GC 2000 Laboratory Universal Gas Chromatograph

User Manual

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Artist of Science

Please read operating manual before installation and operation.

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Table of Contents

1 Overview

1.1 GC 2000 Gas Chromatography

Figure1-1 GC 2000 front view

Figure1-2 GC 2000 rear view

Figure1-3 GC 2000 aerial view

1.1.1 Introduction

GC 2000 is a laboratory dedicated/universal instrument for detection and analysis based on gas chromatography. It adopts advanced electronic flow pressure control system, microfluidic plate control technology, high-precision independent temperature control system and high-sensitivity detector, with flexible & user-friendly window, high-speed sampling frequency & signal processing speed, and networked data & control platform, so as to meet user requirements for instrument analysis capability, reliability, stability and advanced nature.

The instrument is composed of a carrier gas system, a liquid system, a chromatographic column separation system, a detector system, a data recording & processing system, and a chromatographic workstation software system. It is compatible with detectors such as FID, ECD and FPD, as well as mass spectrometer detectors, satisfying the needs of different customers and applications.

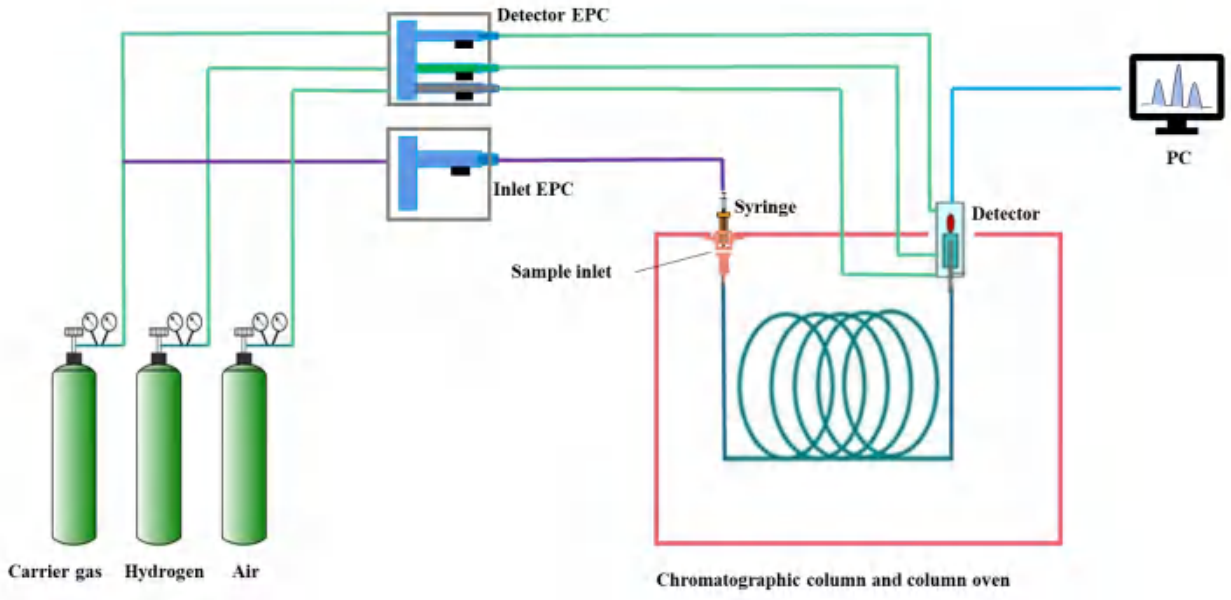


Figure1-4 Composition of GC 2000 system

1.1.2 Essential principles

Gas chromatography is a conventional analysis method, which employs gas as the mobile phase to bring vaporized sample into the chromatographic column with carrier gas. It applies different distribution coefficients of the sample components in the chromatographic column stationary phase for separation, and uses detector for testing. Also, it plots and marks the chromatogram of the time and concentration of each component flowing out of the chromatographic column through appropriate identification and recording systems. According to the peak time and sequence in the chromatogram, the compound can be qualitatively analyzed; according to the height and area of the peak, it is possible to quantitatively analyze the compound.

Gas chromatography is characterized by high efficiency, high sensitivity, strong selectivity, fast analysis speed, wide application, and easy operation. It is suitable for qualitative and quantitative analysis of volatile organic compounds. Non-volatile liquid and solid substances can be analyzed by pyrolysis and vaporization.

1.1.3 Basic functions

Both the sample inlet and the detector are equipped with electronic flow/pressure control modules, which can support up to 18 channels of electronic pressure/flow control, featuring automatic function of atmospheric pressure & temperature compensation, as well as independent technology of temperature control and data collection;

The detector signal is digitized, with a sampling frequency up to 200 Hz, supportive to ultra-high-speed analysis;

The multiple external interfaces can realize the control and communication of external devices, such as automatic sampler and pre-processing equipment;

Full touch screen with graphical display: 8.0-inch LCD display, touch control, with Android system, and analysis parameters can be set directly through the touch screen;

Humanized control and data analysis platform supports remote control of workstations, intelligent diagnosis, advanced alarm and processing mechanisms, and improves operational safety.

1.1.4 Basic configuration

1.1.4.1 Sample inlet

Two sample inlets can be installed at the same time;

Four sample injection modes: split injection, splitless injection, pulse split injection, and pulse splitless injection;

Four pneumatic control modes: constant pressure, constant flow, gradient pressure, and gradient flow. Both gradient pressure and gradient flow support 3-stage 4-segment programmed pressure boost and programmed upflow.

1.1.4.2 Autosampler

Sample digits: support 16-bit and 110-bit;

Syringe volume range: 1 μL, 10 μL, 25 μL, 50 μL, 100 μL, 250 μL and 500 μL available (10 μL as standard);

Injection volume: down to 0.1 μL.

1.1.4.3 Column oven

Number of program segments: support up to 32-stage and 33-segment programmed temperature rise.

1.1.4.4 Detector

Four detectors can be installed at the same time, supporting FID, ECD, FPD and other detectors.

1.1.5 Electronic cable interface

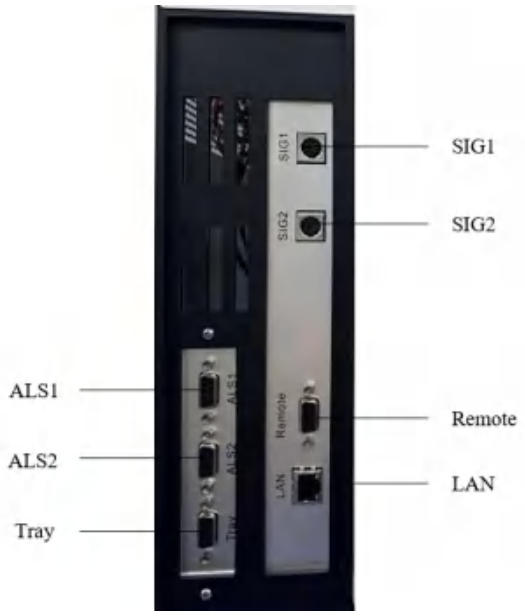


Figure1-5 Electronic cable interface

SIG1: Optional, analog output signal;

SIG2: Optional, analog output signal;

Remote: Provide an interface to remotely start and stop the instrument, and can synchronize multiple instruments;

LAN: Data systems and other device communications;

ALS1: Autosampler communication port 1;

ALS2: Autosampler communication port 2;

Tray: Autosampler tray communication port.

1.2 Man-machine interaction system

1.2.1 Touch screen

GC 2000 adopts an 8.0-inch LCD touch screen.

Figure1-6 Touch screen main window

The main window can display parameters for users to execute commands, such as modifying method parameters, activating methods, and running/stopping methods.

The current state, method parameters, and alarm information of the instrument can be viewed in real time, and the system settings and GC IP address can be modified.

1.2.2 GC 2000 acquisition software

GC 2000 acquisition software controls GC for acquiring data, creating methods, etc. The software is applicable to viewing instrument status and operational status, checking module parameters, creating and editing acquisition methods, running single samples or perform sequential injections, and acquiring spectral signals. It provides a powerful method editor to help you customize your acquisition method for single sample analysis (single injection) and multiple sample analysis (sequential injection).

1.2.3 GC 2000 data analysis software

GC 2000 data analysis software is used to analyze the collected data, which allows users to view data, perform qualitative and quantitative analysis of data files, conduct batch processing, save results, and create and print reports.

1.3 Autosampler

Automatic Liquid Systems (ALS) for GC 2000 instruments include AS 5016 (16-bit sample tray), AS 5110 (110-bit sample tray), AS 3901 (160-bit sample tray) and AS 3016 (16-bit sample tray).

1.3.1 Autosampler for liquid

The main components of autosampler for liquid are:

Injection tower: contains a 10 μL syringe for injection.

Sample tray: holds up to 16/110/160 vials.

Control panel: includes the operating window and display.

Solvent bottle and waste bottle area: are used to hold solvent and waste bottles.

1.4 Sample inlet

GC 2000 liquid system includes a sampling device and a vaporization chamber. Liquid samples are generally injected directly into the injection port using a micro syringe. Gas samples can be injected by needle or valve. GC 2000 offers up to two inlet installations, both electronically controlled.

The entire inlet can be checked for leaks using the pressure decay test in the acquisition software.

The liquid sample is generally injected through the injection port, vaporized in an instant after entering the vaporization chamber, and enters the chromatographic column with the carrier gas. According to different samples to be analyzed, the inlet temperature can be set within the range of 50~450°C.The split/splitless inlet is the most commonly used for a variety of routine sample analysis. The split/splitless inlet can also be used in connection with an autosampler to automatically inject samples through the autosampler for automatic analysis of batch samples.

The split/splitless inlet consists of injection septum, carrier gas inlet, septum purge outlet, vaporization chamber (liner), split outlet, and splitter plate. The injection septum is used for sample needle injection, which plays a sealing role and needs to be replaced after a certain number of uses. After the liquid sample is injected into the inlet through the needle, it is vaporized in the liner. Generally, filling the liner with silanized quartz wool helps the sample vaporize completely, eliminates split discrimination, and can prevent the septum debris generated when the injection needle injects samples from falling into the lower end of the inlet and blocking the inlet. The splitter plate is installed on the lower end of the liner to allow a large amount of gas to enter the split flow path better.

1.4.1 Split injection mode

When the relative concentration of the sample is high, in order to prevent overload, the split injection method is generally used. After injection, a portion of the sample directly enters the column, and the rest is vented from the split outlet.

In split injection, the total flow is controlled by a flow valve, and then the carrier gas is divided into two parts: one is the septum purge gas, and the other is the carrier gas entering the vaporization chamber. After the carrier gas entering the vaporization chamber is mixed with the sample gas, according to the set split ratio, a part is vented through the split port, and the other part enters the chromatographic column.

1.4.2 Splitless injection mode

Generally, splitless injection is used when the sample concentration is low. In splitless injection mode, the split outlet is closed, so all injected sample should enter the column. The splitless glass liner generally has a small section of glass capillary that fits around the injection needle during injection to limit the backflushing of the sample vapor during injection.

During splitless injection, the split valve is closed, and the carrier gas directly brings the sample into the chromatographic column under a certain pressure or flow. Generally, the splitless injection time is 0.5~1.5 min. It is usually recommended to open the split valve after 0.75 min of splitless injection, carry out solvent purging, and

vent the residual sample and solvent from the split outlet, which can reduce the overload to a certain extent and improve separation.

Warning:

- When using hydrogen as a carrier gas, it should be known that hydrogen is a flammable gas. Any leaked hydrogen in a closed space, e.g., a column oven, may cause combustion and explosion. Wherever hydrogen is required, all connections, lines, and valves should be leak-tested before using the instrument.
- Inlet nuts and components may be exposed to high temperatures during instrument operation, and should not be touched without protection.
- Select (4~7) standard atmospheres of nitrogen, helium and air to connect to the instrument. The high-pressure hydrogen outlet is generally selected to be less than 3 standard atmospheres. Workers must pay attention to the safe operation of high-pressure gas.

1.5 Flow and pressure control

Electronic pressure/flow controller (EPC/EFC) is an electric gas pressure/flow control module, which is a gas circuit control system for chromatography. It consists of three components: proportional solenoid valve, pressure sensor/flow sensor, and control board. Simply put, the proportional solenoid valve is equivalent to a variable air resistance. By controlling the size of the input current, the air resistance of the flow path can be adjusted, thereby changing the pressure and flow. The pressure/flow sensor measures the real pressure and flow in the gas circuit and feeds it back to the control board. The control board compares the actual pressure and flow to user setpoints, and adjusts the current input to the proportional valve, enabling electronic control of pressure and flow.

From the application, it is roughly divided into carrier gas controller, detector gas flow controller and auxiliary pressure/flow controller.

1.5.1 Introduction to terminology

Before introducing various gas controllers, users should apprehend the terms involved in this chapter. The descriptions of the following terms are based on GC 2000 system.

(1) Pre-column pressure: The pressure at the inlet of the chromatographic column is also the pressure in the inlet, in kPa or psi.

(2) Column flow: The volume flow in the chromatographic column, which has been converted to room temperature and atmospheric pressure, is equivalent to the volume flow measured at the outlet of the chromatographic column, in mL/min.

(3) Linear velocity: The speed at which the carrier gas moves through the chromatographic column, in cm/s.

(4) Split ratio: The ratio of split outlet flow (split outlet flow = total flow - septum flow - column flow) to column flow, which is a unitless dimension, e.g., 10:1.

(5) Total flow: The total flow of gas entering the inlet, which is controlled by the electronic flow controller

located upstream of the inlet, in mL/min.

(6) Septum purging: It is used to purge the products that will be volatilized by the septum at high temperature, thereby preventing volatile components from entering the chromatographic column and causing ghost peaks or pollution.

(7) Makeup gas: The gas added after the chromatographic column when a capillary column is used.

1.5.2 Inlet module electronic pressure/flow control

The configuration of the inlet module electronic pressure/flow control depends on the choice of inlet type and operating conditions. The split/splitless inlet requires an additional split control on the gas circuit due to its split mode. When using split or splitless injection mode at the same time, the configuration relationship between the proportional valve and the sensor is changed.

