

# Custom Solutions Group LLC

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## Petrochemicals

Petrochemicals are chemicals derived from fossil fuels such as petroleum, natural gas and coal, and from renewable biomass sources such as wood, corn, sugar cane, switchgrass, and palm oil, to name a few. Custom Solutions Group LLC provides a wide variety of high quality solutions in petrochemical gas chromatography. Our petrochemical analyzers meet and exceed industry standard methods from ASTM (American Society of Test and Measurement), UOP (Universal Oil Products), the GPA (Gas Processors Association),

and ISO (International Standards Organization). Analysis types include permanent gas, permanent gas with hydrogen analysis, light hydrocarbon analyzers, refinery gas and refinery gas liquid analyzers, rapid refinery gas analyzers, trace carbon monoxide and trace carbon dioxide analyzers, trace permanent gas analysis, acid gas analysis, trace sulfur analysis, and trace oxygenates systems. All systems emphasize simplicity, serviceability, functionality and the highest quality construction, Made-in-the-U.S.A.



## Permanent Gas Analyzer and Permanent Gas Analyzer with Hydrogen Analysis

The Permanent Gas Analyzer utilizes a single Thermal Conductivity Detector (TCD) on helium or hydrogen carrier. Common analytes include argon/oxygen, nitrogen, methane, carbon monoxide and carbon dioxide. The C2's, including ethane, ethylene, and acetylene, as well as hydrogen sulfide, propane, and propylene, can be added with additional time in the bypass position. Normally, moisture is backflushed, but moisture, too, can be analyzed by relative response factor or subtraction from one hundred percent, even for systems with relatively high moisture content, as is common for certain steam reformation processes. Hydrogen can also be analyzed in a narrow range of concentrations via TCD on a helium carrier, but due to thermal conductivity effects for binary mixtures of helium and hydrogen, argon and nitrogen are the preferred carrier gases for hydrogen analysis, especially for high and broad ranges of hydrogen. The Permanent Gas Analyzer with Hydrogen Analysis utilizes a second TCD on an argon (or nitrogen) carrier. Low levels of helium may also be separated from hydrogen on the argon TCD. Finally, for systems with high or varying levels of hydrogen and other permanent gas analytes above part-per-million levels, a single channel argon TCD can be used.

For permanent gas analysis, backflush and series by-pass are used to: (1) protect molecular sieve columns from contamination, (2) allow elution of all desired components to TCD, and (3) speed run time. Materials and designs are used to allow the simultaneous bake-out of molecular sieve materials without the need for a second bake-out oven and without the need to remove porous polymer columns from the same temperature zone, thus making molecular sieve maintenance simple and easy.

Custom Solutions Group's Permanent Gas Analyzer and Permanent Gas with Hydrogen Analysis Analyzer meet or exceed the performance criteria as specified in ASTM D1946.

