C184-E044

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Gas Chromatograph

System GC

System Examples

System GC refers to systems configured with a sample injection unit, valves, and other components for specific operating environments, such as for quality or process control applications in petrochemical or gas manufacturing plants, environmental gas analysis, or reaction gas research.
The following describes key features of GC systems and examples of past GC system configurations.

1 Robust and Stable

Major benefits of configuring such systems include the ability to analyze specific components using simple operations and the ability to perform long-term analysis with high precision, high sensitivity, and high separation. Systems can also be automated, from sampling to data output, by adding specific valves, solenoid valves and other components and by sequencing programs in the data processing unit. Consequently, systems can be configured to analyze samples continuously with no human intervention, thereby maximizing the benefits of the exceptionally stable performance. Using a combination of valve systems protects columns and detectors from concentrated primary components that can interfere with their performance, enabling analysis of even trace substances with excellent reproducibility.

2 High Separation and Shorter Cycle Times

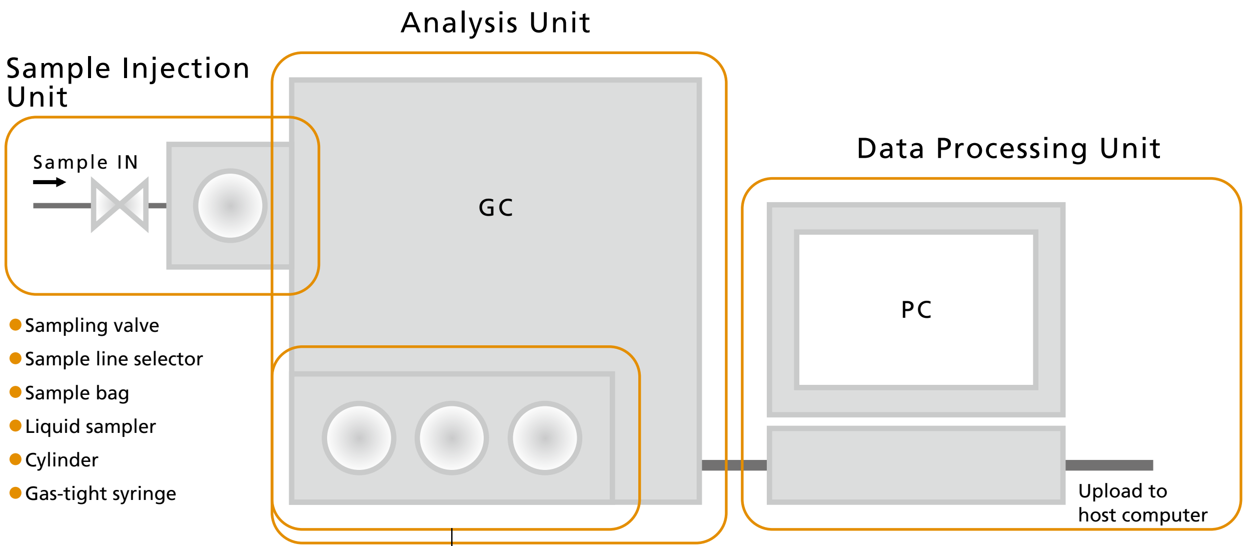
System GC systems only target specific components. By using a special valve system or optimized column configuration, they are able to analyze, with good separation, components that are normally very difficult to detect.
At the same time, they can achieve much shorter cycle times by using multiple columns or a special valve system to shorten the lengthy analytical or stabilization processes that are often required when using conventional methods.

3 High Sensitivity Analysis

Analyzing trace quantities requires increasing the sample quantities injected into the GC by using a larger measuring tube. With general-purpose GC systems, that results in poor separation and target peaks being hidden behind peaks for interfering substances. However, a customized system can detect such trace components.
Even ultra-trace components can be detected by using a detector with higher selectivity, such as an FPD, SCD, or ECD, or a highly sensitive detector, such as a PDD or BID.

System GC Configurations

System GC systems are configured with a sample injection unit, analysis unit (valve system), and data processing unit.



- Sampling valve
- Sample line selector
- Sample bag
- Liquid sampler
- Cylinder
- Gas-tight syringe

- Chromatopac
- Computer (with GCsolution and LabSolutions software)
- Upload to host (via LAN file transfer, 4 to 20 mA output, etc.)
- Corresponding to special requests
  (Excel printing, CSV output, pass/fail judgments, etc.)

Valve System

- Pre-cut
- Heart-cut
- Column switching
- Backflush

Detector

- FID
- TCD
- BID
- FPD
- PDD
- ECD

Valve System

System GC can be optimized with 6-way, 8-way, or 10-way valves to automate and increase the efficiency of analysis.

Sampling	Acquires a fixed quantity of the sample.
Pre-cutting	By analyzing only components that elute early, pre-cutting discharges late-eluting components from the analysis system.
Heart-cutting	Delivers only the trace components, contained among primary components, to the detector.
Column switching	Switches between different columns within the same analysis, depending on the components being analyzed.
Backflush	Elutes multiple late-eluting components at the same time and early.

List of System Examples

The following is a selected list of past system configurations. For more details or information about systems not included in the list, feel free to contact a Shimadzu sales representative.