1.5.3 Detector gas flow control

Most detectors involve gas during use. For example, FID needs to use nitrogen, hydrogen and air, and FPD needs to use hydrogen and air. The size and stability of gas flow often affect the instrument sensitivity and noise level.

The detector gas flow control module of GC 2000 uses electronic flow control for higher control accuracy.

1.6 Chromatographic column and column oven

1.6.1 Column oven overview

The column oven is mainly used to place the chromatographic column, to provide a stable temperature separation environment for the chromatographic column, and to install the inlet and detector. GC 2000 column oven can install 3 chromatographic columns at the same time, with functions such as programmed temperature rise & fall, and rapid temperature rise & fall. High-precision temperature control ensures analysis reproducibility and high efficiency. GC 2000 provides oven temperature control via the touch screen and workstation software.

1.6.2 Chromatographic column overview

A chromatographic column is used to separate components in a mixture, which exploits the difference in the force between the stationary phase and different substances to separate a homogeneously mixed sample into individual components that flow out of the chromatographic column at different times.

When selecting a chromatographic column, the principle of similar compatibility is usually followed, that is, a non-polar stationary phase analyzes non-polar compounds, and a polar stationary phase analyzes polar compounds. Since non-polar stationary phases have a longer lifespan than polar stationary phases, if compounds can be analyzed with stationary phases of different polarities, the least polar stationary phase is generally selected.

1.6.2.1 Chromatographic column type

Two types of chromatographic columns can be installed on GC 2000: packed and capillary.

(1) Packed column

Packed column is a metal tube or glass tube filled with solid packing, which is a kind of chromatographic column commonly used in gas chromatography. Packed columns can accept large sample volumes and have long column life, but have low separation efficiency and are mostly used in specific applications such as permanent gas analysis. The outer diameter of the chromatographic column is usually 2~4 mm, and the length is 0.5~4 m. The packing can be high molecular polymer, molecular sieve or monomer coated with fixed liquid (such as diatomaceous earth). It is usually custom-made or self-filling as needed.

(2) Capillary column

The capillary column is also a ubiquitous column for gas chromatography, which is a quartz capillary with a stationary phase. Despite small column capacity, capillary columns boast of high separation efficiency and short analysis time, and are popular in most applications. The inner diameter of the column is usually 0.1~0.53 mm, with a length of 10 m, 15 m, 25 m, 30 m, 60 m or 100 m, and the film thickness usually between 0.1~5.0 μm.

1.6.2.2 Chromatographic column conditioning

Conditioning is used to bake out contaminants from the column surface (contaminants that enter and condense with the sample or carrier gas, degraded stationary phase debris) to obtain a clean and smooth baseline.

Usually new chromatographic columns need to be conditioned before use. For specific conditioning steps, please refer to the chromatographic column's operation manual.

1.7 Detector

1.7.1 Hydrogen flame ionization detector (FID)

1.7.1.1 Structure and composition

The flame ionization detector (FID) of GC 2000 gas chromatograph consists of:

——Main body of FID

——EPC module

——FID signal board

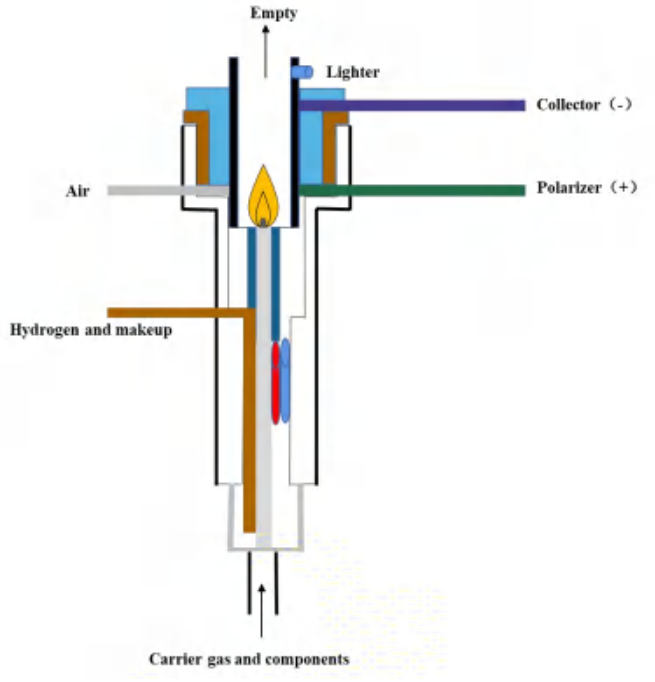


Figure1-7 Schematic diagram of the structure of FID

1.7.1.2 Working principle

Hydrogen flame ionization detector (FID) is a high-sensitivity organic universal detector, which is a typical destructive, mass-type detector. FID is a detector that uses hydrogen flame as ionization source to ionize organic matter and generate microcurrent. FID is characterized by high sensitivity, rapid response and wide linear range, and is suitable for the analysis of most organic compounds ionized in flames, especially for hydrocarbons, whose response is proportional to the number of carbon atoms.

FID is currently the most popular detector, which analyzes the ionized organic substances in the flame, but cannot analyze the non-ionized substances in the flame, such as H_2O, O_2, N_2, CO, CO_2, COS, SO_2 and other organic substances. FID features reliable performance, simple structure and convenient operation. It has virtually zero dead volume and can be directly connected to a fast GC capillary column for the analysis of complex wide-boiling organic compounds in combination with temperature-programmed methods.

FID uses the flame generated by the combustion of hydrogen and air as energy. When the organic compound enters the flame, chemical ionization is generated at high temperature, and the ionization produces ions several orders of magnitude higher than the base current. Under the directional action of the high-voltage electric field, these positively charged ions and negatively charged electrons move to the negative electrode and the positive electrode, respectively, forming an ion current. The weak ion current is amplified by high resistance, and the electrical signal is proportional to the amount of organic compounds entering the flame. According to the size of the signal, the organic matter can be quantitatively analyzed. FID, with a simple structure, a sensitivity up to 10^{-12}~10^{-13} g/s, is insensitive to the fluctuation of the carrier gas, and has a linear range up to 10^7, and a response to most organic compounds, which explains its widest applications among all gas chromatographic detectors.

An FID is composed of a hydrogen flame ionization chamber and an amplifier. See Figures 1-8 for its structure.

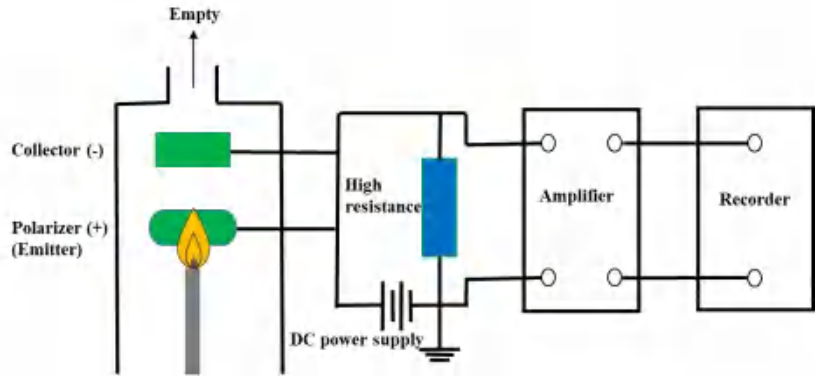


Figure1-8 Schematic diagram of FID structure principle

FID normally uses a stainless steel casing to seal the nozzle, collector, polarizer and ignition coil, etc., leaving an outlet to discharge combustion products. The gas flowing out of the chromatographic column is mixed with hydrogen and makeup gas at the nozzle. The hydrogen flame is ignited with an ignition filament, and air is introduced to assist the combustion. There is an annular metal ring (emitter, or polarizer) near the nozzle, and a metal cylinder (collector) at the upper end, both of which are connected with a DC high voltage of 50~350 V to form an ionizing electric field. After injection, the carrier gas and separated components are ionized into positive, negative ions and electrons in a hydrogen flame. Under the action of the electric field, positive ions move to the collector (negative electrode), and negative ions and electrons move to the polarizer (positive electrode). The ions trapped by the collector flow through the high resistance of the amplifier to generate a signal, which is amplified and sent to a recorder or data processing system. There are holes on the top of the metal cylinder shell of the ionization chamber, from which the exhaust gas and water vapor after combustion are discharged.

1.7.1.3 Selection of test conditions

(1) Selection of gas purity

For constant analysis, the purity of carrier gas, hydrogen and air should be above 99.9%, but for trace analysis, the purity of the three gases should be increased accordingly. The general requirement is more than 99.999%, and the total hydrocarbons in the air are less than 0.1 μL/L. Impurities in the gas source can cause noise, baseline drift, false peaks, column bleed, and reduced column life. Using a gas source with higher purity achieves desirable stability of FID baseline.

(2) Selection of flow rate

The flow ratio directly affects the sensitivity, and a higher sensitivity will be obtained when various gas flow rates and ratios are properly selected.

Recommended nitrogen/hydrogen/air flow rates for GC 2000 FID operation are: nitrogen at 40 mL/min, hydrogen at 40 mL/min, and air at 400 mL/min.

Recommended hydrogen/air flow rates for FID ignition: hydrogen at 40 mL/min, and air at 200 mL/min. When the automatic ignition is abnormal, users should appropriately increase the hydrogen flow and reduce the air flow.

(3) Temperature selection

Detector temperature changes affect FID sensitivity and noise. Since the combustion of hydrogen in FID produces a large amount of water vapor, if the temperature of the detector is too low, the water vapor cannot be discharged from the detector, and will condense into water, leading to lower sensitivity and more noise.

Furthermore, it is easy to cause corrosion in presence of chlorinated solvents or chlorinated samples. Therefore, the temperature of the FID must be above 120°C, and it is generally operated at 250~300°C.When analyzing different samples, the detector temperature needs to be adjusted according to different methods. Generally, the detector temperature is required to be higher than the maximum temperature of the column oven to prevent the condensation of some high-boiling samples from the chromatographic column into the detector and cause tailing.

1.7.2 Electron capture detector (ECD)

The electron capture detector (ECD) of GC 2000 gas chromatograph consists of an ECD, a Ni^{63} radioactive source and an ECD circuit signal board. As ECD contains the radioactive source Ni^{63}, improper operation may cause radiation damage to the human body and the environment. Please read the following precautions and warnings carefully before use**.**

1.7.2.1 Safety information

Note:

Personal safety: ECD contains the radioisotope Ni^{63} which releases beta particles with little penetrating ability, most of which can be blocked by the surface layer of human skin. However, when the isotope Ni^{63} can cause damage when absorbed or inhaled by the human body. Please read the instructions carefully before operate ECD.

Personal protection: During the operation of ECD, the operator should wear goggles, lab coat, gloves, and comply with laboratory operating rules, instead of eating, drinking or smoking. After operation, hands should be cleaned thoroughly with detergent.

Ionizing radiation warning signs: Do not remove any ionizing radiation warning signs and ECD-related labels affixed to ECD and gas chromatograph instrument.

ECD scrapping: Disposal of ECD should be performed with permission. According to relevant Chinese regulations, we will recycle and dispose of the sold ECD and their equipment for free. If you have any scrapped ECD equipment, please contact Drawell Technology Co., Ltd.

ECD damage: If the heating of the column oven and the detector is out of control at the same time, resulting in the temperature being above 350 degrees for more than 12 hours, it may cause permanent damage to the Ni^{63} coating in the detection cell. Please contact your supplier or us to return it to the factory and replace the detection cell.

Disposal of idle ECD: When the ECD is not in use, plugs should be installed on the detector inlet and vent.

ECD exhaust emission: Users should connect polyethylene pipe and PTFE pipe to the vent of the ECD, so that the exhaust gas is discharged to a fume hood or an outdoor unmanned place.

ECD corrosion protection: Any substance that reacts with Ni^{63} to produce volatile products or causes physical degradation of the coating should not be used. These substances include oxidizing compounds, acids, wet halogens, wet nitric acid, ammonia, hydrogen sulfide, polychlorinated biphenyls, and carbon monoxide.

ECD cleaning: Solvents should not be used to clean the ECD.

Instrument precautions: The product should be placed in a safe and clean environment. Users should follow the instructions for use, and observe the label warnings.

Warning:

The ECD may only be removed from the chromatographic instrument for repairs， while ensuring the operator has been specially licensed, otherwise disassembly is not allowed. Please contact your supplier or us for maintenance needs.

Users are not allowed to open the ECD independently, unless approved by the nuclear regulatory agency. The screws inside the upper cover of the detector are used to fix the two parts of the detector together. Removing or loosening these screws may cause safety problems.

If the detection cell is suspiciously damaged, users should immediately stop operating the gas chromatograph and contact us.

1.7.2.2 Structure and composition

The electron capture detector (ECD) of GC 2000 gas chromatograph consists of:

——ECD

——Ni^{63} radioactive source

——EPC module

——ECD signal board

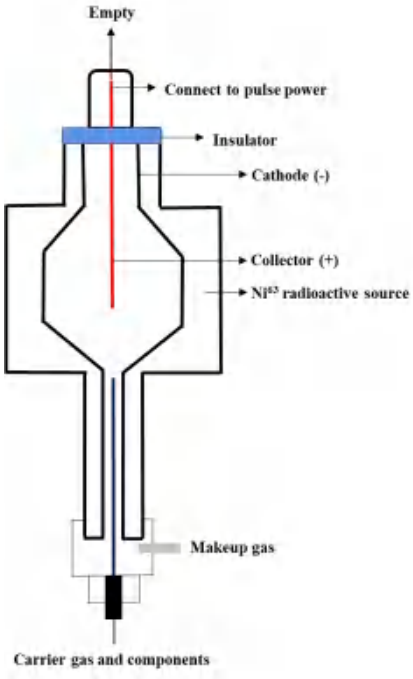


Figure1-9 Schematic diagram of ECD structure

1.7.2.3 Principle features

Electron capture detector (ECD) is the most sensitive gas chromatographic detector, and is also the earliest selective detector. Its response is three orders of magnitude higher than that of hydrocarbons to compounds that can capture electrons, such as electronegative compounds containing S, P, and halogens, and its limit of detection can reach 10^{-12}~10^{-14} g/mL. The minimum detection amount of γ-666 can reach 10^{-13} g, and the ratio of its sensitivity to carbon tetrachloride and n-hexane is 4×10^{8} times. ECD is an ionization detector, but its signal is different from that of FID or other ionization detectors, which is an increase in base current, while the ECD signal is a decrease in high background base current. The downside of ECD is its small linear range, usually only 10^{2}~10^{4}. It can be widely used in environmental protection, food inspection and medical and health departments.

