Shimadzu began building Gas Chromatography products in 1955 and remains committed to building the best GC products in the world. Throughout our long history, the customer’s needs have always been central to all our design, manufacturing, and testing processes.

As part of this continuing commitment, we developed the System GC program, which provides our customers with the best applicated and fully configured GC products available anywhere. Configured and tested in Shimadzu’s System Integration Technology Lab, each system is shipped with proof of performance, QA/QC and a field test standard.

We fully recognize the need for after-sales support, and our state-of-the-art training facility houses 6 labs and classrooms to accommodate up to 6 classes simultaneously. Course development is based on both theoretical and practical applications, and highly qualified instructors provide hands-on training to customers in the operation and maintenance of their Shimadzu instruments.

Upholding the Shimadzu tradition, the System GC group is uncompromising in the quest for excellence and in optimizing separations and making the products easy to use. Expect performance, quality and value with the System GC program!

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Shimadzu has been building GC systems for ASTM-3612 for 25+ years. We pioneered the ASTM “Method B” Oil Stripper system which eliminates the use of Mercury or vacuum extraction. In the last few years we have expanded into building Method C systems as well.

- TOGAS by ASTM-D3612 Method A 30
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Greenhouse Gas Analysis
Shimadzu has been building GC-based systems to analyze for Greenhouse gases for 20+ years. We originally used the GC-mini platform and evolved from there to the GC-14, then GC-17, and now to the GC-2014. In this time we have become the market leader and the instrument of choice for university and government researchers around the US and the world.

- Greenhouse and Atmospheric Gas Analyzer 36
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Shimadzu builds a variety of analyzers to meet the needs of Biofuel production plants and research facilities. Here, we present systems for QC analysis of Bioethanol and Biodiesel by ASTM standards.

- BioEthanol System 43
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Biomass Feedstock Research / Alternative Energy Research
The emergence of the Biomass research field has created a need for analytical tools to analyze reaction and fermentation products. Shimadzu has risen to the task by offering a custom GC program to meet these needs. Described is an example of a system we have designed to meet a specific application need.

- Fuel Cell Gas Analyzer 46

Custom GC Applications
- Configuration Form 47
Valco is the industry standard when it comes to GC valves, and we use their valves in all of our applicated GC systems.

**Rotor Material**

**P Type:** Our standard rotor, this composite consists of PTFE and carbon. Standard specs are 400 psi at 175°C. Routinely used at 1000 psi, 75°C, it can also be used at temperatures approaching 200°C with decreased sealing tension.

**T Type:** This polyimide/PTFE/carbon composite has been used successfully for many years and still cannot be surpassed when applications demand operating temperatures in the 250°C – 350°C range. (Standard specs for most series are 300 psi at 330°C.) However, at temperatures below 150°C, there is a tendency for the seal material to stick to the valve body, making the valve difficult to turn and causing the rotor to crack in extreme cases. Literature provided at the time of purchase contains instructions for reconditioning the material if this condition should arise.

The T material is susceptible to attack from steam, ammonia, hydrazines (anhydrous liquids or vapor), primary and secondary amines, and solutions having a pH of 10 or more. Chemical reagents which act as powerful oxidizing agents (nitric acid, nitrogen tetroxide, etc.) must also be avoided. Valcon T can be used in "hot" GPC/SEC applications with O-dichlorobenzene as a solvent.
**Valve Material**

**Nitronic 50:** Our standard valve material exhibits good resistance to chlorides, sulfuric acid, and sea water. Resistant to sulfur gases such as hydrogen sulfide and sulfur dioxide.

**Hastalloy C:** This is the material most often recommended for corrosion resistance – it works when nothing else will. This versatile nickel-chromium molybdenum alloy has excellent resistance to most acids, including strong oxidizers such as ferric and cupric chlorides; nitric, formic and acetic acids; wet chlorine; sea water and brine solutions; and mixtures containing nitric acid or oxidizing acids with chloride ions. VICI uses only HC-22 for fittings and valve stators, rather than the older and less corrosion resistant HC-276.

**Actuators**

The microelectric valve actuator provides Valco dependability in a unit which is less than half the size of our standard model. The actuator consists of a control module, a stepper motor/gearbox assembly, a manual remote control, interconnecting cables, and a 110/230 VAC to 24 VDC power supply.

The two-position microelectric actuator features exclusive stall-sensing circuitry, which eliminates problems associated with valve/actuator misalignment. Power to the actuator motor is switched off when the driver pin goes against the stop of the valve cutout - no sooner, no later - and it's all done without any mechanical microswitches.

**Heated Valve Enclosure**

- Up to 4 Valco valves can be installed
- 200°C temperature
- Works with both the GC-2010 plus and 2014
- Half Size Box for two valves is available
Our valve bundles include all of the necessary bushings, ferrules and tubing for configuration, and each bundle is plumbed for a specific application. (Sample loops are not included.)

There are 4 part numbers for each bundle that specify the rotor and valve body materials
- -01 = Nitronic 50 and P type
- -02 = Nitronic 50 and T type
- -03 = Hastalloy C and P type
- -04 = Hastalloy C and T type

Valve Bundles

10-port loop injection and backflush of pre-column to vent
- 220-94712-01 to 04

6-port loop injection
- 220-94710-01 to 04

4-port column switching
- 220-94711-01 to 04

6-port column switching/trapping
- 220-94711-01 to 04
Inert Treatment for Analytical Flow Path

Stainless steel can act as a catalyst for sulfur compounds, breaking them down into other molecules or bonding with them, causing a loss of sensitivity. For applications involving sulfur it is recommended that every stainless steel surface that comes into contact with the sample be rendered inert. This is generally accomplished by treating the stainless steel with a special coating.

To address this issue Shimadzu uses the Sulfinert® surface treatment process. Sulfinert treatment eliminates interaction between organo-sulfur compounds and steel.