Analysis of Impurities in Pure Gas

No.	System	Measured Component (Concentration)	Primary Components	Analysis Time	Detector (Carrier Gas)	Valve Configuration
SGC-001	System for analyzing trace nitrogen in inorganic gases	N_2 (ppm)	H_2 / O_2 / Ar	20 min	TCD (He)	6-6 system
SGC-002	System for analyzing trace hydrogen in inorganic gases	H_2 (ppm)	O_2 / Ar / N_2	20 min	TCD (Ar)	6-6 system
SGC-003	System for analyzing trace hydrocarbons (C_1 to C_3) in inorganic gases	C_1~C_3 (ppm)	H_2/ O_2 / Ar / N_2	20 min	FID (N_2)	6-system
SGC-004	System for analyzing trace carbon monoxide and carbon dioxide in inorganic gases	CO, CO_2 (ppm)	H_2 / O_2 / Ar / N_2	20 min	FID (N_2)	6-6-6 system
SGC-005	System for analyzing trace chlorofluorocarbons in inorganic gases	Chlorofluorocarbons (CFCs) (ppm)	H_2 / O_2 / Ar / N_2	20 min	FID (N_2)	Two 6-systems
SGC-006	System for analyzing impurities in high-purity gases (ultra-trace nitrogen analysis)	N_2 (ppb)	H_2 / He / Ar	30 min	PDD (He)	6-6 system
SGC-007	System for analyzing impurities in high-purity gases (ultra-trace hydrogen analysis)	H_2 (ppb)	He / Ar / N_2	30 min	PDD (He)	6-6 system
SGC-008	System for analyzing impurities in high-purity gases (ultra-trace methane, carbon monoxide, and carbon dioxide analysis)	CH_4, CO, CO_2 (ppb)	H_2 / He / Ar / N_2	30 min	FID ×2 (He)	6-6-6 system
SGC-009	System for analyzing medical oxygen and nitrogen	O_2 / N_2 (%)	N_2 / O_2	20 min	TCD (He)	6-system

Environmental Monitoring

Model	System	Measured Component (Concentration)	Primary Components	Analysis Time	Detector (Carrier Gas)	Valve Configuration
SGC-101	System for high-sensitivity analysis of atmospheric methane	CH_4 (ppm)	Air	15 min	FID (N_2)	10-system
SGC-102	System for analyzing trace atmospheric ethylene oxide gases (EOG)	Ethylene oxide (ppm)	Air	4 min	FID (N_2) ×2	Two 10-systems
SGC-103	System for analyzing trace nitrous oxide in the atmosphere or soil	N_2O (ppb)	Air	15 min	ECD ($Ar+CH_4$)	6-8-6 system
SGC-104	System for high-sensitivity analysis of atmospheric greenhouse gases	N_2O (ppb) CO_2, CH_4 (ppm)	Air	10 min	TCD, FID (He) ECD (N_2+CH_4)	6-8-6 system
SGC-105	System for high-sensitivity analysis of atmospheric greenhouse gases	N_2O (ppb) CO_2, CH_4 (ppm)	Air	20〜30 min	BID, FID (He)	MGS-2010
SGC-106	System for analyzing trace ethylene emission from fruits and vegetables (A)	O_2+Ar, N_2, CO_2 (%) Acetaldehyde, C_2H_4 (ppm)	Air	15 min	TCD(He), FID (N_2)	Two 8-6 systems
SGC-107	System for analyzing trace ethylene emission from fruits and vegetables (B)	C_2H_4 (ppm)	Air	10 min	FID (N_2)	8-,8-6 system

List of System Examples

Analysis of Impurities in Carbon Dioxide Gases

	Measured Component (Concentration)	Primary Components	Analysis Time	Detector (Carrier Gas)	Valve Configuration
SGC-201 System for analyzing trace inorganic gas in carbon dioxide	H_2, O_2+Ar, N_2, CH_4, CO (ppm)	CO_2	20 min	PDD (He)	6-8 system
SGC-202 System for analyzing sulfur compounds in carbon dioxide	H_2S, COS, CH_3SH, C_2H_5SH (ppm)	CO_2	20 min	FPD (N_2)	6-, 10- system
SGC-203 System for analyzing aromatics, light hydrocarbons, and alcohols in carbon dioxide	Aromatics, Light hydrocarbons, Alcohols (ppm)	CO_2	60 min	FID (He) ×2, PDD (He)	Two 6-systems, Manually injected
SGC-204 System for analyzing oil in carbon dioxide	C_{30} (ppb)	CO_2	60 min	FID (He)	6-6 system

Fuel Gases

	Measured Component (Concentration)	Primary Components	Analysis Time	Detector (Carrier Gas)	Valve Configuration
SGC-301 Liquid natural gas (LNG) analysis system for GPA compliant commerce	O_2~C_6^+ (%)	CH_4	30 min	TCD (He) ×2	10-,10-6 system
SGC-302 LNG composition analysis system, GC-20B-3SE, compliant with Gas Business Act	H_2~C_6^+ (%)	—	20 min	TCD ×2 (He)	10-,10-10 system
SGC-303 Fuel gas (containing hydrogen sulfide) analysis system, GC-20B-3S	H_2~C_4, H_2S (%)	—	40 min	TCD ×3 (He, N_2)	Four 10-systems
SGC-304 Liquefied petroleum gas (LPG) composition analysis system	C_1~C_3, i-C_4, n-C_4, C_5^+ (%)	—	30 min	TCD (He)	6- system

