with **oxidative conversion module**. Remote monitoring capability. Only air support gas is needed for TSC converter, sulfur impurities are converted into SO_2 for IR measurement. OEM Computer algorithm is used for analyte peak identification / spectral subtraction of foreign bands. Good for use in water-free (low / sub ppm) CO_2 samples with a limited, definable, potential non-target impurity list (ex. ammonia sourced CO_2).

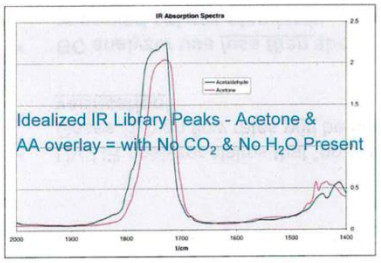
Limitations: Analyzer calibration can **only** be performed by OEM at factory. **Very high** CO_2 sample, cal / verification gas gas flow requirements of between 5 – 15 LPM (ex. 2,630.000 – 7,820,000 LPYr for continuous use) + 70 psig+ high cell pressures, (**small 1L sample cylinders not recommended for use due to high analyzer gas flows!**), multiple, combination verification gases needed in **large** cylinders, verification gases require **precise dilution** system with zero-grade CO_2 gas for delivery at high flow rate (ex. **8 LPM for 10 min**). System requires **frequent** re-zeroing, IR spectral signals cannot be user-monitored which makes data quality verification difficult without an appropriate Verify Gas std. Perpetual 2X/yr service contract by OEM is basically **mandatory**. **Not** recommended for use in remote locations or in periodic batch testing applications. As many small potential impurity molecules (with the same functional groups) have ***very similar*** IR & UV spectra as **key ISBT targets** (ex. acetone vs AA) - the IR spectral correction algorithm is challenged to positively ID & accurately measure these ISBT list analytes (see attached examples). H_2O + CO_2 bands **overlap** many **key areas** of the IR spectra (ex. AA, NO, NO_2, SO_2, & others)**. H_2O vapor present at ISBT acceptable levels can potentially lead to false positive errors** for some ISBT target list analytes. **An add on** trace O_2 analyzer is needed if O_2 needs to be measured. **THC is measured by computer addition of some target organic analytes, this is not a true ISBT recommended method** & may **not correlate** with ISBT method data obtained with a THC analyzer. Some feed gas sources have a **long list** of possible impurities that can lead to false positive errors **if** the IR algorithm is **not** anticipating their presence. Periodic UV lamp & IR source replacements & optical maintenance required. Many of the available target analytes are **not** on the ISBT target list. Detection limits for some available analytes are approximately **10X higher** than recommended in ISBT test methods. Technique of running **liquid** phase CO_2 through **long lengths** of transfer lines to a multi-port vaporizer then *another* transfer line to the analyzer can result in **very long purge delay times** during tank sample changes. **Non-passivated** hardware std. UV / IR Analyzer = **non-modular**. UV / IR System failure affects **all** measurements - **you go dark** (all eggs in 1 – basket scenario – **NO** redundancy). **UV / IR Expense very high.**

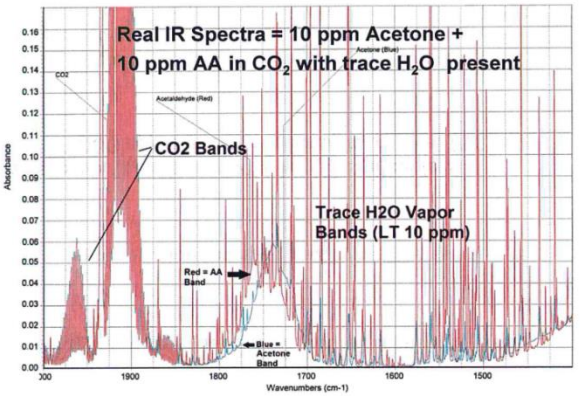
UV / IR Spectral Interference Challenges