Refineries and petrochemical plants use Sulfinert-treated components for sampling and for transferring sample streams. Natural gas and liquid propane gas manufacturers and transfer companies rely on Sulfinert-treated systems to accurately quantify sulfur-containing odorants in natural and liquid propane gas streams. Sulfinert-treated sampling equipment is specified in International Society of Beverage Technologists methods for determining sulfur impurities in beverage-grade carbon dioxide.

Include 220-90817-00 as a line item when sulfur treatment of the analytical flow path is desired.

Installation and Start-Up Supplies

- He Regulator, 2 stage with 1/8th swagelok fitting - 220-90001-03
- N2 Regulator, 2 stage with 1/8th swagelok fitting - 220-90001-04
- Air Regulator, 2 stage with 1/8th swagelok fitting - 220-90001-05
- H2 Regulator, 2 stage with 1/8th swagelok fitting - 220-90001-02
- 1/8th inch Copper tubing, cleaned 50 foot roll - 220-90212-00
- Helium oxygen h-carbon and water trap - 220-90623-01
- Argon, 2 stage with 1/8th swagelok fitting - 220-90001-07

Additional Small Parts for Custom GC Applications

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<th>Misc. Items</th>
<th>Part Number</th>
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<tr>
<td>Needle Valve 1/8th inch</td>
<td>220-94669-02</td>
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<tr>
<td>Treated needle valve 1/16th inch</td>
<td>220-94663-14</td>
</tr>
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<td>Column adapters</td>
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<td>SS Col adapters injection port GC 2014</td>
<td>220-94663-09</td>
</tr>
<tr>
<td>SS Col adapters detector GC-2014</td>
<td>220-94663-10</td>
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<tr>
<td>Tubing, sulfur treated 50’ 1/8</td>
<td>220-94663-11</td>
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<tr>
<td>Tubing sulfur treated 100’ 1/16</td>
<td>220-94663-12</td>
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<th>Unions</th>
<th>Part Number</th>
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<td>1/8 to 1/8 sulfur treated</td>
<td>220-94663-05</td>
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<td>2mm to 1/8</td>
<td>220-90014-01</td>
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<tr>
<td>2mm to 1/8 sulfur treated</td>
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<td>bulkhead 1/8 to 1/8</td>
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<tr>
<td>bulkhead 1/8 to 1/8</td>
<td>220-94663-08</td>
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This GC-2014 based Gas Chromatographic system is constructed according to The Gas Processors Association method 2261. The sample is introduced by filling a sample loop and injection occurs when the valve actuates. C6+ components are grouped into a single peak using a pre-cut column which is backflushed to elute the hexanes and heavier as the first peak. Nitrogen/air, methane, carbon dioxide, and ethane through n-pentane elute on a forward flow of carrier gas through the partition column. H2S is not determined. The chromatography software outputs a mole% report. A post-run program calculates BTU per cubic foot, BTU per pound and gasoline content as per the GPA 2172 method. Run time is approximately 17 minutes. Package includes GCsolution chromatography software, Excel and BTU macro. Data station sold separately.

- Method: GPA 2261
- Part Number: 220-90851-24
- Hardware: GC-2014 TCD, 10 port 1/16 inch Valco valve with micro-electric actuation

**Compounds**
Air/Nitrogen, Methane, CO2, Ethane, Propane, I-Butane, N-Butane, Neo-Pentane, I-Pentane, N-Pentane and Hexanes+ by backflush

**Detection Limits**
The lowest level of quantification for the permanent gases by TCD with Helium carrier is 50ppm (O2, N2, CO and CO2). The hydrocarbons by TCD with Helium carrier will be 50ppm.

**Features**
- Single TCD Chromatogram
- Rugged, well-known packed column methodology
- 17-minute run time
Standard and Consumables

- System Verification Standard: 220-90949-00
  - Contains a Certified Natural Gas Standard

- Suggested Consumables
  - Column Adapters for 1/8th inch stainless columns: 220-90140-05

- Column Set: 220-94795-00
Natural Gas and Permanent Gas Analysis

This GC-2014 based Gas Chromatographic system is constructed according to The Gas Processors Association method 2261, with the addition of a second analytical line. The sample is introduced by filling two sample loops simultaneously. The valves are actuated at the same time to begin the analysis. C6+ components are grouped into a single peak using a pre-cut column which are backflushed to elute the hexanes and heavier as the first peak. Nitrogen/air, methane, carbon dioxide, and ethane through n-pentane elute on a forward flow of carrier gas through the partition column. The permanent gases are determined on the second channel by molecular sieve and porous polymer separation. The chromatography software outputs a mole% report. A post-run program calculates BTU per cubic foot, BTU per pound and gasoline content as per the GPA method. Run time is approximately 20 minutes. Package includes GCsolution chromatography software, Excel and BTU macro. Data station sold separately.

- Methods: GPA 2261, ASTM-D1945, ASTM-D1946 (Argon Carrier Gas)
- Part Number: 220-90852-24
- Hardware: GC-2014 TCD, 2 ten port valco 1/16th inch micro-electric valves

Compounds
Oxygen, Nitrogen, CO, Methane, CO2, Ethane, Propane, I-Butane, N-Butane, Neo-Pentane, I-Pentane, N-Pentane and Hexanes+ by backflush

Detection Limits
The lowest level of quantification for the permanent gases by TCD with Helium carrier is 50ppm (O2, N2, CO and CO2). The hydrocarbons by TCD with Helium carrier will be 50ppm.