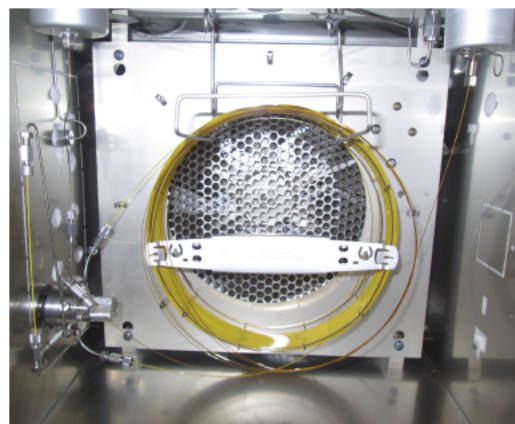


Figure 1 – Capillary Backflush Column

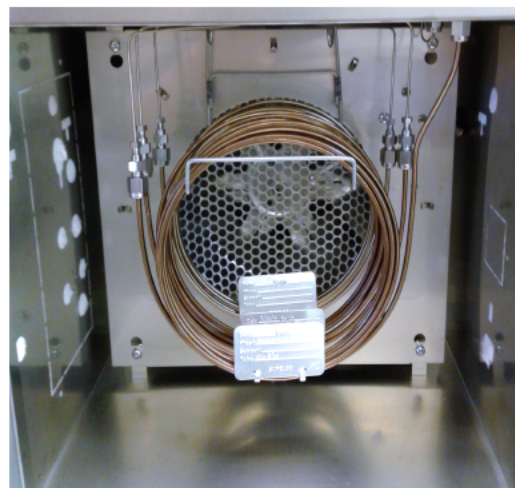


Figure 2 – PGA Column Oven

## Light Hydrocarbon Analyzers

Light hydrocarbon analyzers can inject either gases or liquefied petroleum gases (LPG) or both. Light hydrocarbon analyzers can also include or exclude early re-group peaks. Early re-group peaks can be tuned for pentenes plus, hexane plus, heptanes plus, or even post-toluene plus. Commonly, peaks for gas and LPG include: C6+, methane, ethane, ethylene, propane, cyclopropane, propylene, i-butane, n-butane, 1,2-propadiene, acetylene, t-2-butene, 1-butene, i-butene, cis-2-butene, neopentane, i-pentane, n-pentane, 1,3-butadiene, and methyl acetylene (propyne). 3-methyl-1-butene, t-2-pentene, 2-methyl-2-butene, 1-pentene, 2-methyl-1-butene, and c-2-pentene, can be added with an extension to the run time. 1,2-butadiene, which is commonly analyzed in 1,3-butadiene, can also be added. The column of choice for these separations, no matter the bulk gas, is the Alumina PLOT, Na<sub>2</sub>SO<sub>4</sub> de-activated. The only exceptions are KCl de-activation for 1,3-butadiene analysis and specially stabilized Alumina PLOT's for trace acetylenes (alkynes). The Flame Ionization Detector (FID) is the detector of choice for this analysis.

The high capacity Alumina PLOT column, with an early re-group peak and an eight minute run time through n-pentane, has the ability to analyze a variety of bulk products using the same GC conditions. It is highly linear from very low to very high concentration and has the ability to separate low concentration peaks from high concentration bulk products. Gas injection valves are maintained in high-temperature isothermal ovens, separate from the temperature-programmed column oven, ensuring repeatable total area counts. LPG injections include a high-pressure on/off valve and a high-pressure, clear-view-tube on the Liquid Sample Out, ensuring repeatable retention times on the Alumina PLOT and repeatable total area counts for compressed liquids.

Custom Solutions Group's Light Hydrocarbon Analyzers meet or exceed the performance criteria for a variety of industry standard methods, including ASTM D2163.

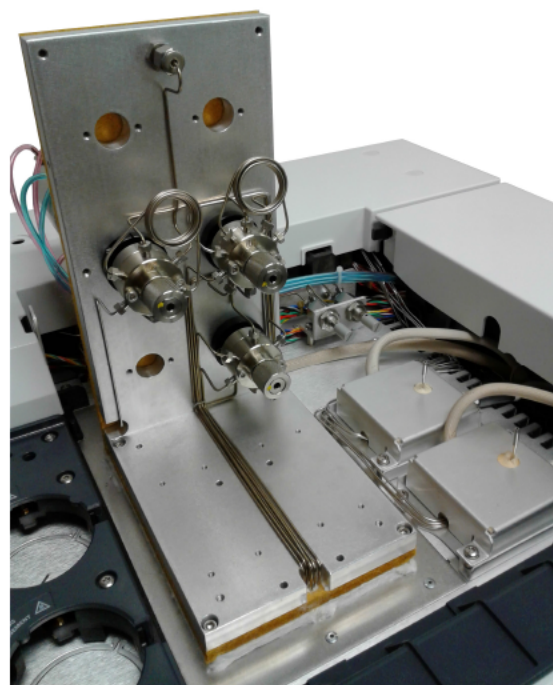


Figure 3 – PGA Aux Oven



Figure 4 – On-Line Complex Gas Analyzer

## Refinery Gas and Refinery Gas Liquid Analyzers

Refinery Gas and Refinery Gas Liquid Analyzers are a combination of the Permanent Gas with Hydrogen Analysis Analyzer and the Light Hydrocarbon Analyzer. Custom Solutions Group's Refinery Gas Analyzers (RGA) can inject either gases or liquefied petroleum gases (LPG) or both. They can include or exclude early re-group peaks. Hydrocarbons are analyzed via FID. Helium and hydrogen are analyzed via argon TCD. The remainder of the permanent gases are analyzed via helium or hydrogen TCD. Hydrogen sulfide and even carbonyl sulfide can be included with an extension to the run time.

All Custom Solutions Group RGA's place the capillary columns in the temperature-programmed column oven. Packed columns are maintained in separate, spacious isothermal ovens. This means that changes to either the packed column analyses or capillary column analyses do not affect each other, greatly simplifying maintenance and analytical development. Early re-group peaks formed by the capillary backflush columns are smooth and contiguous, even when the heavies are at low concentration and spread over a wide carbon range. This makes integration of the early re-group peak certain and simple. Finally, backflush and series-bypass are used to protect columns and speed analyses, with positive outcomes for system separations, linearity, and limits of detection.

Custom Solutions Group's Refinery Gas and Refinery Gas Liquid Analyzers meet or exceed the requirements of GPA 2261, GPA 2177, ASTM D1945, ASTM D1946, ASTM D2163, and UOP 539, among others.