Plant Gas Analysis

Model	System	Measured Component (Concentration)	Primary Components	Analysis Time	Detector (Carrier Gas)	Valve Configuration
SGC-401	Inorganic gas and lower hydrocarbon (up to C_2) analysis system	O_2~C_2 (%)	Ethylene/ propylene	20 min	TCD ×2 (He, N_2)	10-,10-6 system
SGC-402	System for analyzing trace carbon monoxide and carbon dioxide in ethylene or propylene	CO, CO_2 (ppm)	Ethylene/ propylene	30 min	FID ×2 (N_2)	Two 10-6 systems
SGC-403	System for analyzing trace hydrocarbons in ethylene or propylene	C_2~C_5 (ppm)	Ethylene/ propylene	30 min	FID (N_2)	10- system
SGC-404	System for analyzing trace hydrogen in ethylene or propylene	H_2 (%, ppm)	Ethylene/ propylene	20 min	TCD (N_2)	Two 10- systems
SGC-405	System for analyzing trace nitrogen in ethylene or propylene	N_2 (ppm)	Ethylene/ propylene	20 min	TCD (N_2)	10-6 system
SGC-406	System for analyzing trace methanol in ethylene or propylene	MeOH (ppm)	Ethylene/ propylene	30 min	FID (N_2)	6 system
SGC-407	System for analyzing trace hydrogen sulfide and carbonyl sulfide in ethylene or propylene	H_2S, COS (ppm)	Ethylene/ propylene	30 min	FPD (N_2)	6 system
SGC-408	System for analyzing trace methane and acetylene in ethylene or propylene	CH_4, C_2H_2 (ppm)	Ethylene/ propylene	30 min	FID (N_2)	10- system

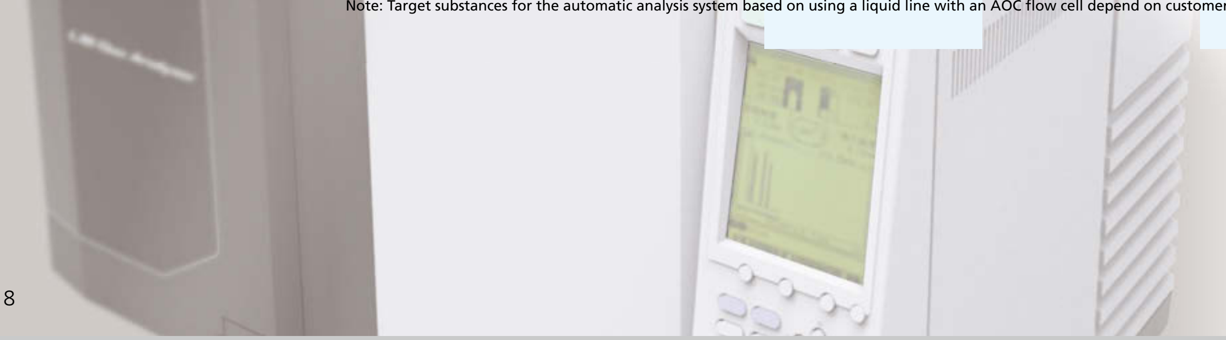
List of System Examples

Other Analysis

System	Name	Measured Component (Concentration)	Primary Components	Analysis Time	Detector (Carrier Gas)	Valve Configuration
SGC-501	Photocatalytic performance evaluation system	CO_2, Acetaldehyde, Toluene (ppm)	Air	10 min	FID ×3 (N_2)	10-, 10-, 10-6 system
SGC-502	System for analyzing trace SF6 in air	SF_6 (ppm)	Air	10 min	BID (He)	6- system
SGC-503	System for analyzing organic solvent recovery	MeOH, EtOH, n-PrOH, n-BuOH (ppm)	—	30 min	FID (N_2)	6-10-6 system
SGC-504	Ethylene oxide gas (EOG) analysis system for sterilization equipment	Ethylene oxide (%)	CO_2	20 min	TCD (He)	10- system
SGC-505	Analytical system for catalytic reaction evaluation	H_2~CO_2, C_1~C_{10}, BTX, etc. (%)	—	60 min	TCD ×2, FID ×2 (He, N_2)	10, 10-6, 10-, 6- system
SGC-506	System for analyzing lithium-ion battery (LIB) gases	H_2, CO, CO_2, C_2H_4, C_2H_6 (ppm)	He	30 min	BID (He)	6- system
SGC-507	Analytical system with capillary pre-column injection (for analyzing beer, polymers, etc.)	EtOH, Monomers, etc.	Beers, polymers, etc.	— Note: Depends on sample	FID (He)	—
SGC-508	AOC online sampling system (automated liquid line batch analysis)	—	—	—	FID (He / N_2)	—

Note (SGC-507): Computer-controlled using special-order software for GC-2010 Plus capillary column analysis system equipped with a pre-cut injection unit

Note (SGC-508): Target substances for the automatic analysis system based on using a liquid line with an AOC flow cell depend on customer sample characteristics.