Features
- Dual-cell TCD produces a single Chromatogram
- Both sides of the TCD utilized for the analysis
- Rugged packed column method
Standard and Consumables

- System Verification Standard: 220-90949-00

- Suggested Consumables
  - Column Adapters for 1/8th inch stainless columns: 220-90140-05

- Column Set
  - 220-94795-00 Natural Gas Columns
  - 220-94714-20 Molecular Sieve 5A
  - 220-94716-10 Hayesep N 1M

Zoomed-in section highlighting the fixed gas separation
Extended Natural Gas Analysis by GPA 2286

This GC-2010 based Gas Chromatographic system provides a detailed compositional analysis to determine the energy content in a natural gas sample. The 2-valve Natural Gas Extended Analysis System traps O2, N2, CH4, CO onto a molecular sieve column and allows for the separation of CO2, H2S, and C2 on a porous polymer column for detection by a TCD-2010. The 10-port sampling valve is set back to the load position which allows the other hydrocarbons to be loaded on a SPL-2010 injector in the split mode. The hydrocarbons are separated by a PONA capillary column for detection by a FID-2010. Analysis time varies depending on the particular specifications set by the operator. In most cases, He and H2 are either not present or present in such small quantities that these need not be determined. Software outputs results in mol%. The post-run macro calculates BTU per cubic foot, BTU per pound, compressibility, gasoline content by GPA 2172 and 2145. Includes GCsolution software, Excel and BTU post-run reporting macro. Data station sold separately.

- Methods: GPA 2286, ASTM-1945
- Part Number: 220-90854-20
- Hardware: GC-2010 TCD/FID, 1 ten port and 1 six port Valco 1/16th micro-electric actuated valves

Compounds
O2, N2, CH4, CO, CO2, H2S, C2, C3, i-C4, N-C4, i-C5, N-C5, C6-C10

Minimum Level of Quantification for TCD Compounds
50ppm except H2S, 500ppm; FID compounds, 10ppm

Features
- Two channels: one TCD and one FID
- PONA column separation of C3 and higher components
TCD Chromatogram

Plumbing Diagram for the Natural Gas and Permanent Gas System

- **System Verification Standard:** 220-90949-00
- **Suggested Consumables**
  - Glass Inserts: 221-14094-00
  - Column Adapters for 1/8th inch stainless columns: 220-90140-05
- **Column Set**
  - 220-94505-01 PONA Column
  - 220-94716-10 Hayesep N 1M
  - 220-94715-20 Hayesep Q 2M
  - 220-94714-25 Molsieve 2.5M
**LP Gas Analysis by GPA 2177**

This GC-2014 based Gas Chromatographic system is constructed according to The Gas Processors Association method 2177. C7+ components are grouped into a single peak using a pre-column which is backflushed to elute the heptanes and heavier as the first peak. Nitrogen/air, methane, carbon dioxide and ethane through n-pentane elute on forward flow of carrier gas through the partition column. TCD is used to detect all components. The chromatography software calculates and outputs the mole % report. A post-run program calculates specific gravity, BTU per cubic foot, BTU per pound and gasoline content. The resulting data is output into a printed report. In most cases, He and H2 are either not present or present in such small quantities that these need not be determined. H2S is not determined. The package includes GCsolution software, Excel and the BTU program. Data station sold separately.

- **Method:** GPA 2177
- **Part Number:** 220-90861-24
- **Hardware:** GC-2014 TCD, 1 six port liquid injection valve, one 1/16th inch 10 port micro-electric valve

**Compounds**

N2, CH4, CO2, C2, C3, i-C4, N-C4, i-C5, N-C5, C6, C7+

**Detection Limits**

The lowest level of quantification for the permanent gases by TCD with Helium carrier is 50ppm (O2, N2, CO and CO2), H2S is 500ppm. The hydrocarbons by TCD with Helium carrier will be 50ppm.
Standard and Consumables

- Suggested Consumables
  - 40 Micron Filter: 220-90658-00
  - Filter Housing: 220-90657-00

- Column Set
  - 220-94800-00
This GC-2010 based Gas Chromatographic system provides a detailed compositional analysis to determine the energy content in a natural gas sample. The 2-valve Natural Gas Extended Analysis System traps O2, N2, CH4, CO onto a molecular sieve column and allows for the separation of CO2, H2S, and C2 on a porous polymer column for detection to a TCD-2010. The 10-port sampling valve is set back to the load position which allows the other hydrocarbons to be loaded on a SPL-2010 injector in the split mode. The hydrocarbons are separated by a PONA capillary column for detection by a FID-2010. Analysis time varies depending on the particular specifications set by the operator. In most cases, He and H2 are either not present or present in such small quantities that these need not be determined. Software outputs results in mol%. The post-run macro calculates BTU per cubic foot, BTU per pound, compressibility, gasoline content by GPA 2172 and 2145. Includes GCsolution software, Excel and BTU post-run reporting macro. Data station sold separately.

- Method: GPA 2186
- Part Number: 220-94825-24
- Hardware: GC-2010 TCD/FID, 3 1/16th inch micro-electric actuated valves

**Compounds**

O2, N2, CH4, CO, CO2, H2S, C2, C3, i-C4, N-C4, I-C5, N-C5, C6-C10

**Detection Limits**

The lowest level of quantification for the permanent gases by TCD with Helium carrier is 50ppm (O2, N2, CO and CO2), H2S is 500ppm. The hydrocarbons by TCD with Helium carrier will be 50ppm. Hydrocarbons by FID will result in a LOQ of 10ppm.
Standard and Consumables

- Suggested Consumables
  - 40 Micron Filter: 220-90658-00
  - Filter Housing: 220-90657-00

- Column Set
  - 220-94795-00
  - 220-94505-01
  - 220-90604-05

A peek inside the oven of a GC-2014
Combined LP Gas and Natural Gas System

This GC-2014 based system is constructed according to The Gas Processors Association methods. Both Natural Gas and LP gas may be analyzed by this dual-channel instrument. The LP gas C7+ components are grouped into a single peak using a pre-cut column, and are backflushed to elute the heptanes and heavier as the first peak. Nitrogen/air, methane, carbon dioxide and ethane through n-pentane elute on forward flow of carrier gas through the partition column. TCD is used to detect all components. Natural gas is analyzed in a similar fashion but with a C6+ backflush. The chromatography software calculates and outputs the mole % report. A post-run program calculates specific gravity, BTU per cubic foot, BTU per pound and gasoline content. The resulting data is output into a printed report. Analysis time is approximately 18 minutes. He, H2 and H2S are not determined. The package includes GCSolution software, Excel and the BTU macro. Data station sold separately.