Figure 5 – Dual Liquid Petroleum Gas (LPG) Sampling Panels

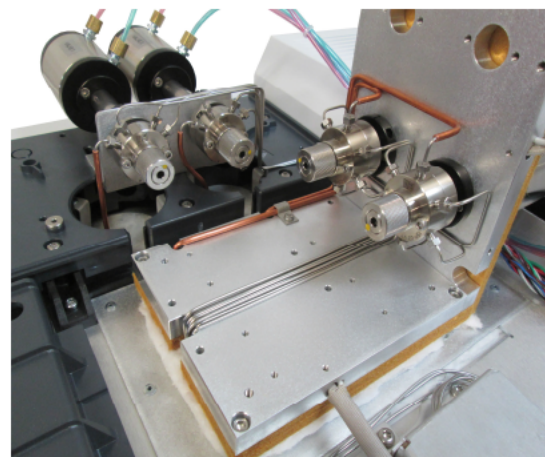


Figure 6 – Dual Liquid Sampling Valves

## Rapid Refinery Gas and Refinery Gas Liquid Analyzers

Custom Solutions Group provides rapid analysis solutions for the analysis of refinery gas and refinery gas liquids. These solutions feature micro-packed columns at isothermal temperature, backflush-to-vent techniques to speed analyses, and rapid, small bore, high resolution capillary column separations. Run times are set to be as fast as Micro GC, without the disadvantages of Micro GC, such as: (1) the inability to run heavy, wet, or highly acidic samples, (2) closed loop non-linearity, (3) plugging of the injection wafer, and (4) expensive repair and replacement costs. Run times through carbon monoxide on the helium TCD channel and n-pentane on the FID channel are as low as four minutes.

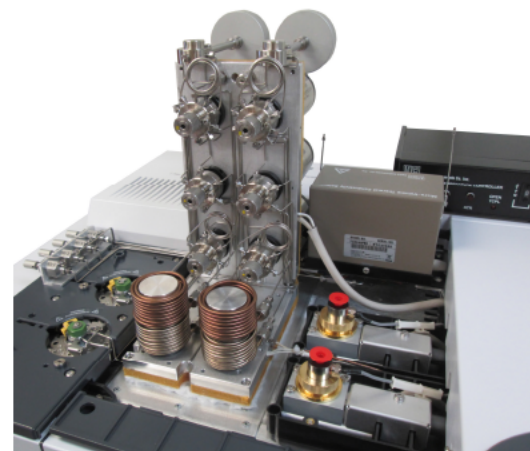
Rapid analysis is most appropriate for process gas, especially synthesis gas, where hydrocarbon concentrations are not too high and high capacities are not needed to separate trace compounds from bulk liquids.

All Custom Solutions Group Permanent Gas, Light Hydrocarbon, and Refinery Gas Analyzers can be adapted to automated and on-line use.

Custom Solutions Group's Rapid Refinery Gas and Refinery Gas Liquid Analyzers meet or exceed the requirements of GPA 2261, GPA 2177, ASTM D1945, ASTM D1946, ASTM D2163, and UOP 539, among others.



**Figure 7 – System for Ultra High Purity Ethylene and Propylene**



**Figure 8 – Aux Valve Oven for Four-Channel System**

## Trace Sulfur Analysis

Custom Solutions Group uses a variety of sulfur-specific detectors for speciation of trace sulfur compounds in petrochemical gases and liquids. Normally, these sulfur-specific detectors include: FPD (Flame Photometric Detector), PFPD (Pulsed Flame Photometric Detector), and SCD (Sulfur Chemiluminescence Detector). Each of these detectors has advantages and disadvantages. Custom Solutions Group listens to and studies the customer's needs to understand which detector is most appropriate in each situation. Hydrogen sulfide, carbonyl sulfide, sulfur dioxide, mercaptans (thiols), and sulfides are commonly analyzed. Trace sulfur systems feature all silcosteel sample wetted lines, for maximum inertness to trace sulfur species, and column-specific separations. Column-specific separations are used because of FPD and PFPD quenching effects caused by the hydrocarbon matrix. The most recent model of the SCD has high selectivity and does not appear to suffer from quenching effects. Either way, strategies are used to ensure both hydrogen sulfide and carbonyl sulfide are accurately and precisely measured down to the double-digit and single digit ppb levels without interference from C1 to C4 hydrocarbons, and instead of two detectors, only one detector is needed for a complete suite of results.

Custom Solutions Group's trace sulfur analyzers meet or exceed requirements of GPA 2199, ASTM D5504, ASTM D6228, and ASTM D5623.

## Acid Gases

Acid gases, gases high in hydrogen sulfide and carbon dioxide, pose a unique challenge. Separations and materials are modified to address these types of samples. Normally, this means that Valco valves and sample wetted tubing will be in Hastelloy C22, for maximum inertness and the longest life. If necessary, nickel filaments can also be used on the TCD.

