# Analysis of $CO_2$ with the Jetanizer™

Application Note

### $CO_2$ Detection with GC/Jetanizer™/FID and Comparison with an Commercial Methanizer

## Author

Tommy Saunders and Charlie Spanjers
Activated Research Company
7561 Corporate Way
Eden Prairie, MN 55344
tommy.saunders@activatedresearch.com

## Abstract

The analysis of carbon monoxide (CO) and carbon dioxide ($CO_2$) with GC/FID is not possible without first converting these to methane. In this application note, we show the analysis of $CO_2$ over a linear range of six orders of magnitude with the Jetanizer™. The limits of detection and peak widths are compared with an commercial methanizer. The Jetanizer™ performance matched that of the commercial methanizer for each experiment performed.

## Introduction

The flame ionization detector (FID) detects $CHO^+$ ions from the combustion of organic molecules in a hydrogen flame. Carbon monoxide and carbon dioxide are not detectable in the FID because they contain no carbon-hydrogen bonds. To overcome this limitation, methanizers have traditionally been used to catalytically convert these compounds to methane, which is easily detected in the FID. Methanizers have been used across many applications including transformer oil gas analysis, air monitoring, waste analysis, environmental analysis, and much more. These methanizers are typically ¼ inch stainless steel cartridges packed with powdered nickel catalyst. The cartridge is fitted with a heater and additional fittings to enable placement between the GC column outlet and the FID inlet. One of the biggest challenges of using methanizers is the difficulty of replacement when the catalyst becomes inactive. Replacing a typical methanizer involves cooling down the reactor, disconnecting all fittings, disassembling the methanizer, packing the catalyst, and repeating this process in reverse. This process can put a GC out of operation for an entire day or more, putting extra strain on a lab's throughput. To help with this problem, ARC developed the Jetanizer™, which is an FID jet that performs in situ methanation (i.e., *inside* of the jet itself). The Jetanizer™ is 3D-printed with stainless steel to maximize the methanation reaction rate and to create geometries that minimize band broadening. A schematic of the Jetanizer™ and the reaction that it performs is shown in Figure 1. Hydrogen is supplied by the FID (similar to a normal FID jet), and this mixes with the analytes as they enter the Jetanizer™. CO and $CO_2$ are subsequently converted to methane, which then passes directly to the FID where it is detected. Within this application note, we show data for the analysis of carbon dioxide with the Jetanizer™, and compare this to an commercial methanizer.

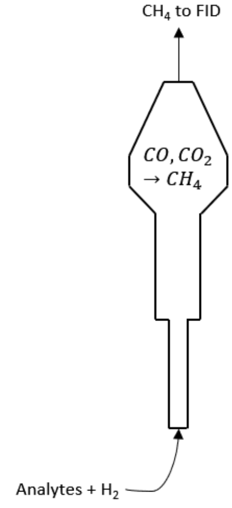


**Figure 1:** Schematic of the Jetanizer™.

# Experimental

An Agilent 7890A GC equipped with a split/splitless inlet (Agilent G3454-64000), a capillary-optimized FID with Jetanizer™ (p/n JT-CAP-P10), and a VICI 6-port injection valve was used for the analysis. Helium (99.999%, Praxair) was used for carrier, FID makeup, and dilution of the sample. Air (zero grade, Praxair) and $H_2$ (99.999%, Praxair) were supplied to the FID.

Varying amounts of $CO_2$ on-column were obtained by by modifying the split ratio in the inlet and by mixing pure $CO_2$ or air (with ~500 ppm $CO_2$) with helium upstream of the VICI 6-port injection valve. For accurate quantification, the actual split ratio was measured for each run with a bubble flow meter. The amount of $CO_2$ on column was then calculated for each run. The Jetanizer™ was compared with an commercial methanizer across six orders of magnitude in $CO_2$ concentration.

**GC conditions**

| | |
|---|---|
| Front inlet | Split/splitless |
| Inlet temperature | 250 °C |
| Inlet linter | Agilent 5190-2295 |
| Carrier gas | He; 2.5 sccm constant flow |
| Septum purge flow | 3 sccm |
| Oven | 100 ºC (hold 2 min) |
| Column | Capillary restrictor (5 m × 0.15 mm) |
| Injection volume | 1 mL |

**FID conditions**

| | |
|---|---|
| Temperature | 450 °C |
| $H_2$ | 35 sccm |
| Air | 350 sccm |
| Makeup | 20 sccm (He) |

# Results

Jetanizer™ performance was evaluated and compared to a commercial methanizer for varying concentrations of $CO_2$ using the experimental method shown above. Each data point was replicated at least three times for both the Jetanizer™ and the methanizer. These replications were averaged for each data point and are reported as such in the linearity plot (Figure 2).