- Methods: GPA 2261, GPA 2177
- Part Number: 220-94802-24
- Hardware: GC-2014 TCD, two 1/16th inch valves with micro-electric actuation

Compounds
N2, CH4, CO2, C2, C3, i-C4, N-C4, i-C5, N-C5, C6, C7+

Detection Limits
The lowest level of quantification for the permanent gases by TCD with Helium carrier is 50ppm (O2, N2, CO and CO2). The hydrocarbons by TCD with Helium carrier will be 50ppm.
Standard and Consumables

- System Verification Standard: 220-90949-00 (Natural Gas Std.)

- Suggested Consumables
  - Septa: 220-94781-00
  - 40 Micron Filter: 220-90658-00
  - Filter Housing: 220-90657-00

- Column Set
  - 220-94800-00 LP Gas
  - 220-94795-00 Natural Gas
Fast Refinery Gas Analysis

This GC-2014 based analyzer determines the composition of a gas sample obtained from the refinery process. This system utilizes four parallel analytical lines by making four simultaneous injections with independent separations and detection. Methane through C4 hydrocarbons and C5 paraffins are reported individually, while C5 olefins and C6+ are reported as a composite. H2S, if present, is determined by TCD to 500ppm. Argon, if present, is not separated from Oxygen. Approximate analysis time is 6 minutes. A mol% report is output by the chromatography software. The BTU per pound, BTU per cubic foot, weight%, specific gravity and compressibility will be determined using Excel (220-94668-00) and the BTU macro (220-94609-00). Includes GCsolution software. Data station sold separately.

- Methods: UOP 539, ASTM-D1945, ASTM-D1946, ASTM-D3588 reporting
- Part Number: 220-94803-24
- Hardware: GC-2014 2X TCD/FID, 4 valves: all 1/16th inch micro-electric
<table>
<thead>
<tr>
<th>Name of Compound</th>
<th>Concentration Range</th>
<th>Detector</th>
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<tr>
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<td>High Conc.</td>
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<tr>
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<td>Oxygen</td>
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<td>Nitrogen (N2)</td>
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<td>Acetylene (C2H2)</td>
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<td>C6 plus</td>
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**Standard and Consumables**

- System Verification Standard: 220-90299-00
- Suggested Consumables
  - Septa: 220-94781-00
  - Syringe: Gas-tight syringe sold separately
  - Glass Inserts: 221-14094-00
  - Column Adapters for 1/8th inch stainless columns: 220-90140-05
- Columns
  - 220-90616-06, RT Q Plot 0.53 X 30M
  - 220-90616-04, MS 5A 0.53 X 30M, Two for each system
  - 220-94805-00, RT Q Plot 0.53 X 10M
  - 220-90616-08, Alumina Plot 0.53 X 30M
  - 220-94716-60, Hayesep N 1M X 1/16th
  - 220-94806-10, 10% OV-1 Chromsorb W 1M
Simulated Distillation by Gas Chromatography

This GC-2010 based system is designed with the appropriate hardware and software to perform the following simulated distillation ASTM methods: ASTM-D2887, ASTM-D3710, ASTM-D5307, and ASTM-D6352. The package includes an enhanced data station, column, C6 to C44 alkane standard, GCsolution software and SimDist GC software. Cryogenic cooling (221-49588-92) may be required for light hydrocarbon gasoline range fractionation by D2887 and is sold separately. Autosampler sold separately.

- Methods: ASTM-D2887, ASTM-D3710, ASTM-D5307 and ASTM-D6352
- Part Number: 220-90863-20
- Hardware: GC-2014 TCD, two 1/16th inch valves with micro-electric actuation

Package Includes
GC-2010 OCI/PTV, GCsolution software, Distillation Software, SimDist Capillary Column and Alkane standard C7 to C44 appropriate for D2887, D3710, and D5307.
- For D5307 it is necessary to purchase the internal standard mix and column resolution test mix separately.
- For D6352 it is necessary to purchase the C90 calibration standard separately.

Features
- SimDist software fully integrated into GCsolution
- Simple automated operation
- Distillation reports and curve data can be easily exported as ascii data to Excel
- Results correlated to D86 or D1160
- Distillation Data Results can be reported to 1% increments
Standard and Consumables

- System Standards
  - Alkane standard (C6 to C44): 220-90607-02

- Suggested Consumables
  - Septa: 220-94781-00
  - Syringe, with replaceable 0.47 mm needle: 220-90282-21
  - Replacement needle: 220-90282-22 (2 pk)
  - OCI metal needle guide/insert: 221-49298-91
  - FID Jet: 221-48258-91
  - Ferrules: 221-32126-08 0.8mm for 0.53mm ID columns (10pk)

- Column
  - 220-90604-03
The PONA Analyzer is a GC-2010 based, single-column application for the separation and identification of five main compound classes in spark ignition fuel samples: paraffins, olefins, naphthalenes, aromatics, and oxygenates. Special PONA software is used to group each of these classes and report amount content. This system comes with the appropriate hardware and software to perform the application. Satisfies ASTM-D6729. Includes enhanced data station, GCsolution software.