Facts & Questions

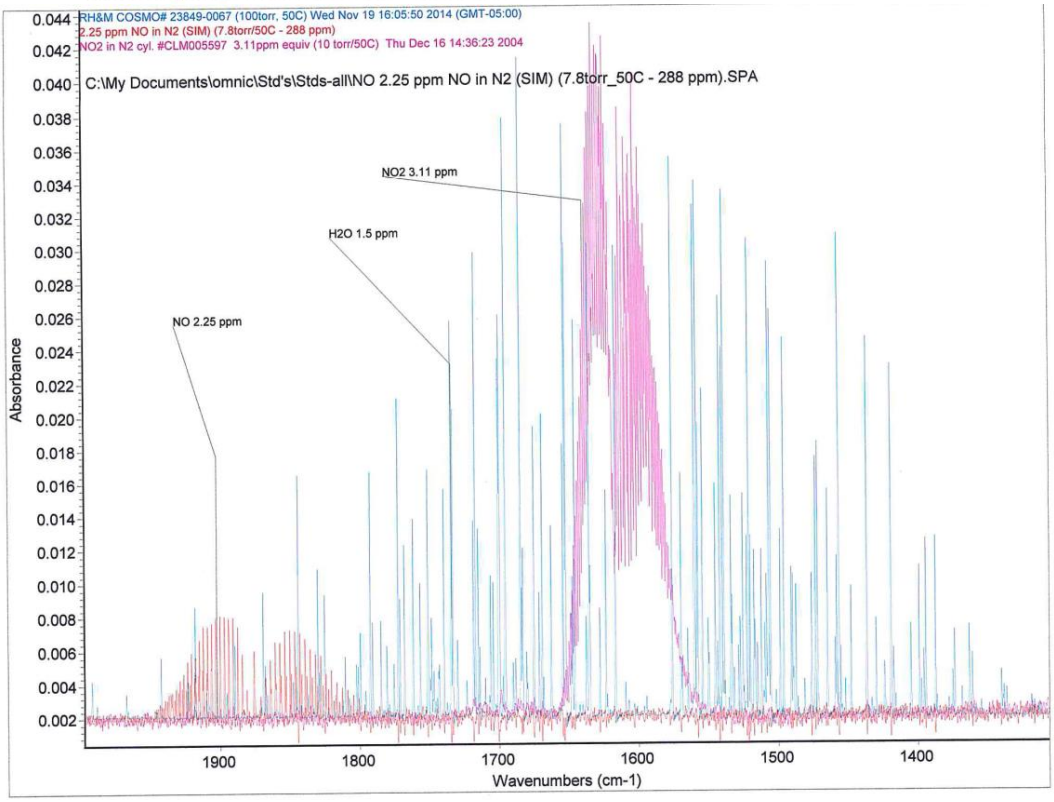
(ex. Key Measurement Challenges)

- ***High AA is a common source of odor complaints & a TCCC / ISBT target impurity***
- ***High AA is common in <u>both</u> Fermentation & Combustion FG Sources***
- - UV / IR Analyzer Chemometrics algorithms face the challenge of properly identifying & measuring impurities with *very similar* UV or IR absorption profiles (ex. acetone vs acetaldehyde [AA] in CO_2 with trace H_2O present)