The ECD system consists of an ECD cell and a detection circuit, as shown in Figure 1-10.

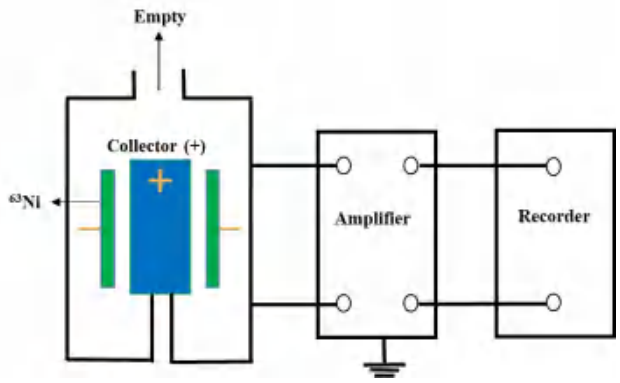


Figure1-10 Schematic diagram of ECD structure principle

The carrier gas and purge gas flowing out of the chromatographic column enter the ECD cell, and are ionized under the bombardment of β-rays emitted by the radioactive source, producing a large number of electrons. Under the action of the power supply, cathode and anode electric fields, the electrons flow to the anode, resulting in a base current of 10^{-9}~10^{-8} A. When the electronegative component enters the detector from the back of the column,

it captures the electrons in the cell, which reduces the base current and produces a negative peak. The signal, amplified by the amplifier and recorded in the recorder, is the response signal. Its size is proportional to the amount of components entering the pool.

The ECD cell contains a thin sheet of metallic nickel wrapped around a cylinder through which the carrier gas can pass. The activity of the isotope radioactive substance Ni^{63} is 10 millicuries.

1.7.2.4 Selection of test conditions

The response characteristics of ECD are extremely special, and the response varies greatly depending on the type of compound. There will be great differences between similar substances as long as their molecular structures are slightly different. For the same component, the response also varies depending on the structure of the detector, temperature, applied voltage, etc. Therefore, the selection of ECD conditions has a great impact on the test.

(1) Selection of gas purity

The purity of the carrier gas directly affects the base current of the ECD. Generally, high-purity N2 (99.999%) containing O2<10 mg/L is used. If ordinary N2 (containing O2 content of 100 mg/L) is used, the residual oxygen and water must be purified and removed, because O2 is an electronegative substance, which will greatly reduce the base current. Low-purity carrier gas can degrade its sensitivity and linearity. When noble gases such as helium (He) or argon (Ar) are used as carrier gas, 1-5% methane (CH4) must be added.

(2) Selection of flow rate

The gas flow rate of ECD makeup gas is 40~120 mL/min, and the carrier gas flow rate is selected according to the analysis conditions.

(3) Detector temperature

The response of the ECD is obviously affected by the detector temperature. Therefore, the detector temperature fluctuation must be less than ± (0.1~0.3)℃ to ensure a measurement accuracy within 1%.Thus, the detector temperature should be the same when comparing response values or minimum detection amounts for the same compound. The maximum operating temperature of the ECD is determined by the radioactive source used. When the maximum operating temperature is exceeded, the loss of the radioactive source will increase, the detector will be damaged, and the instrument and the working environment will be polluted. This detector uses a Ni63 radioactive source and its highest temperature is 350℃.

(4) Base current size

The ECD should have sufficient base current, generally 2/3 of the saturation current. The saturation current refers to the current when the base current does not rise with the increasing frequency when the pulse frequency increases to a certain extent. The ECD in GC 2000 adopts the constant current pulse modulation mode, where the ECD outputs a frequency signal.

1.7.3 Flame photometric detector (FPD)

Warning:

Due to the large flow of hydrogen used during the use of FPD, please pay attention to the safety of hydrogen use. Before the instrument uses hydrogen, the hydrogen source should be turned off. When hydrogen is supplied to the instrument, make sure that the interface between the inlet and the detector column are connected to the chromatographic column, or sealed with caps.

When using hydrogen as a carrier gas, it should be known that hydrogen is a flammable gas. Any leaked hydrogen in a closed space, e.g., a column oven, may cause combustion and explosion. Wherever hydrogen is required, all connections, lines, and valves should be leak-tested before using the instrument.

1.7.3.1 Structure and composition

The flame photometric detector (FPD) of GC 2000 gas chromatograph consists of:

——Main body of FPD

——Photomultiplier tube (PMT)

——EPC module

——FPD signal board

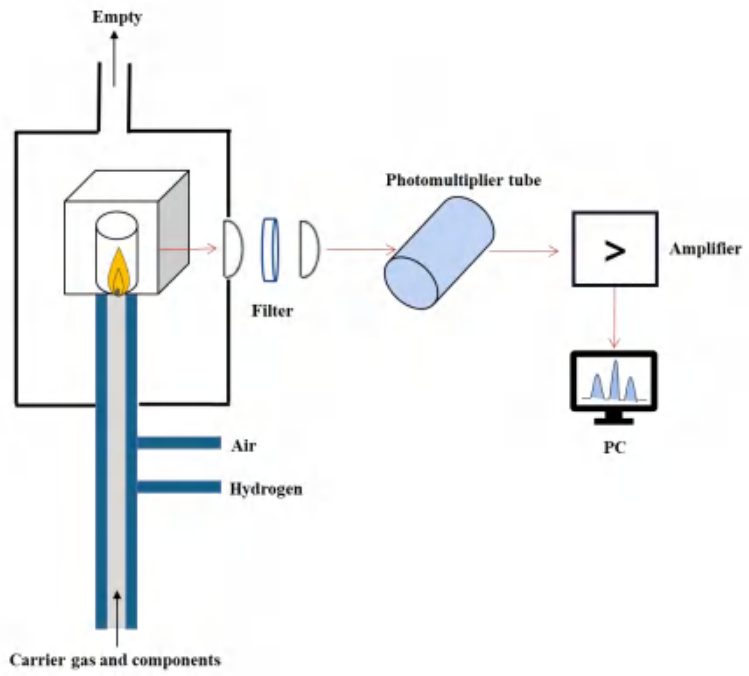


Figure1-11 Schematic diagram of FPD structure

1.7.3.2 Working principle

The FPD is a selective detector which is often used to detect and has a high response to compounds containing S and P. Its working principle is shown in the figure below. The sample is brought to the nozzle by the

carrier gas/hydrogen, where it is mixed with air and burned. When the flow rate of hydrogen and air meets a certain ratio, a hydrogen-rich flame is formed, and compounds containing sulfur and phosphorus are decomposed and react in this flame, emitting light in a characteristic band. The emitted light is collected by the lens to reach the filter. Different filters can selectively transmit light of different wavelengths. Usually, a filter with a wavelength of 526 nm is selected for sulfur measurement, and a filter with a wavelength of 394 nm is selected for phosphorus measurement. The light of a specific wavelength that passes through the filter is received by a photomultiplier (PMT), and is amplified and converted into an electrical signal according to the light intensity, which is collected and recorded by the workstation. Since there is a certain proportional relationship between the characteristic light intensity and the content of S- and P-containing compounds, the latter can be quantified according to the electrical signal intensity collected by PMT.

(1) Response characteristics

The linear characteristics of S- and P-containing compounds are related to their response mechanisms. The response mechanism of the P-containing compound is relatively simple. It first decomposes in the hydrogen-rich flame, , and forms an excited state HPO* group through a series of reactions. When it returns to the ground state, it emits light in a characteristic band, and the light intensity is proportional to the HPO. The concentration has a linear relationship with the concentration of P atoms.

The response mechanism of S-containing compounds is relatively complex, and there is no conclusion yet, but it is generally believed that the luminescent fragments formed by them in the hydrogen-rich flame are excited S_2* whose response to sulfur is nonlinear, and whose signal strength is proportional to the square of the concentration of sulfur atoms.

(2) Quenching effect

The quenching effect refers to the phenomenon that the response value of the target component drops significantly or even has no response, when a large amount of hydrocarbons and the target S- and P-containing compound enter the flame simultaneously.

The most direct solution is to adjust the chromatographic analysis conditions so that hydrocarbon compounds and S- and P-containing compound are separated and enter the detector at different times. In addition, maintaining the cleanliness of the detector and the gas used also helps suppress the quenching effect.

1.7.3.3 Selection of test conditions

(1) Selection of gas purity

To ensure the performance of the instrument, the gas used must meet the following purity and pressure requirements before connection:

Carrier gas (nitrogen or helium): purity not less than 99.999%, 400 kPa;

Hydrogen: purity not less than 99.999%, 200 kPa;

Air: total hydrocarbon content not higher than 1 ppm, 400 kPa.

(2) Selection of flow rate

Recommended hydrogen/air flow rate when GC 2000 FPD is working: hydrogen at 90 mL/min, air at 110 mL/min (for measuring S); hydrogen at 70 mL/min, and air at 120 mL/min (for measuring P).

Recommended hydrogen/air flow for FPD ignition: hydrogen at 40 mL/min, and air at 200 mL/min.

(3) Temperature selection

The normal working temperature of FPD is usually 120~250°C.Excessive FPD temperatures can degrade

detector performance and shorten the life of photomultiplier tubes (PMT). When it works at a high temperature of 250~450°C, attention should be paid to the temperature of the photomultiplier tube. A fan on the FPD cools the detector and protects the filter and PMT from high temperature damage.

2 Instrument installation

2.1 Safety precautions

Warning:

- This instrument should only be used by trained personnel.
- When operating the instrument, users should be aware of the follows:
- 1 to 6 standard atmospheres of nitrogen, hydrogen and air should be chosen to connect to the instrument. Staff must pay attention to the safe operation of high-pressure gas, ensuring that hydrogen is less than 3 standard atmospheres.
- Many parts of the instrument, including the oven and internal components, inlets and detectors, operate at high temperatures that can cause severe burns. The power supply should be turned off until these parts cool down before servicing such parts.
- After the oven is opened to cool down, the instrument should not be touched during operation, to prevent burns by hot airflow.
- Hydrogen is a flammable gas. Leaked hydrogen can be a fire and explosion hazard if enclosed in a confined space, such as a valve box or oven. Wherever hydrogen is required, all connections, lines, and valves should be leak-tested before using the instrument.
- When using toxic and harmful solvents and detecting toxic and harmful substances, users should pay attention to leading the split outlet of the inlet and the vent of the detector to the outdoor or fume hood with pipelines, so as to avoid the accumulation of toxic gases indoors.
- In case of maintenance, please consult professional maintenance personnel before maintenance. Substitution of other company's spare parts or any unauthorized modification of the instrument may cause a safety incident.

Note:

- Upon receipt of the instrument, the instrument should be inspected for any shipment damage. If there is damage, please contact the supplier within 8 days of reception.
- Please read Chapter 1 before installing the instrument, and Chapter 3 and Chapter 4 before opening the instrument.
- Keep gas and power disconnected before opening the inside of the instrument.
- When using a gas generator, it must be dehumidified and have organic matter removed before it is connected to the instrument; otherwise it may easily cause pipeline pollution.

- Any material that filters and purifies gas has a lifespan and should be replaced in a timely manner, so as to prevent gas pollution.
- Do not move the instrument while it is working.
- The warranty period for the product is one year after delivery, excluding consumables such as septa, liners and columns.
- If there is any problem during the operation of the instrument, please contact your supplier or Drawell Technology Co., Ltd.

2.2 Installation requirements

Table 2-1 Installation requirements

Power requirements	220 VAC, 50 Hz
Space requirements	The test bench should provide enough space for equipment such as GC, PC, and printer, and for various gases (in cylinder gas or gas generator).
Indoor temperature requirements	(15~35)°C, while the best ambient temperature is recommended as 15~28°C.
Relative humidity requirements	(5~95)%RH, preferably not more than 75%.
Installation requirements	The instrument should not be mounted at the places near air conditioners and heaters, or with direct fan blowing or direct sunlight. Exhaust equipment should be installed above the experimental bench.
Gas connection	All gas fittings connected to the instrument use 1/8" compression fittings. The cylinder pressure reducing valve must meet the requirements of gas chromatography.
Carrier gas	Nitrogen: Mass N 5.0 (i.e. 99.999%), 5 bar. Common carrier gas purification devices include dehydration tubes, dehydrocarbon tubes and deoxygenation tubes, all of which are called traps. Universal integrated traps can also be used.
Additional gas	FID/FPD: Hydrogen: Mass N 5.0, 2 bar, with a consumption of about (20~30) mL/min, using hydrogen bottle or hydrogen generator for gas supply. Air: With a consumption of about (200~300) mL/min, 2 bar, using air cylinder or air generator for air supply, preferably employing zero-grade air to obtain lower background noise. ECD only needs nitrogen as make-up gas, rather than hydrogen or air.

Note: a nickel-plated brass pressure reducing valve should be used for nitrogen; while helium/hydrogen needs a special pressure reducing valve. The instrument should never be run without carrier gas.

2.3 Installation process

2.3.1 Instrument acceptance

The installation engineer unpacks the instrument, and checks whether the instrument is damaged and whether the gas chromatograph host, accessories, tools, etc., are complete against the packing list. If any problem is found, it should be immediately reported to the product manager. After taking the instrument out, the personnel should put the packaged materials back in the shipment box and store the empty box.

2.3.2 Instrument placement

The gas chromatograph, computer, and printer should be placed on the bench, and the nitrogen/hydrogen/air cylinder or nitrogen/hydrogen/air generator placed next to or behind the bench.

2.3.3 Gas chromatograph installment

For details, see the installation manual of gas chromatograph.

2.3.4 Installment of PC system and workstation

A PC system consists of a host computer, a monitor, a mouse, a keyboard and a printer.