- Method: ASTM-D6729
- Part Number: 220-90864-20
- Hardware: GC-2010 Split/Splitless Inlet, Flame Ionization Detector, PONA capillary column, GCsolution Chromatography Software, PONA Solutions Software Package, Excel, PONA standard
- Sample Type: Liquid Spark Ignition Fuels, Light Hydrocarbon Liquid Blends and Mixtures

Features:
- PONA software fully integrated into GCsolution
- Advanced Flow Control with Constant Linear Velocity of carrier gas provides exceptionally stable retention times, minimizing adjustments to the peak table.
- Reports % components including oxygenates and will calculate a distillation curve and distillation table
Standard and Consumables
- System Verification Standard
  - 220-90607-01 Piano Standard
  - 220-90607-05 Gasoline Standard
- Suggested Consumables
  - Septa: 220-94781-00
  - Syringe: AOC-20i 10ul fixed needle: 221-34618-00
  - Glass Inserts: 220-90784-00
  - Ferrules: 221-32126-05, 10 pk, 0.5 mm for 0.25mm ID columns
- Column
  - 220-90604-02 RTX-Pona 100m X 0.25mm X 0.5uf
Oxygenates In Gasoline

This GC-2010 or GC-2014 based system is dedicated to determining oxygenates in gasoline according to ASTM Method D 4815. Individual ethers are determined from 0.1 to 20.0 as %. Individual alcohols are determined from 0.1 to 12.0 mass %. Analysis time is approximately 15 minutes. Data station and autosampler sold separately.

- Method: ASTM-D4815
- Part Number: 220-90462-20 GC-2010 System
- Part Number: 220-90462-24 GC-2014 System
- Hardware: GC-2010 or GC-2014 Split/Splitless inlet, capillary FID, 8 port 1/16th inch backflush valve, two analytical columns

Features
- Rugged configuration
- Economical

Detection Limits
Meets method requirements
Standard and Consumables

- Test Standard: 220-94833-00
- Suggested Consumables
  - Septa: 220-94781-00
  - Syringe: AOC-20i 10ul fixed needle: 221-34618-00
  - Glass Inserts: 220-90784-00
  - Ferrules: 221-32126-05, 10 pk, 0.5 mm for 0.25mm ID columns
- Column
  - 220-90467-00 TCEP
  - 220-90467-01 RTX-1 0.53 X 30M X 3uf
Benzene and Toluene in Gasoline

This GC-2014 based analyzer is dedicated to the separation and quantification of benzene and toluene in finished gasoline. Benzene can be determined between the levels of 0.1 and 5 volume % and toluene can be determined between the levels of 2 and 20 volume %. Ethanol co-elution is managed by using a special proprietary column set. Analysis time is approximately 10 minutes. GCsolution and data station sold separately.

- Method: ASTM-D3606, D5580
- Part Number: 220-90870-24
- Hardware: GC-2014 Split/Splitless Inlet, FID

Detection Limits
Meets method requirements

Chromatogram
Standard and Consumables

- System Verification Standard: 220-94834-00

- Suggested Consumables
  - Septa: 220-94781-00
  - Syringe: AOC-20i 10ul fixed needle: 221-34618-00
  - Glass Inserts: 221-14093-00

- Column Set
  - 220-94755-00
This GC-2014 based analyzer is constructed to meet or exceed the method requirements of ASTM-D3612 Dissolved Gases in Transformer Oil. This elegant yet simple design improves upon the classic TOGA system in three areas: Hydrogen and CO detection limits are increased 10X by using a PDHID, separation of C3 and C4 gases is performed within 18 minutes and a custom report is automatically generated at the end of each analysis. This analyzer uses two valves, three detectors and four columns. This method requires a vacuum extraction of the gases from each oil sample prior to analysis, as per Method A of the ASTM standard. The glassware and vacuum apparatus for this procedure are not included. CLASS-VP is required for automatic custom report. Software and data station sold separately.

- Method: ASTM-D3612 Method A
- Part Number: 220-94736-00
- Hardware: GC-2014 FID/TCD/PDHID, two 4 port valves, methanizer and 4 columns

Detection Limits
Meets method requirements
The GC-2014 based Transformer Oil Gas Analysis System is our third-generation system built specifically to run ASTM-D3612 section B. The GC-2014A TOGAS gives accurate measurement of dissolved gases which include H2, O2, N2, CH4, CO, CO2, C2H6, C2H4, and C2H2 in mineral spirit-based transformer oil via direct injection and oil stripper extraction. Meets ASTM-D3612-98 section B requirements. Features a GC-2014A with FID and TCD detectors, valves, columns, methanizer, and oil stripper. System operation is completely automated. Analysis time is approximately 25 minutes. Must include a data processor or data station.

- Method: ASTM-D3612 Method B
- Part Number: 220-90249-24
- Hardware: GC-2014 FID/TCD, one 10 port valve and one 4 port valve, methanizer.

**Detection Limits**
Meets method requirements

**Standard and Consumables**
- System Verification Standard:
  - 220-90946-00: Low Standard
  - 220-90945-00: High Standard
- Suggested Consumables
  - Septa: 220-94781-00
  - Glass Inserts: 221-14093-00
- Column Set
  - 220-90845-00
This GC-2014 based analyzer is constructed to meet or exceed the method requirements of ASTM-D3612 Dissolved Gases in Transformer Oil. This elegant yet simple design improves upon the classic TOGA system in three areas: Hydrogen and CO detection limits are increased 10X by using a PDHID, separation of C3 and C4 gases is performed within 18 minutes and a custom report is automatically generated at the end of each analysis. This analyzer uses two valves, three detectors and five columns. This system deviates from the ASTM standard by using helium carrier gas and purge gas instead of Argon. CLASS-VP is required for generating the automatic custom report. HT-3, software and data station sold separately.