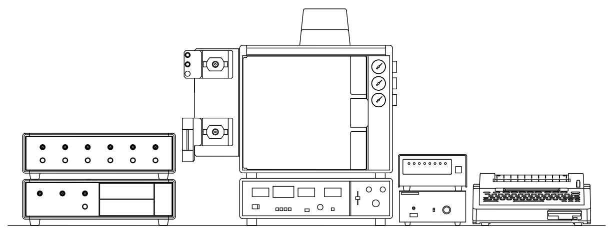


Description of System Examples

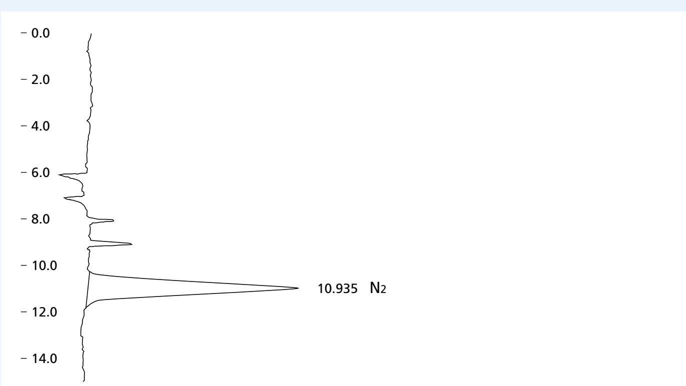
SGC-001 Automatic Inorganic Gas Analysis System (Trace Nitrogen Analysis)

Overview

This system is intended for measuring trace quantities of nitrogen in hydrogen, oxygen, and argon gases. The output signal from the GC-8APT gas chromatograph equipped with a high-sensitivity TCD detector is amplified by a preamplifier and detected nitrogen is quantitated using a data processor. Each action during analysis is automated using a PGR-102A programmer, 10-way valve, 6-way valve, and sample line selector.



Sample gases targeted for analysis	Hydrogen, oxygen, and argon
Sample gas conditions	Pressure: 10 to 30 kPa Temperature: Room temperature Conditions: Gas contains no dust or mist
Measured components	Nitrogen (2 ppm) Lower limit of detection of nitrogen in hydrogen, oxygen, and argon indicated in parentheses.
Analysis time	20 minutes
Calibration method	Absolute calibration curve method using standard gas
Equipment used	Gas chromatograph (special GC-8APT model) Programmer (PRG-102A) Pre-amplifier (AMP-7B) Data processor (GCsolution or Chromatopac)
Valve configuration	6-6 heart-cut system
Standard gas	Nitrogen 10 ppm with helium balance
Carrier gas	Helium (min. 99.9995% purity) Pressure 600 kPa
Valve actuation air supply	Dehumidified air with no oil content at 350 to 500 kPa pressure
Installation space	W1250 mm × D900 mm

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** CALCULATION REPORT **  Calibration with final standard
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1    1     10.935      12281     346           1                   N2
                   ---------------------              ------------
           TOTAL       12281     346                        0

** CALIBRATION DATA **   9:@FIL11. FIL
IDENTIFICATION  TABLE
    IDNO    Name          Time    Band      Conc        Factor(1)       Factor(2)
     1     N2             10.9    0.5       10.1        0.000822408
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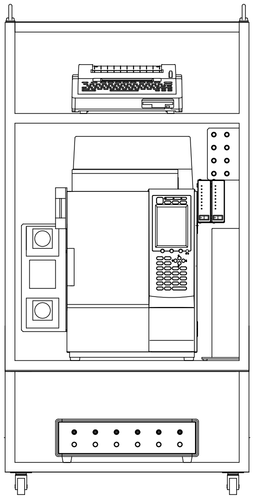
Description of System Examples

SGC-006 System for Analyzing Impurities in High-purity Gases

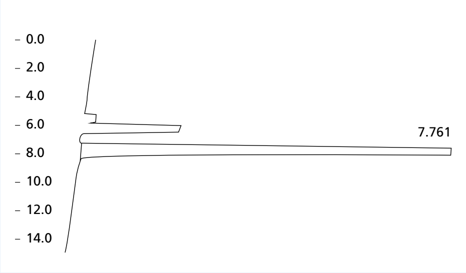


Overview

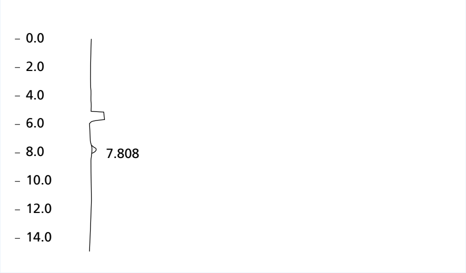
This system is intended for analyzing trace quantities of nitrogen in high-purity gases (helium, argon, and hydrogen).
It uses a GC-2014A gas chromatograph equipped with a high-sensitivity PDD detector in combination with a C-R8A Chromatopac data processor.
Each action during analysis is automated using a PRG-2010+PRG-BOX programmer, 6-way valve, and sample line selector.