Place the PC on the test bench, and connect the monitor, mouse, keyboard and printer to the interfaces of the host according to different plug specifications. One end of the PC host power cord is connected to the power jack at the back of the host; the other is connected to a 220 V power supply; and the power cord behind the printer is connected to a 220 V power supply.

Start the PC, insert the software key, and install GC 2000 workstation (including GC 2000 acquisition software and data analysis software).

2.3.5 Connect communication equipment

Connect the LAN port on the back of GC to the LAN port on the back of the PC with a network cable.

Turn on GC 2000, check the IP address, and change the IP address of the PC to the IP address of the same segment of the gas chromatograph (generally, this step is only required when the instrument is installed for the first time), enter GC instrument control software, and the instrument status displays ready.

2.3.6 Instrument debugging and performance testing

Before leaving the factory, the instrument will be tested for the performance of the whole machine to ensure that the instrument is delivered in the best state to the customer. After the engineer has completed the above steps, enable ventilation.

2.3.7 On-site training for users

After completing the above work, the engineer should arrange on-site training for users, train the operation of instrument software, basic maintenance, etc., and conduct on-site Q&A.

3 Man-machine interaction

3.1 Touch screen operation

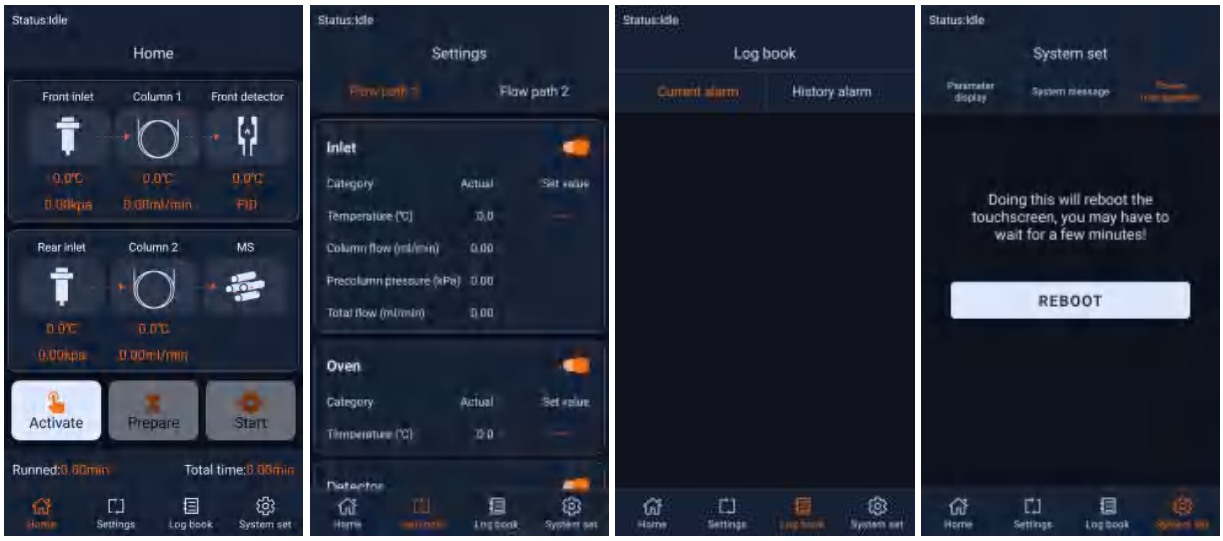


Figure 3-1 Touch screen interface (main interface, method setup, logging and system setup)

The main interface of the touch screen mainly displays the current flow path configuration and parameters of the instrument.

Click the main interface to view the running status of the instrument, the elapsed time and the total method time in real time, and view the inlet (temperature and precolumn pressure), column oven (temperature and column flow), and detector (temperature and type), and other real-time status parameters, and execute related commands, such as method activation, method preparation, method start/stop.

The method parameters can be set on the touch screen method setting. Click the method setting to set and save the currently configured parameters, such as inlet temperature and pre-column pressure, column oven temperature, detector temperature and flow rate.

Click the log record to view the alarm information, including current alarm information and historical alarm information;

Click the system settings to perform operations such as flow configuration, system information, power management, and setting the GC IP address.

3.2 Acquisition software operation

Double-click the GC 2000 acquisition software to enter the user login interface. It is required to enter the password admin (administrator as the default user name) to enter the main interface of the software. After entering the main interface, the power-on self-test will be performed. If the self-test is not passed, it means that the communication has failed. It is necessary to check whether the network port is connected normally, and whether the computer IP address and the GC IP address are in the same network segment; if there is no prompt, the instrument status displays ready, it means that the self-test is passed, and the access will be given to the main interface of the GC 2000 acquisition software.

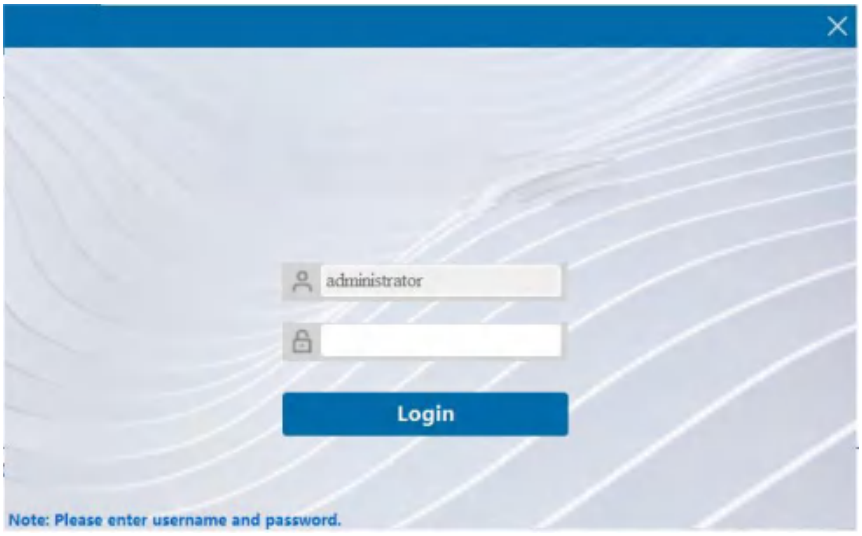


Figure 3-2 User login interface

3.2.1 Status

(1) Status display on the main interface

Figure 3-3 Main interface status display window

Running status: fault/alarm, ready, not ready, ready for sample, running, stopped, post-run;

Instrument status: offline, fault/alarm, ready;

Sample name: displays the sample name of a single sample analysis or sequence injection;

Data file: display the result path of single sample analysis or sequence injection;

Single run: click the single run button for single sample analysis;

Running time: the top is the method running time progress, and the bottom is the total method running time;

Stop method: click the Stop Method button to stop the current single run and sequence run;

Work log: click the Work Log button to view the activity log which includes the time (date and time), user,

type and content (details) of the activity. The query can be filtered by time range and log type (syslog, run log, and instrument action).

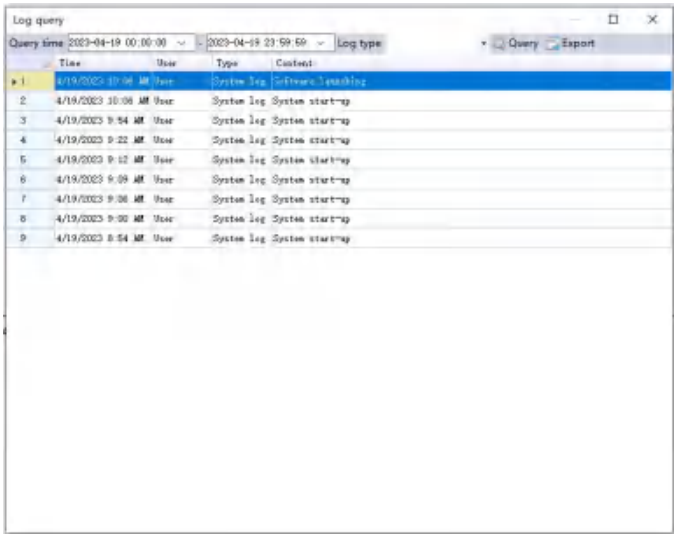


Figure 3-4 Log query window

Ready state: Click the Ready state button to enter the ready state view window; click Auto Refresh to view modules that are not ready; and click Manual Refresh to view that a specific parameter of the module is not ready.

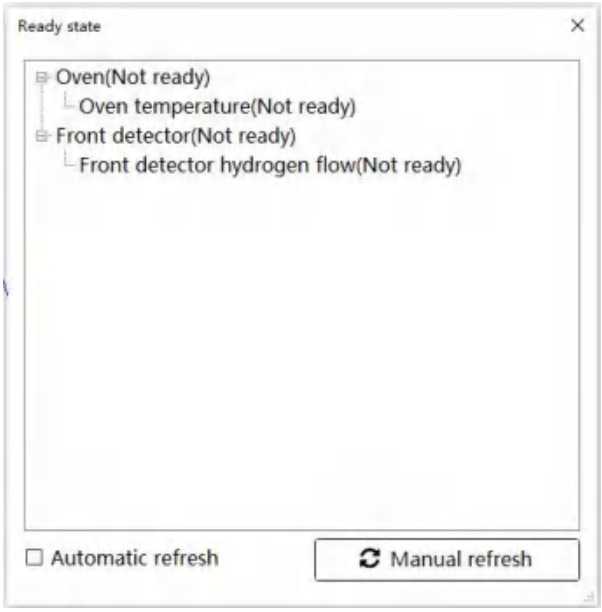


Figure 3-5 Ready status view window

Note: The ignition status of the detector includes five types: to be ignited, igniting, ignited, not ignited and flameout.

(2) Shortcut buttons

Figure 3-6 Shortcut window

Sequence: call sequence, edit sequence, run sequence; click the edit sequence button to quickly enter the sequence table editing interface; the function of the run sequence button is the same as that of the run button in the sequence table.

Method: call method, edit method, run method; click the edit method button to quickly enter the current method editing interface;

Instrument: inlet, column oven, detector; click the inlet, column oven, detector button to quickly enter the method editing window of each module.

Note: Running method is the process that the instrument runs and analyzes the sample according to the currently activated method.

(3) Monitoring column

Figure 3-7 Monitoring windows (up to 8 by default)

Users may view the real-time parameters of each module in the monitoring window, including instrument status, method running time, parameter status of modules such as front/rear inlet, column oven, front/rear detector, and auxiliary EPC. They can also customize and select monitoring parameters, and the monitoring window displays 8 by default.

(4) Online signal

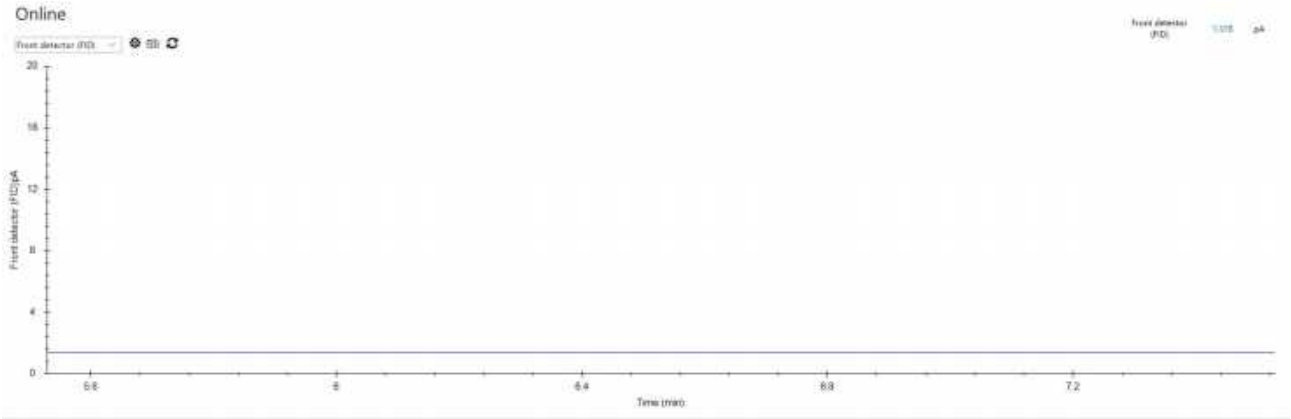


Figure 3-8 Online signal window

Click the drop-down box of online signal display to select double-layer signal display/display only signal 1/display only signal 2;

Click ⚙ to enter the signal setting window, where users can set the signal X- and Y-axis ranges (adaptive growth/limiting range) of signal source 1/2, and click Save;

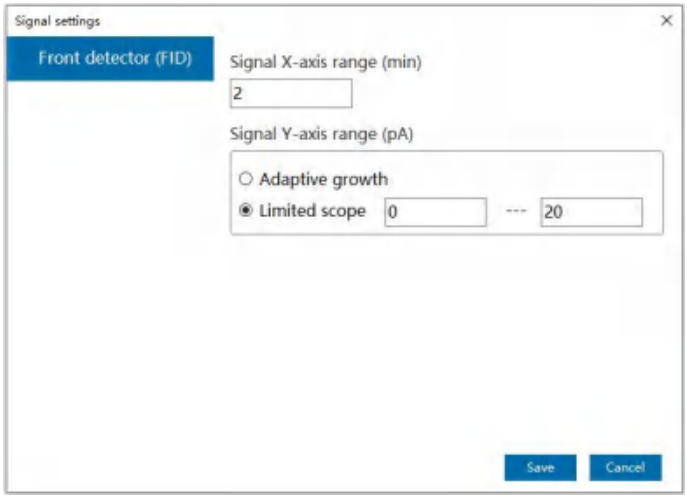


Figure 3-9 Signal setup window

Click to take a snapshot of the spectrum;

Click to restore the online signal to the initial state.

Note: When a single injection or sequence injection is running, users may click the spectrum snapshot function in the online signal window to analyze the data collected so far. The currently collected data can be opened and processed with the analysis software, and the instrument continues to collect data.

The spectral signal can be selected by the left and right mouse buttons to zoom in by dragging (when a cross appears) or dragging the coordinate axis (when an arrow appears).