- Method: ASTM-D3612 Method C
- Part Number: 220-94736-00
- Hardware: GC-2014 FID/TCD/PDHID, two 4 port valves, methanizer and 4 columns
- Tekmar HT-3 Static Headspace Autosampler: 220-94677-51

Detection Limits
Meets method requirements except for Hydrogen and CO which exceed the requirement

The System:
- GC with TCD, FID and PDHID
- Tekmar HT-3 Static Headspace Sampler
- Two Valco 1/8th inch 4 port electrically actuated valves
- 5 packed columns
- Data station and software

Carrier 1: Helium 300kPa
Carrier 2: Helium 301kPa
Carrier 3: Helium 310kPa

Column 1 = 2m X 1/8 Hayesep Q 80/100
Column 2 = 2.5m X 1/8 MS 5A 60/80
Column 3 = 2.5M Hayesep T 80/100
Column 4 = 2M restrictor
Column 5 = 2M restrictor
• Gas Standards were prepared using the procedure outlined above
• Three concentrations were made:
  • 50ppm
  • 500ppm
  • 5000ppm
• Five vials of each concentration were loaded on the HT-3 and analyzed; results are shown in the table below

<table>
<thead>
<tr>
<th>N=5</th>
<th>H2</th>
<th>O2</th>
<th>N2</th>
<th>CH4</th>
<th>CO</th>
<th>CO2</th>
<th>C2H4</th>
<th>C2H6</th>
<th>C2H2</th>
<th>C3H8</th>
<th>C3H6</th>
<th>C4H10</th>
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</thead>
<tbody>
<tr>
<td>50ppm Mean</td>
<td>53</td>
<td>N/D</td>
<td>1267</td>
<td>49</td>
<td>77</td>
<td>54</td>
<td>51</td>
<td>51</td>
<td>48</td>
<td>50</td>
<td>51</td>
<td>50</td>
</tr>
<tr>
<td>STDEV</td>
<td>0.84</td>
<td>N/D</td>
<td>549.82</td>
<td>0.30</td>
<td>8.15</td>
<td>0.84</td>
<td>0.24</td>
<td>0.22</td>
<td>0.44</td>
<td>0.26</td>
<td>0.24</td>
<td>0.36</td>
</tr>
<tr>
<td>%RSD</td>
<td>1.60</td>
<td>N/D</td>
<td>43.38</td>
<td>0.62</td>
<td>10.6</td>
<td>1.55</td>
<td>0.47</td>
<td>0.43</td>
<td>0.92</td>
<td>0.52</td>
<td>0.47</td>
<td>0.72</td>
</tr>
<tr>
<td>500ppm Mean</td>
<td>697</td>
<td>842</td>
<td>5959</td>
<td>560</td>
<td>708</td>
<td>997</td>
<td>492</td>
<td>494</td>
<td>472</td>
<td>497</td>
<td>541</td>
<td>504</td>
</tr>
<tr>
<td>STDEV</td>
<td>4.71</td>
<td>240.95</td>
<td>208.18</td>
<td>2.58</td>
<td>4.41</td>
<td>5.99</td>
<td>2.75</td>
<td>2.85</td>
<td>7.45</td>
<td>3.23</td>
<td>3.29</td>
<td>2.87</td>
</tr>
<tr>
<td>%RSD</td>
<td>0.68</td>
<td>28.62</td>
<td>3.49</td>
<td>0.46</td>
<td>0.62</td>
<td>0.60</td>
<td>0.58</td>
<td>1.58</td>
<td>0.65</td>
<td>0.61</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>5000ppm Mean</td>
<td>4376</td>
<td>9654</td>
<td>50525</td>
<td>4014</td>
<td>4435</td>
<td>5068</td>
<td>5112</td>
<td>5139</td>
<td>5111</td>
<td>5099</td>
<td>5124</td>
<td>5020</td>
</tr>
<tr>
<td>STDEV</td>
<td>34.8</td>
<td>151.39</td>
<td>214.31</td>
<td>48.85</td>
<td>34.40</td>
<td>23.76</td>
<td>24.52</td>
<td>25.11</td>
<td>66.16</td>
<td>31.21</td>
<td>23.74</td>
<td></td>
</tr>
<tr>
<td>%RSD</td>
<td>0.80</td>
<td>1.57</td>
<td>0.42</td>
<td>1.22</td>
<td>0.77</td>
<td>0.47</td>
<td>0.48</td>
<td>0.49</td>
<td>1.29</td>
<td>0.42</td>
<td>0.61</td>
<td>0.47</td>
</tr>
</tbody>
</table>
Oil Sample Chromatograms

- A single lab analyzed the oil from a single transformer
- 16 syringes each in duplicate for 32 total analyses
- Acetylene was determined to not be present in this oil sample
An automated report is generated at the end of each analysis.

This report corrects for actual temperature, pressure, sample amount and the solubility coefficient of each analyte.

---

**Toga Analysis Report**

**SAMPLE ID:** True North 100 A inj 002  
**Analysis Date and Time:** 3/7/11 8:23:35 PM  
**File Name:** True North Multiple Run 025.dta

- **Vo (Volume of Headspace):** 7.8
- **Vo Of Ol (Vo):** 14
- **Pim Temp (P):** 255.63
- **Ideal Temp:** 273
- **Ideal Press:** 780

### DFID

<table>
<thead>
<tr>
<th>Peak Name</th>
<th>Area</th>
<th>Raw Conc</th>
<th>K</th>
<th>Corrected Conc.</th>
<th>Final Result STP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>1078121</td>
<td>0.77</td>
<td>1.00</td>
<td>105.36</td>
<td>5.56</td>
</tr>
<tr>
<td>Methane</td>
<td>8902112</td>
<td>64.52</td>
<td>1.00</td>
<td>100.47</td>
<td>3.80</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>5269223</td>
<td>90.90</td>
<td>1.00</td>
<td>141.54</td>
<td>5.97</td>
</tr>
</tbody>
</table>