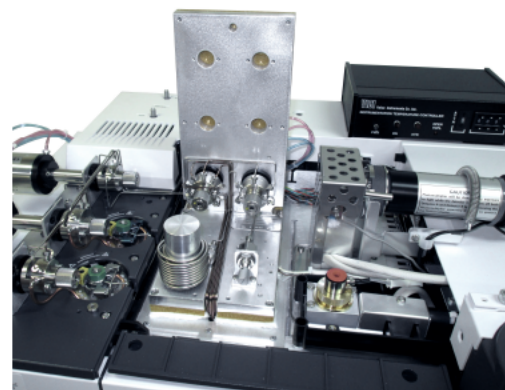


Figure 9 – System with Flame Photometric Detector

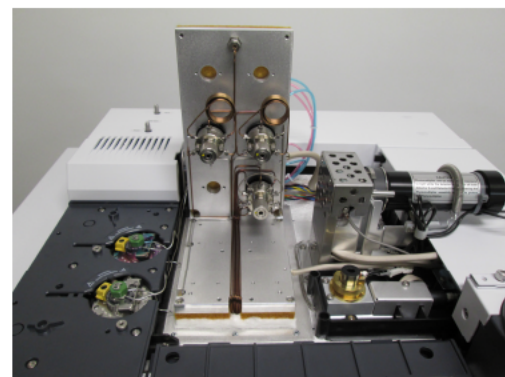


Figure 10 – System with Pulsed Flame Photometric Detector

## Trace Carbon Monoxide and Trace Carbon Dioxide Analyzer

In the petrochemical industry, trace carbon monoxide and trace carbon dioxide are well known catalyst killers. To analyze these compounds at low levels, methanizers and FID's are used. Methanizers are high temperature, nickel oxide catalysts in a hydrogen atmosphere. They convert traces of carbon monoxide and carbon dioxide to methane. The methane is subsequently analyzed via FID, thus lowering detection limits compared to TCD. Trace carbon monoxide and trace carbon dioxide can be analyzed from either the gas or LPG phases. The nickel oxide catalyst in the methanizer is protected via backflush and methanizer bypass.

## Trace Permanent Gas Analyzer

Trace amounts of hydrogen, oxygen, nitrogen, carbon monoxide, methane, and carbon dioxide, in ultra high purity ethylene and ultra high purity propylene, can be analyzed via Pulsed Discharge Helium Ionization Detection (PDHID). Since the PDHID is a universal trace detector, it can detect all of these components in parts-per-billion concentrations. This design can be combined with a light hydrocarbon channel to obtain a complete suite of trace analyses in ultra high purity ethylene or ultra high purity propylene from a single injection in a single run. The PDHID also does not suffer from the same contamination problems as the nickel oxide catalyst in the methanizer tube.

## Trace Oxygenates

Custom Solutions Group provides a variety of solutions for the analysis of trace oxygenates in petrochemicals. Given its high selectivity for oxygenates, the LowOx column is at the heart of these systems. Large injection volumes, special techniques for carrier gas filtering, silco coating, and capillary pressure point backflushing are all used to maximize response and minimize baseline noise, run times, and machine maintenance. Gases, LPG's, and liquids can all be injected and analyzed.

Custom Solutions Group's trace oxygenate analyzers meet or exceed the requirements of ASTM D7423.

## Conclusion

Custom Solutions Group offers the widest variety of high quality-solutions in petrochemical gas chromatography. Custom Solutions Group analyzers feature simplicity, serviceability, functionality and the highest quality construction, Made-in-the-U.S.A.

## Reporting

Petrochemical analyses often use multiple channels for a complete suite of results from a single injection in a single run. Therefore, multi-channel normalization of results is often required. Different softwares handle the multi-channel reporting different ways. Our preference is for Diablo Analytical's EZReporter Standard Edition Software. EZReporter, which works in conjunction with a variety of chromatography data systems, provides an easy and automated means to normalize up to four channels of data into a single report. For petrochemical process gases where the energy content is of importance, EZReporter NatGas Edition provides individual and total results per physical constants from GPA 2145, TP-17, the GPSA Engineering Databook, ISO 6976, ASTM D3588, and ASTM DS 4B. Peak tables are user configurable, extended reporting can be used or not used, results can be bridged across multiple detectors, and calculations can be made for mole percent, weight percent, and liquid volume percent. Results can be exported to text files, and PDF reports can be automatically generated. Formulas to make additional calculations are user-configurable. Results from moisture analyzers, total sulfur analyzers, and Drager tubes can be included in the results table. Report formats are easily customized.

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