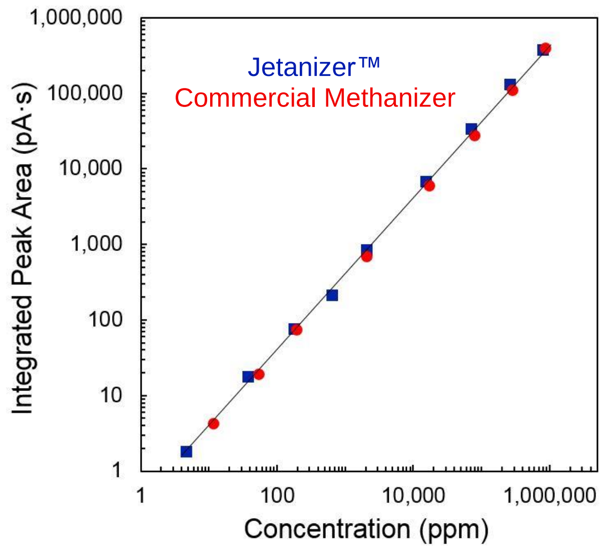


**Figure 2.** Concentration of $CO_2$ versus integrated peak area for the Jetanizer™ (blue square) and commercial methanizer (red circle), demonstrating a linear relationship over six orders of magnitude.

The limits of detection (LOD) and limits of quantification (LOQ) are similar when comparing the methanizer and the Jetanizer™. The results are summarized in Table 1.

**Table 1:** Limits of detection (LOD) and limits of quantification (LOQ) for $CO_2$ analysis with the Jetanizer™ and commercial methanizer.

| | LOD (pg C) | LOQ (pg C) |
|---|---|---|
| *Jetanizer™* | 10 | 30 |
| *Methanizer* | 10 | 30 |

Peak widths at half maximum for varying $CO_2$ masses on-column for the Jetanizer™ and the methanizer are presented in Table 2. Figure 3 shows the resolution of peaks from 1 ppm $CO_2$ to 100% $CO_2$.

**Table 2:** Peak full widths at half maximum (FWHM) for three concentrations of CO2 with the Jetanizer™ and commercial methanizer.

| | $CO_2$ on Column (ng) | FWHM (min) |
|---|---|---|
| *Commercial Methanizer* | 8.8 | 0.054 |
| | 340 | 0.014 |
| | 140,000 | 0.046 |
| *Jetanizer™* | 6.3 | 0.057 |
| | 340 | 0.014 |
| | 130,000 | 0.045 |

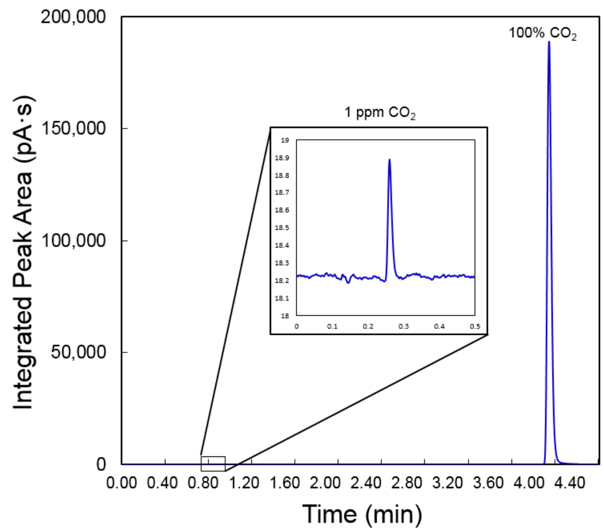


**Figure 3.** Chromatogram showing Jetanizer™ data for 1 ppm $CO_2$ and 100% $CO_2$ injections.

## Discussion

There are many applications where methanizers provide a great advantage, but their difficulty of installation and replacement has been a major pain point for scientists. The Jetanizer™ has been developed to be an easy-to-use replacement for methanizers, with substantially fewer components and fittings than a traditional methanizer.

The performance of the Jetanizer™ was found to be equivalent to a commercial methanizer. The Jetanizer™ can convert $CO_2$ to methane from ppm to 100% range. This performance was proven over a wide linear range with good peak resolution and signal to noise ratio.

The primary advantage the Jetanizer™ provides over traditional methanizers is its ease of installation. The process is as simple as replacing an FID jet, taking approximately 5 minutes. Traditional methanizers, on the other hand, can take up to a day to replace, and the process is very involved - including making new fittings, using insulation, and re-packing the catalyst.

## Conclusions

The Jetanizer™ is a useful tool for the analysis of CO and $CO_2$ over six orders of magnitude in linear range because of its ease of installation, robustness, and safety. The Jetanizer™ has been shown to perform as well as traditional methanizers, making it a clear choice for those experiencing difficulties with using their methanizers. Further work will continue to explore the range of molecules that can be tolerated by the Jetanizer™ and what methods can benefit from its use.

## Contact Us

For more information or to purchase a Jetanizer™, please contact us at 612-787-2721 or contact@activatedresearch.com.

Please visit our website for details and additional technical literature.


Printed in the USA
January 11, 2018
JT-APP-1811