### TCD-L

<table>
<thead>
<tr>
<th>Peak Name</th>
<th>Area</th>
<th>Raw Conc</th>
<th>K</th>
<th>Corrected Conc.</th>
<th>Final Result STP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>294561</td>
<td>71.90</td>
<td>1.00</td>
<td>111.96</td>
<td>4.01</td>
</tr>
<tr>
<td>Ethylene</td>
<td>274493</td>
<td>38.42</td>
<td>1.00</td>
<td>01.39</td>
<td>2.20</td>
</tr>
<tr>
<td>Ethane</td>
<td>220042</td>
<td>32.11</td>
<td>1.00</td>
<td>60.00</td>
<td>1.70</td>
</tr>
<tr>
<td>Acetylene</td>
<td>283267</td>
<td>47.34</td>
<td>1.00</td>
<td>73.72</td>
<td>2.64</td>
</tr>
<tr>
<td>Propane</td>
<td>171587</td>
<td>16.65</td>
<td>1.00</td>
<td>25.92</td>
<td>0.93</td>
</tr>
<tr>
<td>Propylene</td>
<td>0</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Isobutane</td>
<td>0</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### PDHD

<table>
<thead>
<tr>
<th>Peak Name</th>
<th>Area</th>
<th>Raw Conc</th>
<th>K</th>
<th>Corrected Conc.</th>
<th>Final Result STP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>24225</td>
<td>14580.04</td>
<td>1.00</td>
<td>23103.23</td>
<td>826.06</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>68670</td>
<td>54093.80</td>
<td>1.00</td>
<td>86627.96</td>
<td>3064.92</td>
</tr>
</tbody>
</table>

**Reviewed:**

---

**Standard and Consumables**

- **System Verification Standard:** 220-90948-02 Low Standard, in Helium  
  220-90947-00 High, in Helium

- **Suggested Consumables**
  - Septa: 220-94781-00
  - Glass Inserts: 221-14093-00

- **Column Set**
  - HayesepQ: 220-94715-20
  - MS 5A: 220-94714-25
  - HayesepT: 220-94717-25
Greenhouse and Atmospheric Gas Analyzer

This GC-2014 based system quantifies N2O, CO2 and CH4 in atmospheric air. This system will also separate and provide quantitative information for N2, O2 and CO. It contains two ten port, one six port and one four port valve. It uses an ECD, TCD, methanizer and FID to detect the list of gases. Detection levels range from 100ppb for N2O to mid % levels for atmospheric N2 and O2. Data station and software sold separately. GCsolution is the recommended chromatography software data package. The run time can be extended to include ethane, ethylene and acetylene in the analysis.

- Part Number: 220-94725-00
- Hardware: GC-2014 TCD/FID/ECD, methanizer, two 10 port valves, one 6 port and one 4 port valve

**Compounds**

N2O, CH4, CO2, O2, N2, CO

**Detection Limits**

N2O: 100ppb, CO2: 10ppm(FID), CH4: 0.1ppm

**Gas Calibration Standard**

220-94676-01, 600ppm CO2, 1ppm N2O, and 5ppm CH4

Greenhouse and Atmospheric Gas Analyzer Chromatograms; Left - FID Channel, Middle - ECD Channel, Right - TCD Channel
Greenhouse and Atmospheric Gas Plumbing Diagram
Greenhouse Gas Analyzer #2

This GC-2014 based analyzer quantitates three trace gases: CO2, CH4, N2O, in an air matrix. The system is equipped with 1 sample loop, three valves and 5 columns. The separation scheme backflushes water and other heavy components from the pre-column to protect the analytical flow path from contamination. N2O is heart cut to the ECD, not allowing atmospheric levels of oxygen from making contact and potentially degrading its source. Analysis time is approximately 6 minutes. Data station and chromatography software sold separately. An AOC-5000 static head space sampler may be added to this system for automation and higher throughput.

- Part Number: 220-90804-24
- Hardware: GC-2014 ECD/FID, methanizer, one 10 port valve, two 4 port valves

Compounds
N2O, CH4, CO2

Detection Limits
N2O: 100ppb, CO2: 10ppm (FID), CH4: 0.1ppm

Gas Calibration Standard
220-94676-01, 600ppm CO2, 1ppm N2O and 5ppm CH4

Nitrous Oxide System
GC-2014 based system for nitrous oxide, identical to the greenhouse gas analyzer #2 N2O analytical line.

- Part Number: 220-90886-24
- Hardware: GC-2014, methanizer, one 10 port valve, one 4 port valve

Greenhouse Gas Chromatograms; Left - FID Trace, Right - ECD Trace
Standard and Consumables

- System Verification Standard: 220-94676-01 (included with each system)
  - N2O 1000ppb
  - CO2 600ppm
  - CH4 5ppm

- Suggested Consumables
  - Septa: 220-94781-00

- Column Set
  - HayesepT : 220-94717-25
  - HayesepD: 220-94718-30
  - MS 5A: 220-94714-25
  - HayesepN 1/16th inch: 220-94716-60
Permanent Gas Analyzer

This GC-2014 based system will analyze for impurities in a variety of gas matrices. This system will analyze for O2, N2, CH4, CO, CO2, C2 isomers in gas matrices such as air, Chlorine or Isoprene. The concentration of the matrix gas is not determined. Components that elute later than C3, including the matrix gas, are backflushed out of the system. The range of concentrations determined is low ppm for the CO, hydrocarbons and CO2 up to low % levels. O2 and N2 can be detected and quantified from mid ppm to mid % levels. The system includes two valves, a 10 port and 6 port, TCD, FID and a catalytic methanizer for the reduction of CO2 into methane. Hydrogen determination requires a separate analytical line and can be added as a custom GC system. Software and data station sold separately.