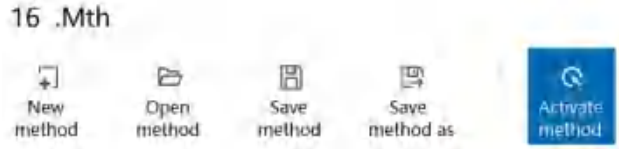
3.2.2 Method

An analytical method is a collection of parameter values that the instrument needs to set when running a single sample. It includes parameters such as inlet temperature, flow rate, oven temperature, detector temperature and flow rate. Activating the corresponding method can quickly restore the instrument to the optimal operating state without resetting all parameter values.

Method includes New Method, Open Method, Save Method, Save Method As, Print Method, and Method Activation.

Note: After entering the method interface, users may create a new method, and edit the method properties, enter the method configuration editing interface. Click Configure to perform unit selection, chromatographic column configuration (for flow path configuration), check ready status, module gas type selection and detector configuration, and then edit the method parameters of each module.

3.2.2.1 Method edit



Click the [New method] button to create a new injection method, and the system will name it by default. Click save method to show a pop-up box of storage address. Users may modify the method file name, but the method file storage path is constant;

Click the [Open method] button, find the path of the previously saved method, select the method file, and click open to call the saved method and overwrite the currently edited method;

Click the [Save method] button to save the currently edited or modified method;

Click the [Save method as] button to save the current method to the specified path and modify the method name;

Click the [Activate method] button to ensure the instrument reaches the analytical running state according to the currently set method. After the method is activated, the parameters in the current method will reach the set value: the state of each configuration of the instrument (such as detector, injection port), including temperature and the flow rate of each gas path, will reach the set value in the method.

Note:

Before single injection or sequential injection, users must ensure that the ready status of each module of the instrument is checked, otherwise the instrument will run the method under the state that the set value is not reached, which will affect the sample analysis effect.

3.2.2.2 Method attribute

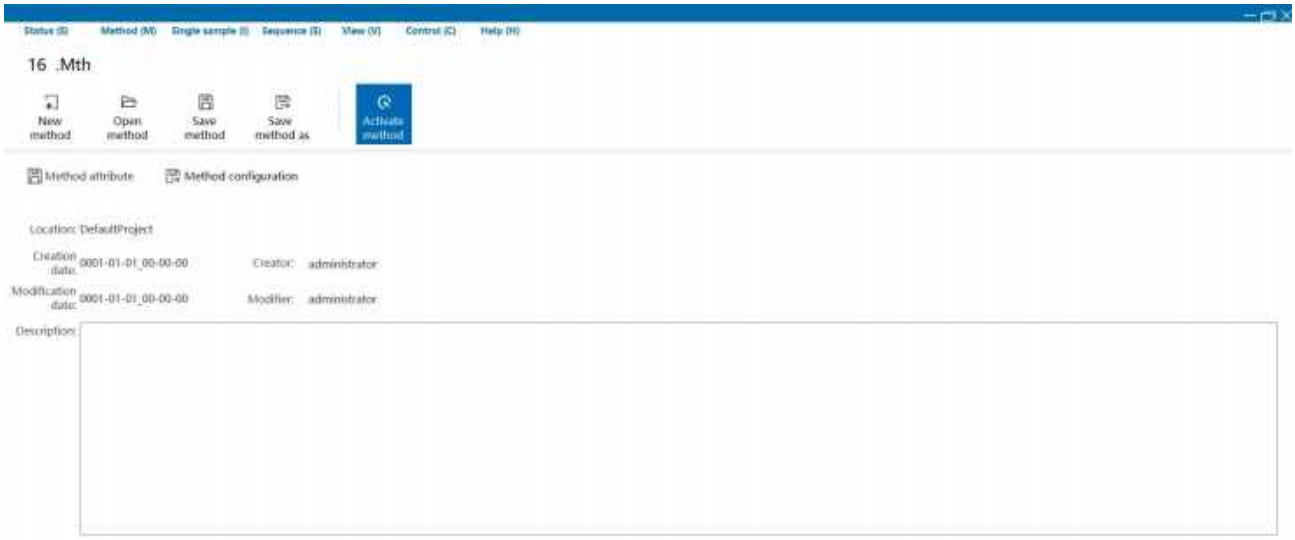


Figure 3-10 Method attribute interface

Location: the default storage path of the current method;

Creation date: the date and time when the current method was created;

Modification date: the date and time after the current method is modified and saved;

Description: for commenting on the current method.

3.2.2.3 Method configuration

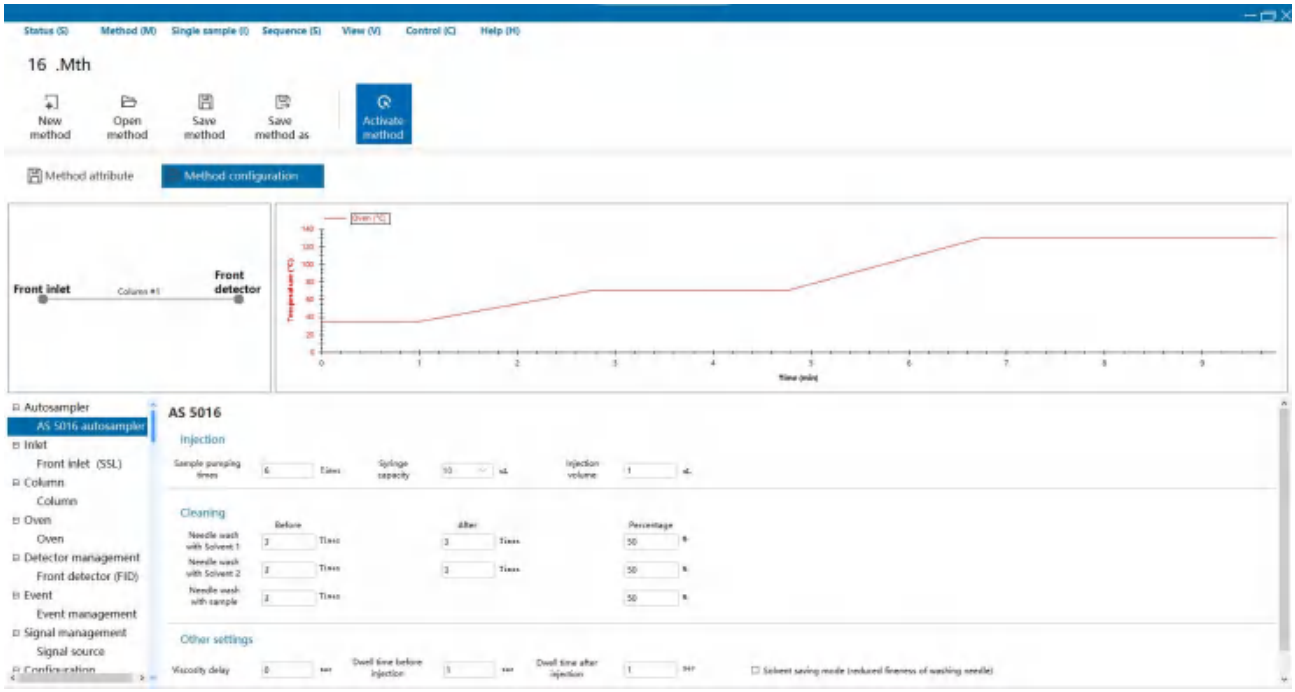


Figure 3-11 Method configuration interface

(1) Autosampler (optional)

If autosampler is selected as the injection source in single injection and sequential injection, the autosampler method needs to be edited. There are autosamplers available, such as AS 5016, AS 5110, AS 3091 and AS 3016.

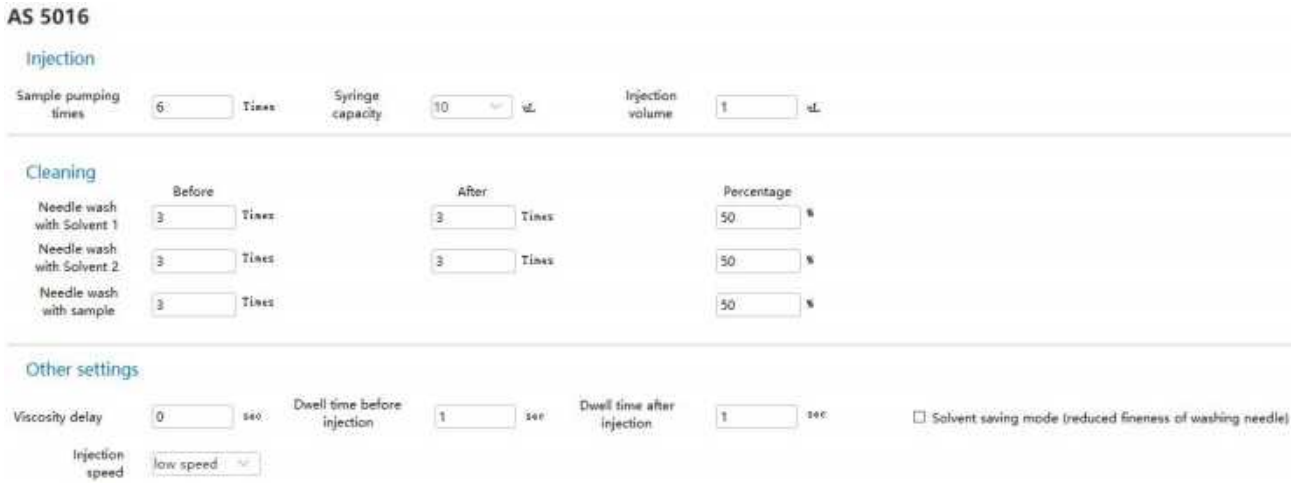


Figure 3-12 Method Edit Window of AS 5016 Autosampler

According to the configured autosampler, perform injection, cleaning (the number of needle washes and usage) and other settings, and select the connection port (com port) to automatically identify the autosampler model.

- Injection

Number of pump samples: set the number of times to pump samples to the injection needle before injection between 0~15.Syringe pumping is mainly to ensure eliminate air bubbles in the sample drawn from the sampling needle during each injection, so as to prevent it affecting the actual measurement results. Generally, the number of pumping samples is available between 4~5.

Syringe volume: click the drop-down box; the syringe volume can be 1, 5, 10, 25, 50, 100, 250 and 500 μL;

Injection volume: for entering injection volume;

- Cleaning

Solvent 1 needle wash: Set the number and usage of solvent 1 needle wash before or after injection. The number of needle washes can be selected between 0~20. Users may set the amount of needle washing independently (represented by %), but the amount should not be more than 70%, within the range of the syringe used (100%).

Solvent 2 needle wash: Set the number and usage of solvent 2 needle wash before or after injection. The number of needle washes and the amount used are the same as above.

Solvent 3 wash: Set the number of solvent 3 needle washes and the amount used before or after injection. The number of needle washes and the amount used are the same as above.

Sample needle wash: Set the number of sample needle washes and the amount used before or after injection. The number of needle washes and the amount used are the same as above.

- Other settings

Viscosity delay seconds: Some sample solutions have high concentration (or viscosity). Therefore, it is necessary to draw slowly or wait for a period of time to ensure that the sample is completely drawn. The waiting time is the viscosity delay time, which is generally set to be 2 s.

Dwell seconds before/after injection: Dwelling before injection is a hot needle process to ensure that samples to be analyzed with different boiling points can be fully or completely vaporized during injection. Dwelling after injection is to ensure that the sample that may remain at the tip of the injection needle is completely vaporized after injection, and is generally set to be 3 s.

Syringe sampling speed: Set the speed value when the syringe takes samples.

Syringe injection speed: Set the speed value of the syringe injection.

(2) Sample inlet

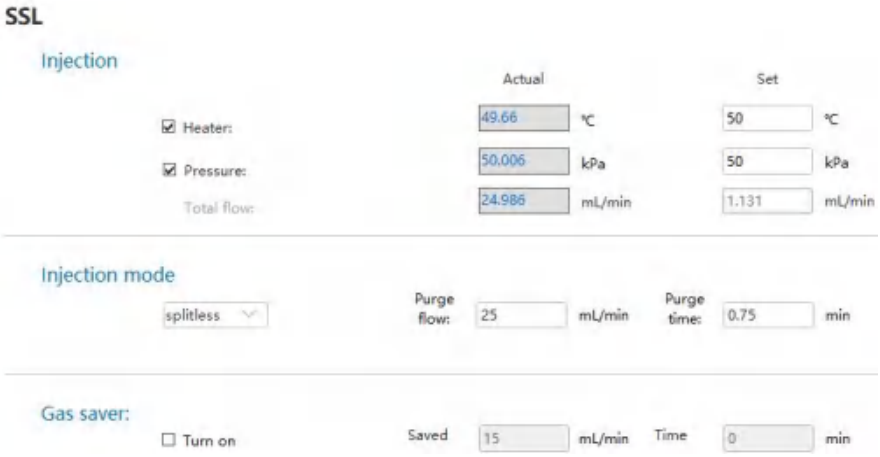


Figure 3-13 Inlet method edit window

The types of front and rear inlets include split/splitless injection inlets and packed column inlets (optional). Users may set specific parameters of each inlet (inlet temperature, pressure, etc.), select the injection mode, and decide whether to enable the carrier gas saver, etc.

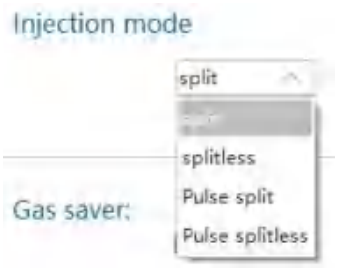


Figure 3-14 Four injection modes

There are four injection modes: split, splitless, pulse split and pulse splitless injection. Split injection mode is used for the analysis of components with higher content, where the split ratio needs to be set, and the split flow rate is equal to the column flow multiplied by the split ratio; splitless injection is used for the analysis of trace components, where the purge flow and purge time need to be set; pulse split injection sets the pulse pressure and pulse time on the basis of splitting, allows fast injection, primarily to speed up the sample entering the chromatographic column and prevent the sample from decomposing at the inlet; pulse splitless injection allows larger sample injection than pulse split injection.