Sample gases targeted for analysis	Helium, argon, and hydrogen
Sample gas conditions	Pressure: 10～30 kpa Temperature: Room temperature Conditions: Gas contains no dust or mist
Measured components	Nitrogen (50 ppb)
Analysis time	30 minutes
Calibration method	Absolute calibration curve method using standard gas
Equipment used	Gas chromatograph (special GC-2014 + PDD detector) Programmer (PRG-2010+PRG-BOX) Data processor (C-R8A) Sample line selector
Valve configuration	6-6 heart-cut system
Standard gas	Nitrogen 1 ppm/He balance
Carrier gas	Helium (min. 99.9999% purity) Pressure 600 kPa
Valve actuation air supply	Dehumidified air with no oil content at 350 to 500 kPa pressure
Installation space	W750 mm × D840 mm × H1460 mm (using a system rack)

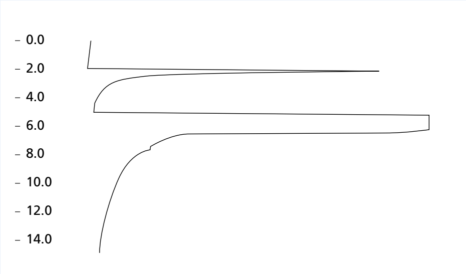
Standard Gas Analysis Example



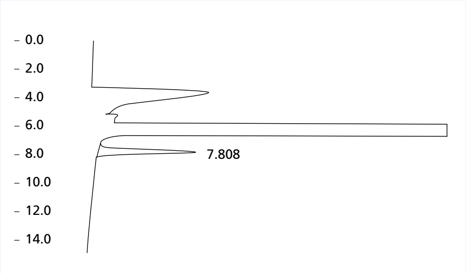
High-Purity Helium Analysis Example



High-Purity Hydrogen Analysis Example



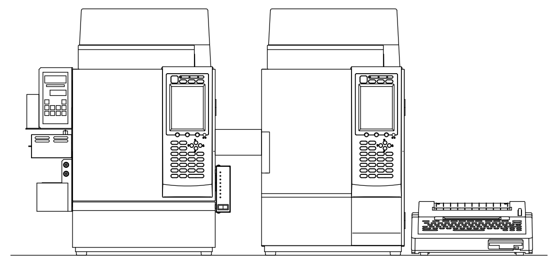
High-Purity Argon Analysis Example



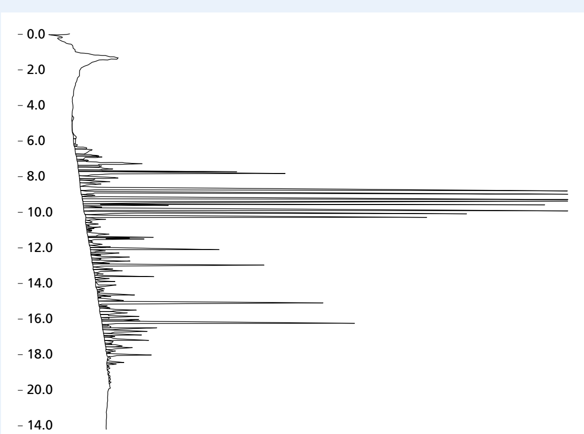
SGC-204 System for Analyzing Oil Content in Carbon Dioxide

Overview

This system is intended to automate the analysis of trace quantities of oil in carbon dioxide gas. After vaporizing liquid samples, samples are concentrated and injected through a column to calculate the oil concentration using an integrating flowmeter.
Two GC-2014 gas chromatographs are used in combination with a C-R8A Chromatopac data processor.
Each action during analysis is controlled using a PRG-2010+PRG-BOX programmer and automated using a 6-6 valve system.



Sample gases targeted for analysis	Carbon dioxide gas
Sample gas conditions	Temperature: Room temperature Condition: Samples are in liquefied carbon dioxide form
Measured components	C_{30} (10～100 ppb)
Analysis time	40 minutes
Calibration method	Absolute calibration curve method using standard gas
Equipment used	Gas chromatograph (special GC-2014A + GC-2014AFsc system) Programmer (PRG-2010 + PRG-BOX) Data processor (Chromatopac)
Valve configuration	6-6 system
Standard gas	C_{30} 0.2 ppm / n-C_6H_{14} balance
Carrier gas	Helium (min. 99.9995% purity) Pressure 600 kpa
Valve actuation air supply	Dehumidified air with no oil content at 350 to 500 kPa pressure
Installation space	W1900 mm × D800 mm × H690 mm



Oil concentration in CO_2

Cumulative quantity of concentrated CO_2		5.005	L
Flow speed of concentrated CO_2		500	ml/min
C10	Converted concentration	1.449	ppb (g/L)
C12	Converted concentration	13.169	ppb (g/L)
C14	Converted concentration	0.466	ppb (g/L)
C16	Converted concentration	0.306	ppb (g/L)
C18	Converted concentration	0.426	ppb (g/L)
C20	Converted concentration	0.452	ppb (g/L)
C22	Converted concentration	0.184	ppb (g/L)
C24	Converted concentration	0.541	ppb (g/L)
C28	Converted concentration	0.913	ppb (g/L)
C30	Converted concentration	0.111	ppb (g/L)
C32	Converted concentration	0.237	ppb (g/L)
C36	Converted concentration	0.067	ppb (g/L)
Total converted concentration		18.32	ppb (g/L)