- Part Number: 220-94724-01, GC-2014 TCD
- Part Number: 220-94724-02, GC-2014 TCD, Methanizer, FID
- Hardware: GC-2014, TCD (Methanizer, FID with -02 system) one 10 port valve and one 6 port valve, 5 packed columns

Compounds
O2, N2, CH4, CO, CO2, C2, C3, C4

Detection Limits
N2, O2: 10ppm, CH4, C2 gases: 1ppm, CO, CO2: 10ppm

Hayesep Q or N

Permanent Gas Chromatogram
- N2, O2, CO, CO2----TCD 10ppm to 60%
- CH4, C2....-----FID 1ppm to 60%
- CO, CO2---methanizer -FID

MSSA Peaks
Greenhouse Gas Plumbing Diagram
Chlorine Gas Impurities Analyzer

This GC-8AIT based analyzer will separate and quantify permanent gas impurities in Chlorine Gas. Chlorine concentration is not determined. Chlorine and components heavier than CO2 are backflushed out of the GC system. Analysis time is approximately 11 minutes. Data station and software sold separately.

- Method: ASTM D1746
- Part Number: 220-90465-00
- Hardware: GC-8AIT, 10 port valve, 4 port valve

Compounds
H2, O2, N2, CH4, CO, CO2

Chlorine Gas Chromatogram

Chlorine Gas Plumbing Diagram
BioEthanol System

This GC-2014 system package for Bioethanol analysis includes a GC-2014 Split injection port, capillary FID, Restek column and syringe autosampler with 12-position rack. Satisfies method requirements for ASTM-5501. Data Station and software sold separately.

- Part Number: 220-94732-01
- Hardware: GC-2014 FID, PONA column

![BioEthanol Chromatogram](image)

Standard & Consumables

- Suggested Consumables
  - Pona Column: 220-90604-02
  - Septa: 220-94781-00
  - Inserts: 220-90784-00
  - Syringe: 10ul fixed needle .63mm teflon-tipped plunger: 220-90624-00
  - O-Ring: 036-11203-84
  - RID JET: 221-48258-91

SPEX XP-3669 Ethanol Industry GC standard 4x15nl
96% Ethanol, 0.1% Methanol, 3.9% Heptane (all mass %)
BioDiesel by ASTM-D6584

This package includes the items necessary for the analysis of Free and Total Glycerine in B100 biodiesel as per ASTM-6584. This system consists of a GC-2010 equipped with an On-column injector (OCI-2010), Flame Ionization detector and capillary column. This package includes EZStart chromatography data software, the method file, one package of glyceride standards and custom reports which fulfill the ASTM requirements. Data station and autosampler sold separately.

- Part Number: 220-94683-01
### Standard and Consumables

- **System Verification Standard:** 220-94696-00
- **Suggested Consumables**
  - Septa: 220-94781-00
  - Syringe, 10ul, with replaceable 0.47 mm needle: 220-90282-21
  - Replacement needles: 220-90282-22 (2pk)
  - OCI metal needle guide/insert: 221-49298-91
  - FID Jet: 221-48258-91
  - Ferrules: 221-32126-08 0.8mm for 0.53mm ID columns (10pk)
- **Column**
  - 220-94709-00
Fuel Cell Gas Analyzer

This GC-2014 based system is designed for the analysis of gases produced from the catalytic production of Hydrogen and hydrocarbon fuels. The system provides valuable information for the design, performance and optimization of the reaction process. The system may also be used to characterize gases created in the fermentation process related to biofuels research. A second analytical line can be added for the analysis of alcohols, aldehydes and ketones. Data station and GCsolution sold separately.

- **Methods**: Hydrogen Fuel Cell Research, Biomass Fuel Research
- **Part Number**: 220-90862-24
- **Hardware**: GC-2014, FID,TCD, 10 port valve, 6 port valve and 4 port valve

**Compounds**

H2, O2, N2, CH4, CO, CO2, C2, C3 and C4 alkanes

A second analytical line is required and must be added for the analysis of Alcohols, Aldehydes and Ketones.

**Detection Limits**

TCD compounds with argon carrier 10ppm H2 100ppm O2, N2, CH4, CO FID compounds 10ppm CO2, 1ppm hydrocarbons.

Fuel Cell Plumbing Diagram

Fuel Cell Chromatogram

FID Trace
**Custom GC Configuration Form**

Contact your local Shimadzu representative who will work with you to define your analytical chromatography needs. Using the worksheet below, list your desired components with concentrations, describe the matrix of your sample, and list any interfering components.

Name

Company

Address

City    State    Zip

Phone    Email

This form must be completed in full. All information is necessary for Shimadzu’s System GC team to configure the hardware properly for the application and for meeting your requirements.

**SAMPLE COMPOSITION**

List all components in the sample, regardless of whether they need measured. Complete data is necessary to take interferences into consideration.

<table>
<thead>
<tr>
<th>Component*</th>
<th>Concentration Minimum</th>
<th>Concentration Maximum</th>
<th>Detection Limit**</th>
<th>Concentration Units</th>
<th>Quantitation Required (yes or no)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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</tbody>
</table>

*Use another sheet if necessary; **Most important and REQUIRED

Balance of the mixture

Sample State (please check one): □ Gas    □ Liquefied Gas    □ Liquid

Sample Temperature ______ Sample Pressure ______

Volume of Sample ______ Type of Sample Container ______

**PAST METHOD/APPLICATION**

Have you done this method before? □ Yes    □ No

If yes, please complete the following:

Column Description and dimensions

Column Oven State Temperature ______ Temperature Program ______

Injector Temperature ______ Detector Temperature ______ Carrier Gas ______

Flow Rates (mL/min) ______ Injector 1 (OCl, SPL, etc.) ______ Injector 2 ______

Detector 1 (FID, TCD, etc.) ______ Detector 2 ______

How would you like to improve the current method? (more sensitivity, shorter run time, etc.)

**ADDITIONAL NOTES AND REQUIREMENTS**

Analysis Frequency/Cycle Time Requirements (if any)

Special Requirements/additional Information

Sample Injection Method
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