Note: Purge flow is enabled by default in splitless injection mode. In the splitless injection mode, all the injected samples will enter the chromatographic column, which can easily lead to overloading of the chromatographic column and affect the analysis effect. The carrier gas purging function is to turn on the split function after a period of time (usually 1~2 min) after the sample is injected to prevent all the sample from entering the chromatographic column.

Pulse injection is an additional feature provided when fast injection is required. When this function is necessary, choose pulse split or pulse splitless injection mode; the set pressure value is greater than the pre-column pressure value used for normal analysis, and the duration is usually 0.2~0.5 min. Increase the inlet pressure at the beginning (at the "Pulse Pressure" setting) and return to normal pressure after the specified time (at the "Pulse Time" setting).Pulse injection maintains a high pressure at the inlet, and the sample enters the chromatographic column at a fast speed to reduce the chance of sample decomposition at the inlet. From the end of the injection to the end of the analysis, the inlet pressure drops to the pressure corresponding to the column flow. Pulse injection is recommended when the sample is thermally unstable.

Carrier gas saver is an additional feature that saves unnecessary carrier gas waste. When this function is necessary, check it to enable, and the set flow value is smaller than the total flow value used for normal analysis. This function is available when the sample is injected for a period of time (usually 4~5 min), that is, the total flow is reduced to the carrier gas saving set value after 4~5 min.

(3) Chromatographic column

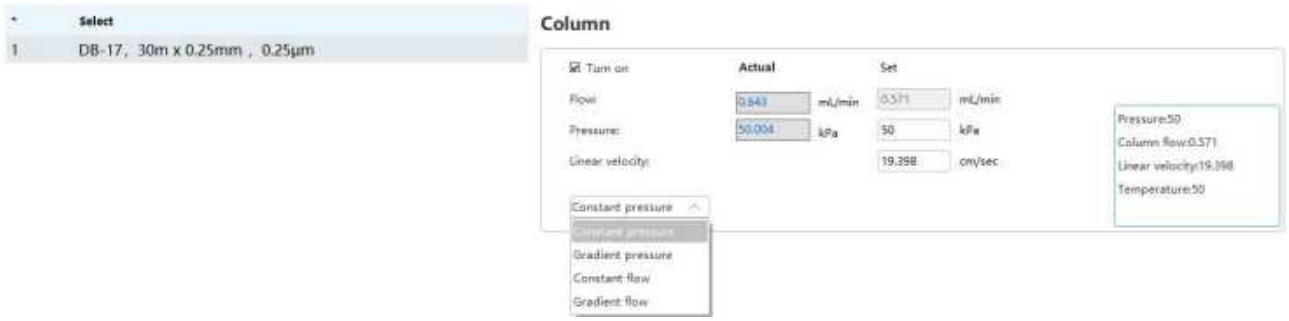


Figure 3-15 Chromatographic column method edit window

It can set specific parameters such as flow and pressure, and select the flow mode. There are 4 flow modes: constant pressure, gradient pressure, constant flow, and gradient flow. Both gradient pressure and gradient flow support 3 stages and 4 segments.

Figure 3-16 Gradient pressure edit interface

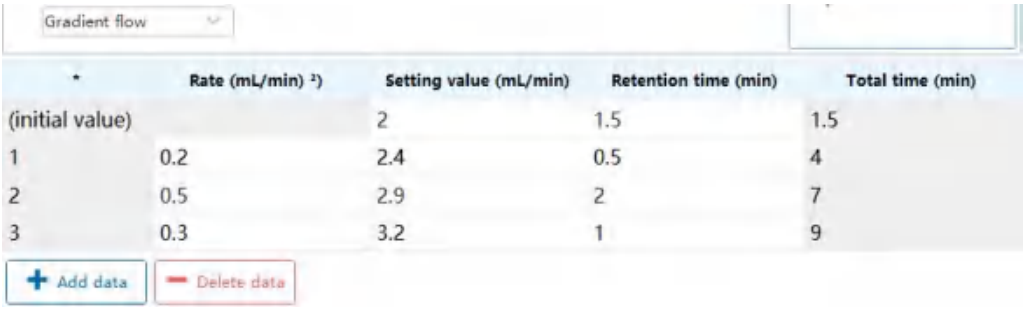


Figure 3-17 Gradient flow edit interface

Note:

Regardless of the control mode (constant voltage, constant current, programed boost, programed boost), the pulse injection function has the highest priority.

(4) Column box

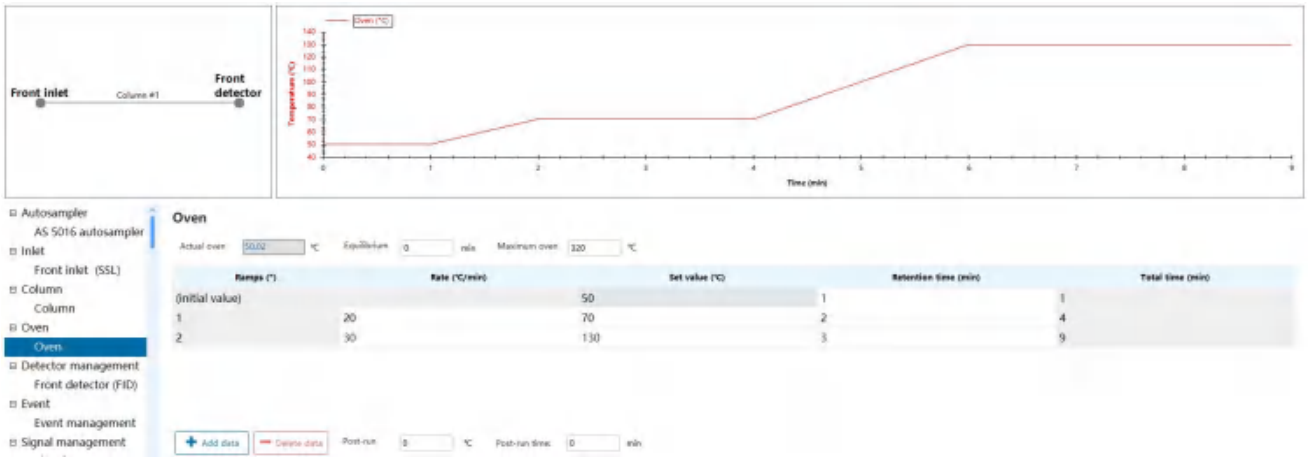


Figure 3-18 Oven method edit window

Users may set specific parameters, such as column oven equilibration time, maximum oven temperature, oven temperature (initial temperature, ramp rate, target temperature, hold time, etc.), post-run temperature and time. GC 2000 features constant temperature and programmed heating/cooling operations, which are designed for samples with a narrow boiling point range and a wide boiling point range, respectively.

The order can be added by adding data on the window, while the selected order can be deleted by deleting data. The set temperature program is displayed above the setting area in the form of a curve.

Note: Equilibration time refers to the time that the column oven stabilizes at the specified temperature before running, that is, after the system reaches the set temperature from the non-set temperature of the column oven, the time allows the system to maintain the temperature for a period of time and then run the method.

The maximum oven temperature refers to the maximum set temperature in the editing oven constant temperature or programed heating and cooling. Generally, the set value cannot exceed the maximum working temperature of the chromatographic column.

Post-run means that after the run is completed, the temperature is rapidly raised to the high temperature section, and the temperature of the column oven (post-run temperature) is maintained for a period of time (post-run time), which is used to bake out high-boiling impurities in the chromatographic column for an extended period of time. The signal is recorded and does not count towards the total time to run the method.

(5) Detector management

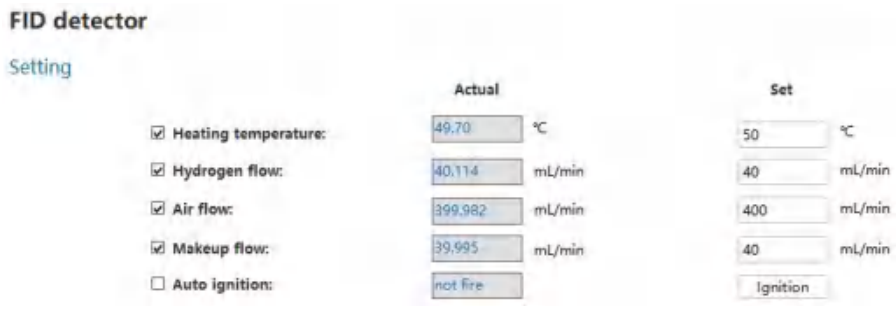


Figure 3-19 FID method edit window

The front and rear detectors include FID, ECD and FPD. Parameters specific to each detector (detector temperature, nitrogen-hydrogen air flow, ignition, etc.) can be set.

Users may check Auto Ignition, click Method Activation, and the detector will automatically ignite when the temperature and flow rate of the detector reach the ready state; users can also uncheck Auto Ignition, click the Method Activation, and click the Ignition button after the instrument is ready. Both automatic ignition and manual ignition can achieve FID/FPD ignition.

(6) Events

Figure 3-20 Event management method edit window

Event management is mainly to set the timing of valve injection, and control the sampling and injection time. Auxiliary EPC pressure setting is available for the non-methane total hydrocarbon version. Click Add Event to add an event, and click Delete Event to delete the selected event.

(7) Signal management

Figure 3-21 Signal management method edit window

Signal management can set specific parameters such as signal source and data acquisition frequency. The signal source can be selected from none or a front/rear detector. The signal acquisition frequency means the number of signal points taken per second, and the data acquisition frequency can be 10, 20, 50, 100 and 200 Hz.

Note:

An excessively high signal rate will intensify signal noise; conversely, too low a signal rate can distort chromatographic peak shape.

---

(8) Configuration

The instrument analysis method is based on the actual instrument configuration, so it is necessary to determine the instrument configuration before editing the instrument acquisition method. The configuration mainly includes five parts: others, chromatographic column, ready state, module and detector configuration.

- Others

Three pressure units available: kPa, psi, bar.

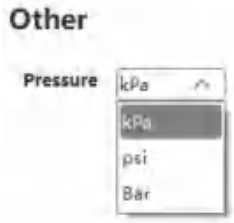


Figure 3-22 Other configuration windows

- Chromatographic column

By clicking Add and Delete, users may configure the flow path, and click Edit to edit the column information or choose the column, and select the column inlet, outlet and heating device. The inlet has 5 options: front inlet, rear inlet, auxiliary EPC1, auxiliary EPC2, and unspecified. The outlet has 6 options: front detector, rear detector, auxiliary EPC1, auxiliary EPC2, and MS. The heating device has 3 options: oven, valve box, and others.

Note: The selection of inlet and outlet depends on the module configuration. For example, if the module configuration selects the front inlet and the front detector, while other modules do not use them, the inlet will only have 2 options (i.e. the front inlet and the unspecified), and the outlet will only have 3 options (i.e. detector, MS and others).

Figure 3-23 Chromatographic column configuration window

In the Edit Column Information window, users may edit the column parameters (column length, inner diameter, film thickness) and name, etc., and select the column type (capillary and packed column). Click "Save to Local" to save the column to the local library, or click "Select from Catalog" to enter the column library management interface to select the corresponding column, and click "OK" to complete the editing of the column information.

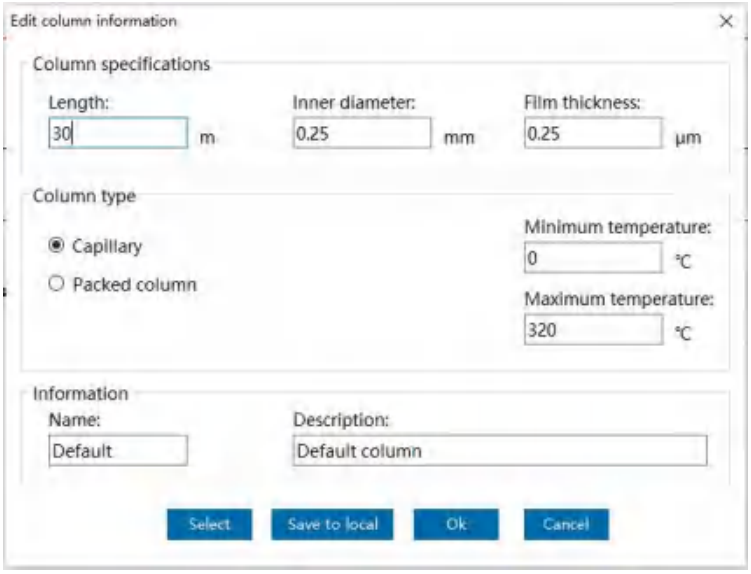


Figure 3-24 Edit Column Information Window

- Ready state

Users may check each module to judge the ready state of the instrument, including the front inlet, rear inlet, column oven, valve box, front detector, rear detector, auxiliary EPC1 and auxiliary EPC2 modules. For example, if the oven is checked, the instrument will judge whether the temperature of the oven reaches the set value of the currently activated method, and the status of other modules that are not checked will not be judged. When the oven temperature reaches the set value, the running status shows ready; otherwise, the running status shows not ready.

Note: Modules in the ready state are based on the module configuration usage selection.

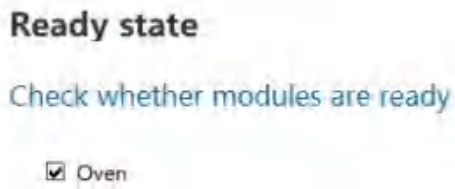


Figure 3-25 Ready state configuration window

- Module

It is possible to configure and choose the gas types of the inlet, detector and auxiliary EPC modules. There are 3 options for inlet gas types: nitrogen, hydrogen and helium.