** Quantitative calculation results **

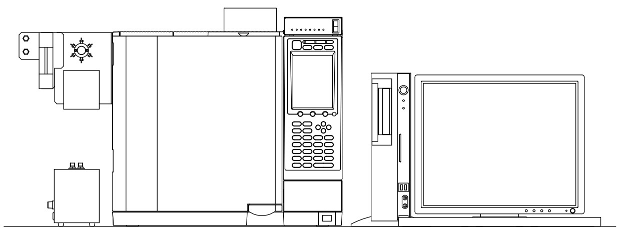
CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC	NAME
1	1	4.72	635	53		1	0.0477	C10
	2	5.772	1167	107		1	0.0875	C10
	3	6.215	1357	93	V	1	0.1018	C10
	99	19.313	279	45	V	12	0.0209	C36
	100	19.529	303	70		12	0.0227	C36
	TOTAL		1222575	463314			91.6929	

Description of System Examples

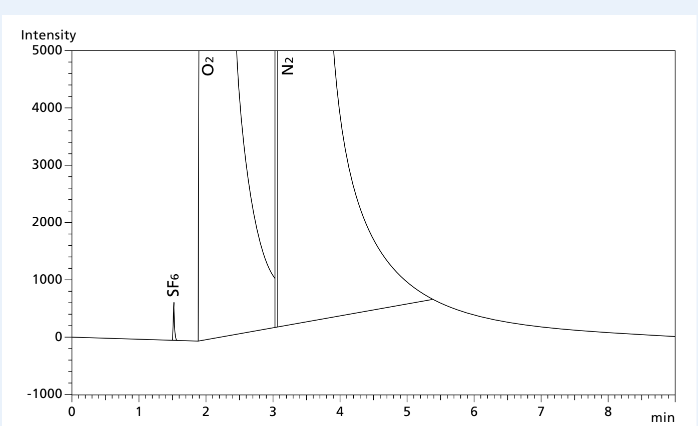
SGC-502 System for Analyzing Trace SF_6 in Air

Overview

Sulfur hexafluoride (SF_6) is a tasteless odorless gas that, due to its chemically stable insulative properties, is commonly used in electrical equipment, such as gas-insulated transformers and circuit breakers. However, because of its high global warming effects, trace analysis is required to check for leakage from equipment or check for residual quantities during recovery, so that its release into the atmosphere can be avoided.
This system uses a helium carrier gas and capillary column to separate the SF_6 from air for analysis using a BID detector.



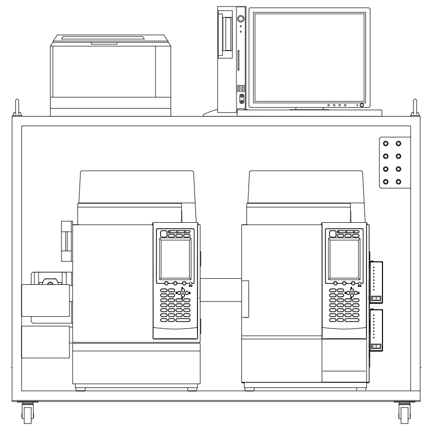
Sample gases targeted for analysis	Air
Sample gas conditions	Pressure: 10～30 kPa Temperature: Room temperature Conditions: Gas contains no dust or mist
Measured components	Sulfur hexafluoride (SF_6) 0.1 ppm
Analysis time	10 minutes (per sample)
Calibration method	Absolute calibration curve method using standard gas
Equipment used	Gas chromatograph (special GC-2010 Plus + BID detector) Programmer (PRG–BOX) Data processor (GCsolution)
Valve configuration	6- system
Standard gas	SF_6 10 ppm/He balance
Carrier gas	Helium (min. 99.9999% purity) Pressure 600 kPa
Valve actuation air supply	Dehumidified air with no oil content at 350 to 500 kPa pressure
Installation space	W1300 mm × D800 mm



SGC-505 Analytical System for Catalytic Reaction Evaluation

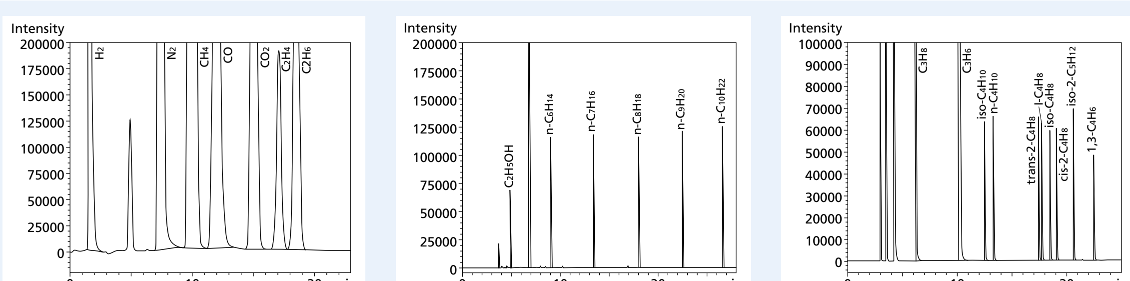
Overview

Catalysts are commonly researched and developed for a wide variety of fields and applications, such as to modify or desulfurize fuel cell materials, to clean combustion gas emissions, and for organic synthesis. This system is used to analyze and evaluate the sample gases emitted from a catalytic reactor. TCD1 measures H_2 using a N_2 carrier gas and TCD2 separates and analyzes Ar to C_2 using a helium carrier gas. In addition, the system uses two capillary columns to split samples and analyze C_3 to C_5 with detector FID1 and C_5 to C_{10}, BTX, and EtOH with detector FID2.