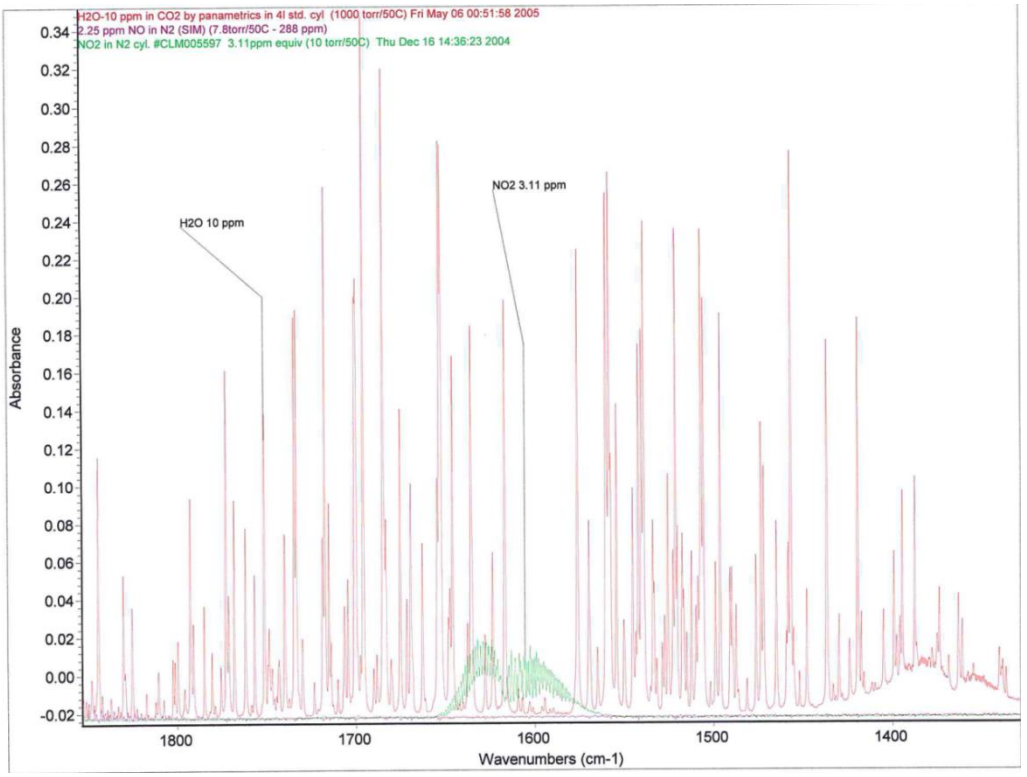


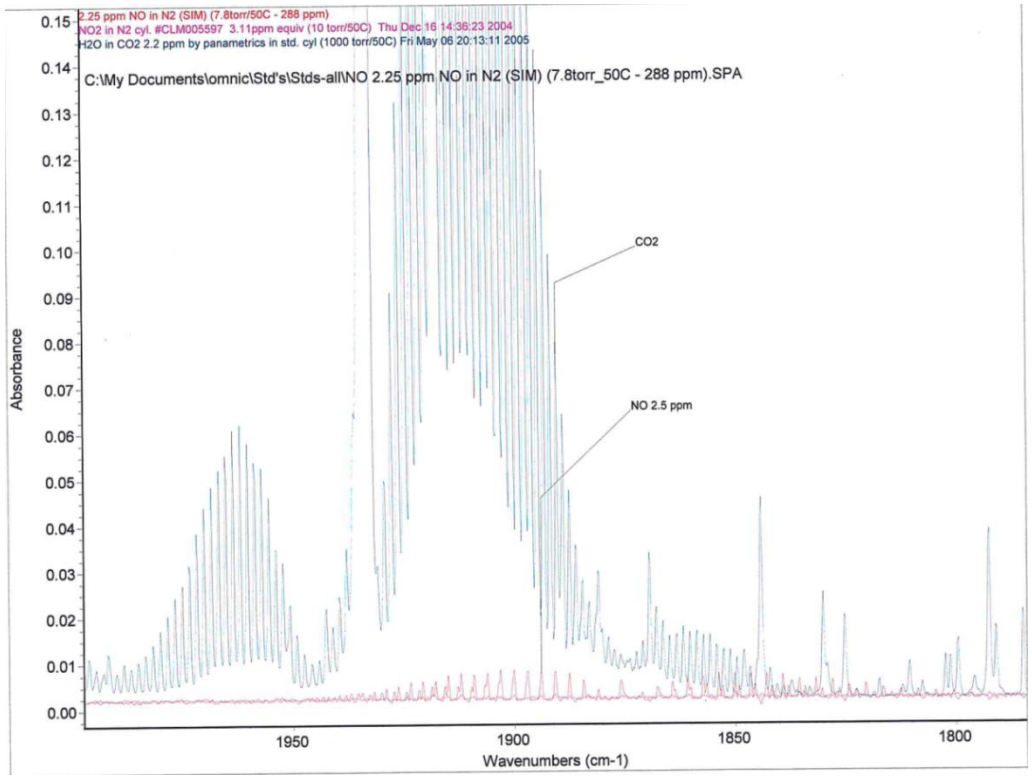


- GC analyzers <u>easily</u> separate AA peak from acetone & others & accurately measure an AA impurity in fermentation / combustion-based sources.



UV / IR Spectral Interference Challenges





Why Airborne Labs International?

- ***ALI*** recommends modular, integrated analyzer systems for most user applications ranging from very small to very large operations

- ***ALI*** recommends DT based back-up redundancy insurance capability for all analyzer systems – especially for remote area ops so you never go dark

- ***ALI*** recommends high resolution, selective GC-based analyzers for continuous monitoring of big 3 critical impurities: Benzene, TSC, AA. This is especially true when CO_2 comes from complex Feed Gas sources such as biomass fermentation, combustion & acid neutralization

- ***ALI 's*** systems are all fully passivated, and recommends the use of passivated hardware to avoid false negative results which others who do not use passivated hardware can receive

- ***ALI*** systems can employ small 1L cylinder sample sources. Gas volume requirements are LOW for samples & gas standards!

- ***ALI*** systems can be highly automated to include automatic stream sampling / time sequencing of up to 10 sample lines, remote monitoring, remote QC actions, data-logging, alarming, custom report generation including input of all manual DT, NVR/NVOR, % purity & sensory data

- ***ALI*** systems can be user calibrated & all data easily & visually verified

Why Airborne Labs International? Cont.

- ***ALI*** methods are fully validated & meet all **ISBT** performance criteria
- ***ALI*** & its regional service agents provide installation, full training, Preventative Maintenance, Repair & Mainteinance + approved laboratory back-up support – a benefit unique only to ***ALI!***
- ***ALI*** systems are approved, WIKI-listed, time-tested, and used worldwide with great success. Refer to our website http://www.airbornelabs.com for testimonials
- ***ALI*** offers a full line of certified gas standards, all technical supplies, spares, etc.
- ***ALI*** developed methods have been adapted by **ISBT** for most listed impurities – we are truly experts in the industry
- ***ALI*** systems are very versatile & field upgradeable for future demands
- ***ALI*** staff are world-recognized experts in Analytical Chemistry – we know your application inside out & can get you the right hardware to do the job – at a fair price!

We look forward to being of service to you!