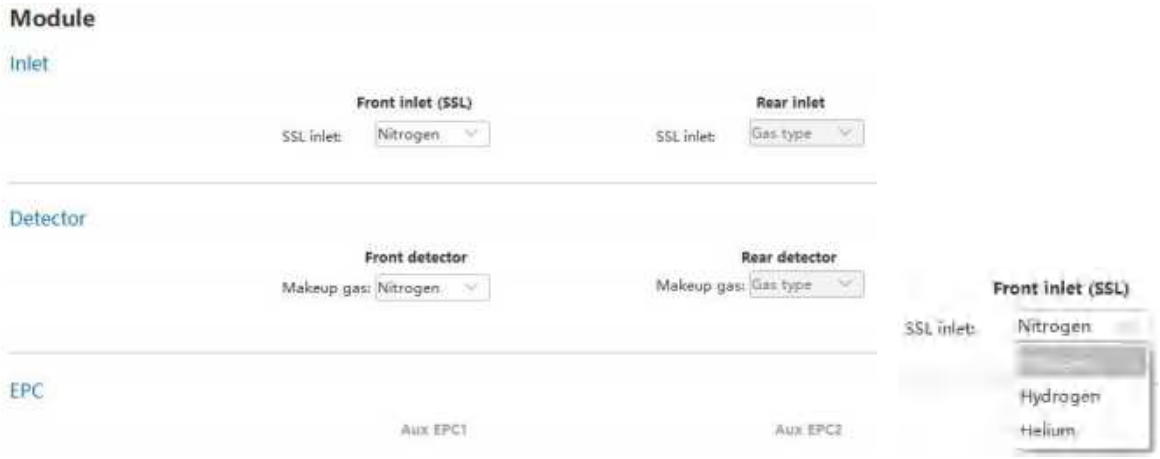


Figure 3-26 Module configuration window

- Detector

The front/rear detectors can be configured, including parameters such as ignition judgment, ignition duration, and ignition flow.

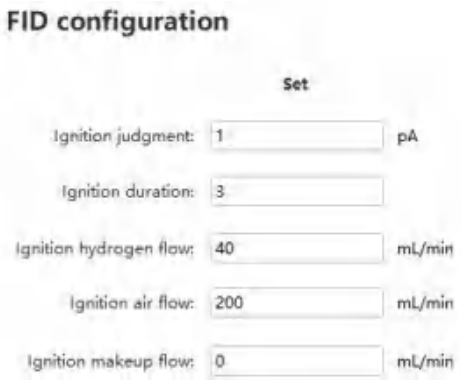


Figure 3-27 FID configuration window

FID: A hydrogen flame ionization detector, which can set parameters such as ignition judgment, ignition time, ignition hydrogen flow, ignition air flow and ignition makeup flow.

FPD: A sulfur and phosphorus detector, which can set parameters such as ignition judgment, ignition time, ignition hydrogen and air flow, PMT voltage and PMT ignition voltage.

3.2.3 Single sample

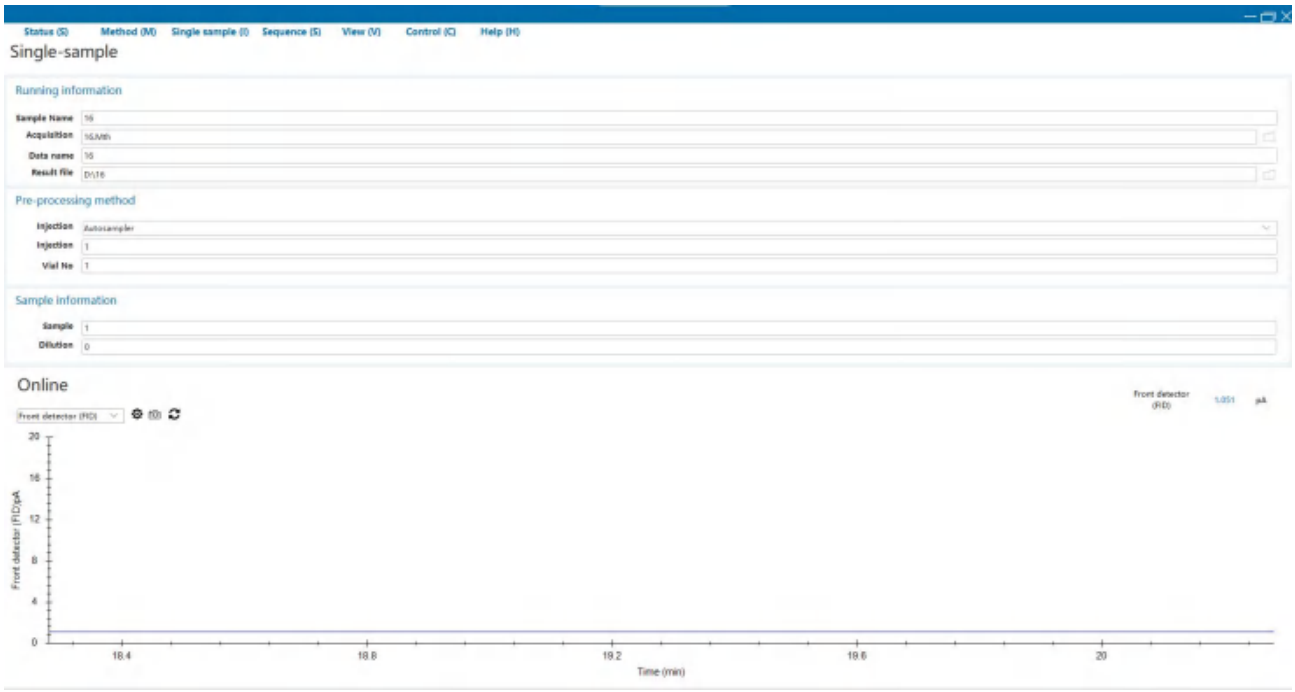


Figure 3-28 Single sample analysis edit window

3.2.3.1 Running information

Sample name: Set the name of the current sample, which will be displayed in the report generated by the analysis, and can be customized according to the actual sample, such as hexadecane, methyl parathion;

Collection method: The method used to collect the data;

Result path: The location where the data file is stored after the operation is completed, and the storage path can be customized and selected;

Data name: The name used when the data file is saved.

3.2.3.2 Preprocessing method

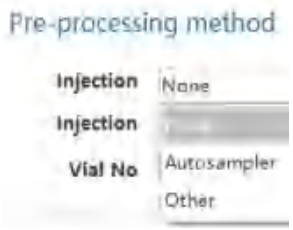


Figure 3-29 Preprocessing method selection interface

Sampling source: there are 3 options: autosampler, others (pre-processing equipment) and none (manual injection);

Injection volume: the amount to be injected (microliters), where users should also set the injection volume of the injection needle according to the actual needs, which is generally 1 μL if injecting through an autosampler;

Sampling vial number: Set the position of the currently injected sample on the sample tray of the autosampler.

3.2.3.3 Sample information

Sample content: The concentration of the sample used for injection before dilution;

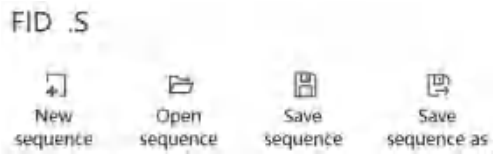
Dilution factor: The dilution factor of the sample, which is mainly used for sample processing of analysis software.

3.2.3.4 Online signal

Consistent with the status/online signal.

3.2.4 Sequence

3.2.4.1 Sequence editing



Sequence refers to the list of samples to be analyzed and the method used for each analysis.

Click the [New Sequence] button to create a new injection sequence with default name. Click Save Sequence to show the storage address pop-up box. Users may modify the sequence file name, but the file storage path is constant. All information in the sequence table needs to be re-entered;

Click the [Open Sequence] button, choose the path where the target sequence file is saved, and select the corresponding sequence file. Click the Open button to call the saved sequence file and overwrite the currently edited sequence;

Click the [Save Sequence] button to save the currently edited or modified sequence file;

Click the [Save Sequence as] button, select the target path and modify the file name. Click OK, then the sequence file will be saved in the specified path.

3.2.4.2 Sequence attribute

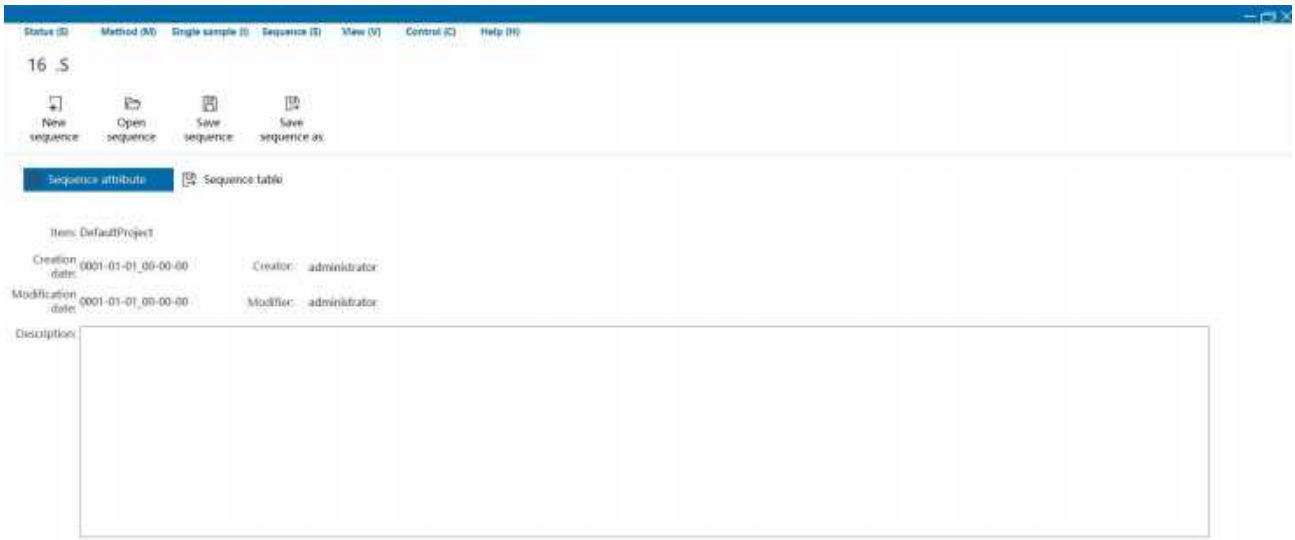


Figure 3-30 Sequence attribute interface

Item: the default storage path of the current sequence;

Creation date: the date and time when the current sequence was created;

Modification date: the date and time after the modification and saving of the current sequence;

Description: for commenting on the current sequence.

3.2.4.3 Sequence list

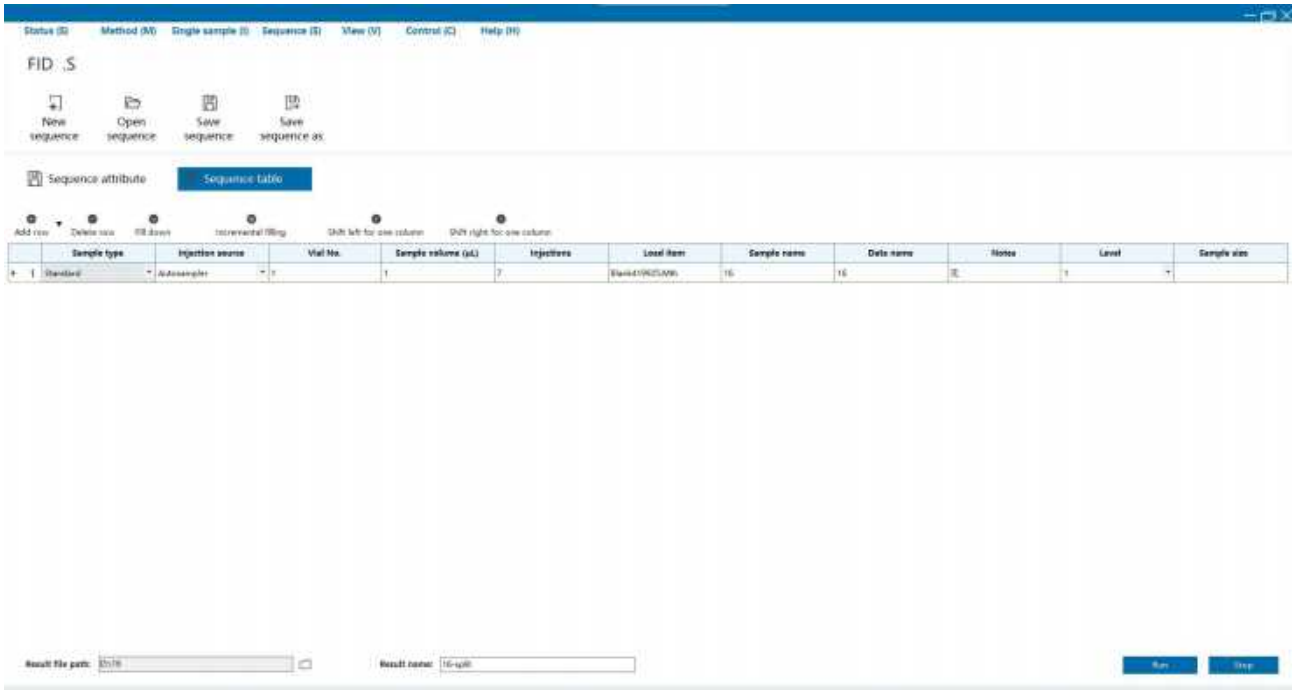


Figure 3-31 Sequence list editing interface

(1) Sequence list editing

Click the [Add Row] button to add a new row sequence based on the existing sequence.

Click the [Delete Row] button to delete the unneeded sequence of the selected row; if multiple rows are selected, the selected row will be deleted by default.

Click the [Fill Down] button, or right-click fill this column down, then all cells below the selected cell will have the same value as the selected cell;

Click the [Incremental filling] button, or right-click fill this column incrementally, then the values of all cells below the selected cell will be incremented;

Click the [Shift left for one column] button, then the selected column will move forward;

Click the [Shift right for one column] button, then the selected column will move backward;

Right-click - Edit Column: for editing the header display required by the sequence table, and it will be displayed when checked.

Right-click - Copy: copy the selected line of sequence information;

Right-click - Paste: paste the copied line of sequence information to the selected line; select multiple lines, and paste the last selected line by default;

Right-click - Insert Row: insert a blank row before the selected row of sequence information;

Right-click - Delete: delete one or more lines of sequence information selected.