Sample gases targeted for analysis	Gases that exit the catalytic reactor are kept warmed before injection
Sample gas conditions	Pressure: 10～30 kPa Temperature: 110～150 ˚C Conditions: Gas contains no dust or mist
Measured components	H_2～C_3 (*)0.1～20%) C_4～C_{10}、BTX (*)0.1～1%) EtOH (*)0.1～50%) Measurement range indicated in parentheses and lower limit of detection by asterisk
Analysis time	60 minutes
Calibration method	Calibration is by the absolute calibration curve method using standard gases, where liquid components are calibrated based on their correlation to the gases.
Equipment used	Gas chromatograph (special GC-2014ATT model) Gas chromatograph (special GC-2014AFF model) Programmer (PRG–BOX)*2 PC (GCsolution)
Valve configuration	H_2 analyzer unit 10-system N_2 to C_2 analyzer unit 10-6 system C_3 to C_5 analyzer unit 10-system C_5 to C_{10} + BTX analyzer unit 6-system
Example of standard gas and standard solution	Gas mixture with composition similar to sample
Carrier gas	Helium (min. 99.999% purity) Pressure 600 kPa Nitrogen (min. 99.999% purity) Pressure 600 kPa
Hydrogen gas	Nitrogen (min. 99.999% purity, Pressure: 300 kPa)
Valve actuation air supply	Dehumidified air with no oil content at 350 to 500 kPa pressure
Installation space	W1370 mm × H1285 mm × D800 mm (including computer)

Standard gas analysis example

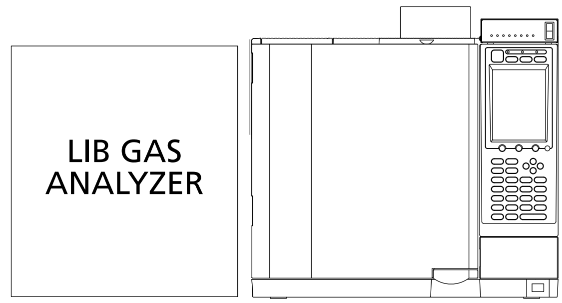


Description of System Examples

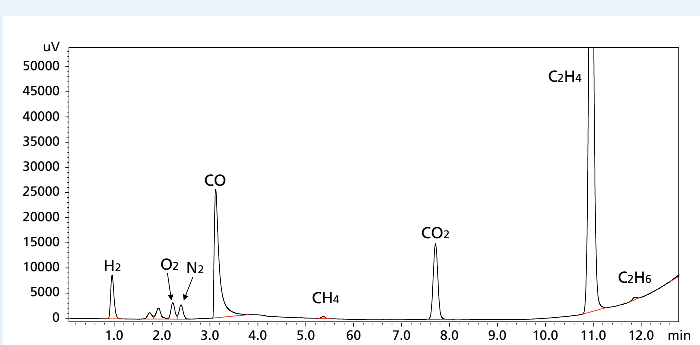
SGC-506 System for Analyzing Lithium-ion Battery (LIB) Gases*

Overview

This system evaluates the performance of precision battery materials (such as electrolyte solution, electrodes, and separators) by continuously analyzing the gases generated inside batteries.
Until now, the generated gases were manually sampled from a sealed cell for analysis. The system is able to measure the amount generated by automatically acquiring samples at fixed intervals while continuously purging the gases generated during charging and discharging. Furthermore, it is able to prevent ambient air from leaking in during sampling.
The barrier discharge ionization detector (BID) installed in the Tracera high-sensitivity gas chromatograph allows analyzing a wide range of measurement components, which makes the system ideal for evaluating battery materials.



Sample gases targeted for analysis	Air
Sample gas conditions	Pressure: 10 to 30 kPa Temperature: Battery cell (30 to 80 °C) Conditions: Gases generated from battery contain no dust or mist
Measured components	H_2, O_2, CO, CH_4, CO_2, C_2H_4, C_2H_6 (0.2 ppm each)
Analysis time	30 minutes
Calibration method	Absolute calibration curve method using standard gas
Equipment used	Gas chromatograph (Tracera + LIB GAS ANALYZER) Programmer (PRG-2010 + PRG-BOX) Data processor (LabSolutions)
Valve configuration	6- system
Standard gas	H_2~CO_2, C_2, C_3 (5 ppm each)/He balance
Carrier gas	Helium (min. 99.9999% purity) Pressure 600 kPa
Valve actuation air supply	Dehumidified air with no oil content at 350 to 500 kPa pressure
Installation space	W850 mm × D800 mm × H570 mm (excluding computer)



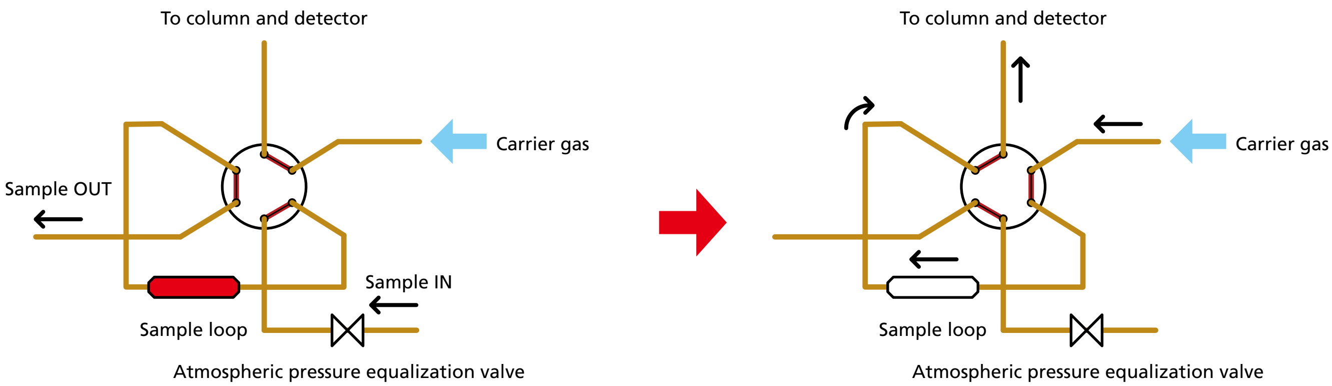
*This system may not be for sale, depending on the region. Check with your sales representative.

Sample Injection Methods

Sampling injection methods are configured according to customer preferences.
For sample introduction, either an automatic or manual gas sampler, sample line selector, sample bags, or a gas-tight syringe, can be selected based on the analytical techniques involved.
More stable analysis can be achieved by configuring the system with an appropriate sampling method.

Automatic Gas Sampler

The gas sampler collects a fixed quantity of sample in the sample loop and then delivers it to the column.



① Sample gas flows into the sample loop for a fixed period of time. Then the atmospheric pressure equalization valve is closed to equalize the pressure. Equalizing the atmospheric pressure ensures that a fixed quantity of sample is measured.

② The sample in the sample loop is delivered to the column by switching the sampling valve.

Manual Gas Sampler (MGS)

A knob is turned by hand to switch between two lines, such as standard gas and sample lines.
This eliminates the trouble of having to reconnect lines each time.

Sample Bag

This plastic bag is made of polyethylene terephthalate (PET) and other materials.
After collecting a sample in the bag, the bag is connected to the intake port and the sample is pumped into the measuring tube.

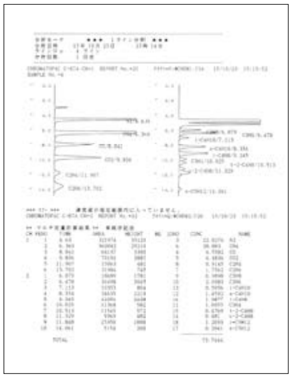
Sample Line Selector (SLS)

Switches between lines when using multiple sample lines for analysis (up to 14 lines, including standard gas lines).
It is designed to prevent contamination between lines, and lines can be switched automatically or skipped to improve system efficiency.

Report Output Examples

Report output formats can be tailored to specific customer requirements.

Output Example Using Chromatopac

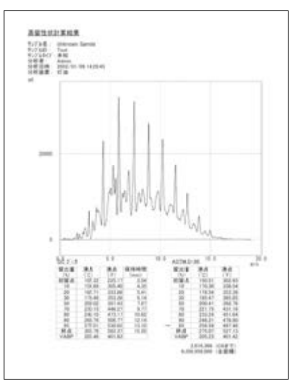


Output Example of
Chromatogram from Fuel Gas Analysis

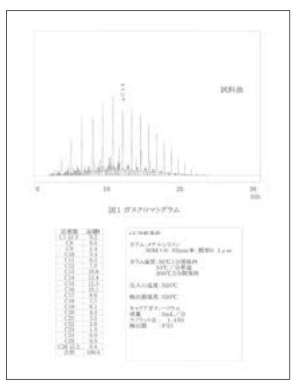
Output Example of Heat Measurement Table
(Compliant with Gas Business Act)

Output Example of
Combustion Characteristics Calculation Results

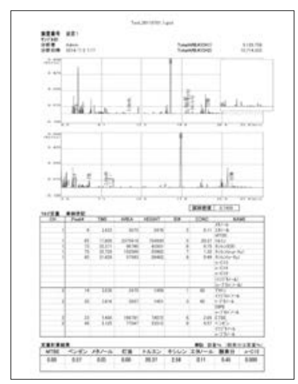
Output Example Using a Computer



Output Example of
Distillation GC Report



Output Example of
Hydrocarbon Analysis Results



Output Example of
Gasoline Analysis Results

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