(2) Parameter meaning

The meanings of each parameter in the sequence table editing window list are as follows:

Sample type: Set the current sample type, which can be selected from unknown, sample, blank, spiked and standard sample options;

Sampling source: 3 options available, namely autosampler, others (pre-processing equipment) and none;

Sampling position: Set the position of the currently used sample on the sample tray of the autosampler;

Sample volume: The amount to be injected (microliters), where users should also set the injection volume of the injection needle according to the actual needs, which is generally 1 μL;

Injection times: Set the injection times of a line in the sequence between 0~999;

Load project: The method used to collect data;

Sample name: Set the name of the current sample, which will be displayed in the report generated by the analysis, and can be customized according to the actual sample, such as hexadecane, methyl parathion;

Data name: The name used when saving the data file;

Description: For note description;

Level: The standard level, for calibration standard;

Sample content: The concentration of the sample used for injection before dilution;

Result path: The path where the data file is saved, which is selectable;

Result name: the file name under the save path of the data file;

Run: After the sequence is edited and saved, click Run to submit the sequence table. After the instrument is ready, the instrument will perform data acquisition and analysis in the order of the currently saved sequence, and the real-time spectrum will be displayed in the Status/Online Signal window. After clicking Run, the button will change to Pause; click Pause, the instrument will finish running the current sample, and other sequences will wait to run; after clicking Pause, the button will change to Continue; click Continue, the instrument will run the rest of the sequence according to the sequence table.

Stop: When the sequence is running, the sequence will stop running and the real-time spectrum will stop collecting data.

3.2.5 View

Click View/View Edit to enter the view edit window. The windows are classified by modules. Users may select the window and click "Add" or "Remove" to customize the necessary parameters to monitor, and configure up to 8 parameters. Click "Restore Ex-factory", the default selected window is the column oven temperature; click "OK" to show the selected window in the status-monitoring column.

Figure 3-32 View edit window

3.2.6 Control

3.2.6.1 Switch user

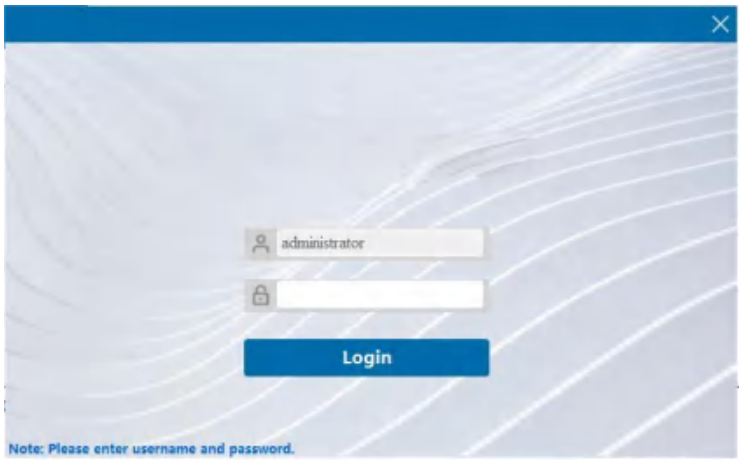


Figure 3-33 User login interface (user name and password required)

Click [Control/Switch User] to log in other users (can be customized according to requirements). Users need to re-enter the user name and password to enter the acquisition software for related operations.

3.2.6.2 Lock screen

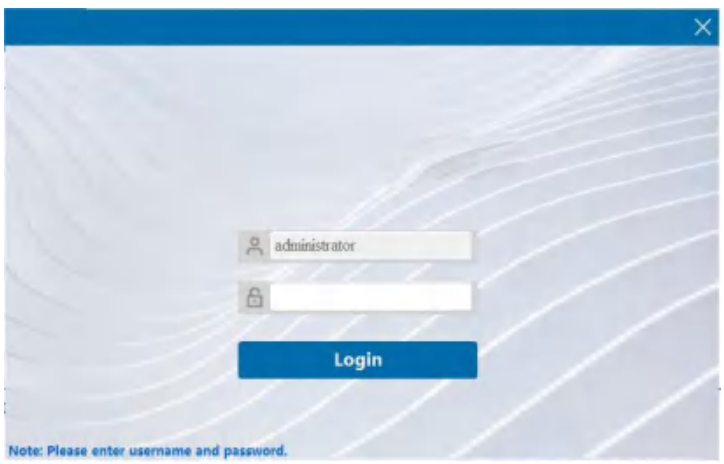
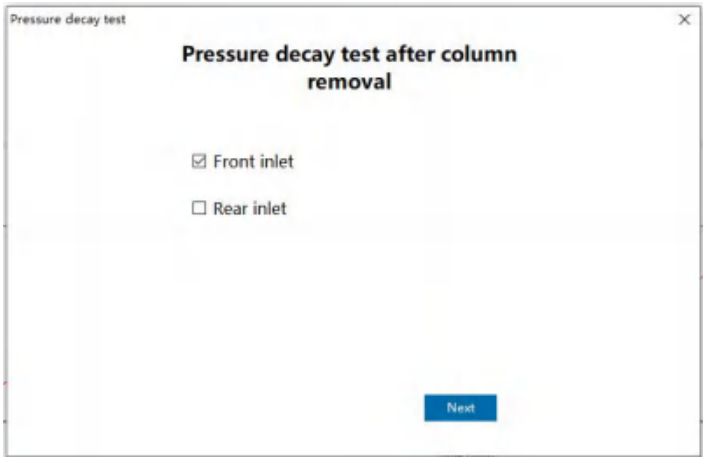
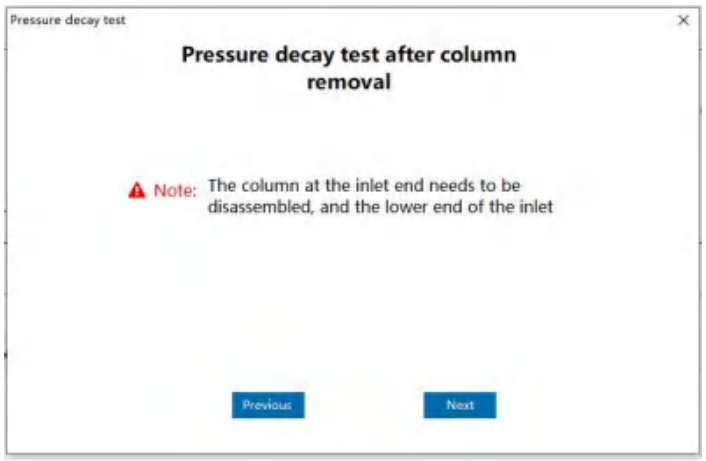


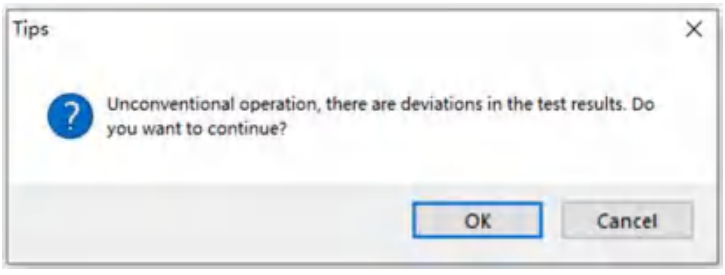
Figure 3-34 User lock login screen (password required)

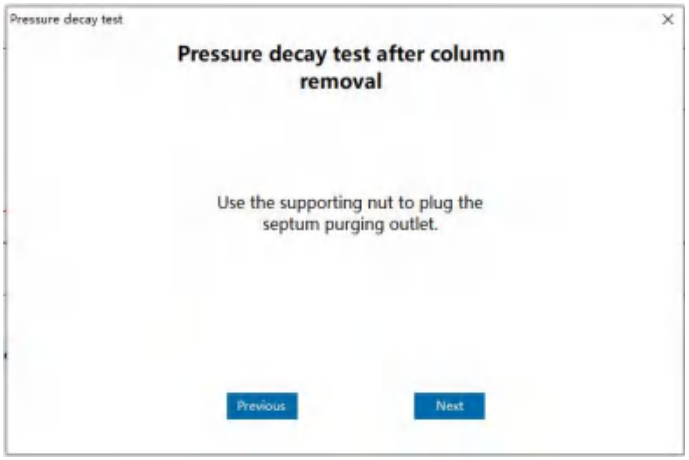
Click [Control/Lock Screen] to lock the current user, where any operations cannot be performed on the software. To resume operation, users only need to re-enter the password to enter the acquisition software without the necessity to enter a user name. If no one operates the software within 5 min, the acquisition software will automatically lock the screen.

3.2.6.3 Pressure decay test









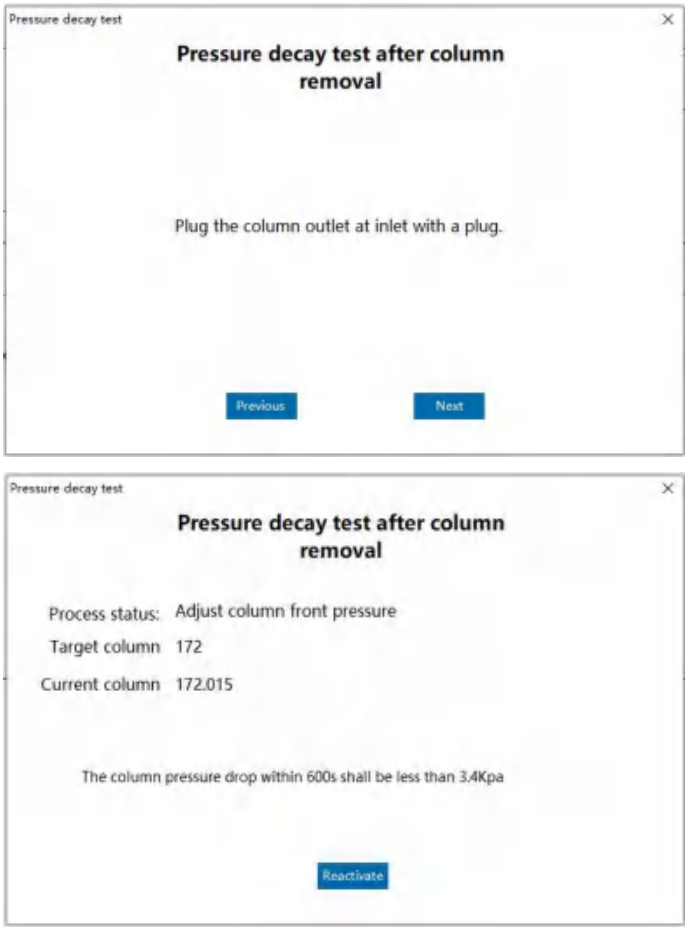


Figure 3-35 Pressure decay test window

The pressure decay test is the holding pressure test, which is used to determine whether the inlet system is leaking. The internal and external air tightness test will be carried out in the factory test of the instrument, so users generally do not need to carry out the pressure decay test when using the instrument.

Click [Control/Pressure Decay Test] to select the front/rear injection port for pressure decay test. Check the location of the inlet, click "Next", follow the test steps to remove the chromatographic column, and judge whether the temperature of the inlet and column oven is below 50°C, then click "Next", and "OK". Follow the prompts "Please use the matching nut to block the septum purge outlet" and "Please use the chromatographic column plug to block the injection port chromatographic outlet", use the sealing nut and the chromatographic column plug, respectively, to block the septum purge outlet and the inlet chromatographic column connection port. Click "Next" to start the pressure decay test. A drop value of the precolumn pressure exceeding 3.4 kPa within 10 min indicates an air leak in the inlet system, when the positioning problem needs to be checked.

3.2.6.4 Communication settings

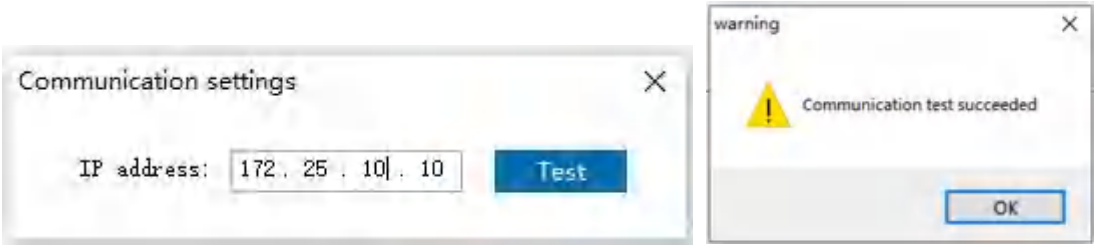


Figure 3-36 Communication settings window

Click [Control/Communication Settings], enter GC IP address 172.25.10.10, and click "Test" to test the communication connection. If it shows that the communication test failed, it means the failure of communication, and the positioning problem needs to be checked.

3.2.6.5 Module configuration

Figure 3-37 Module configuration window

Click [Control/Module Configuration] to enter the module configuration interface, click "Read" to read the use or non-use status of all configuration modules of the current instrument; to change the module use status, click "Set" to change the use or non-use status of each module.

3.2.7 Help

3.2.7.1 About

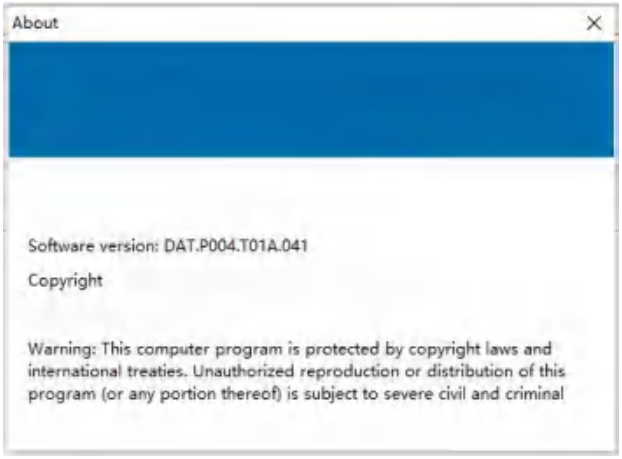


Figure 3-38 About the view window

Click [Help/About] to view GC 2000 acquisition software version and company website and other related information.

3.2.7.2 User Manual

Click [Help/User Manual] to view GC 2000 User Manual.

3.2.7.3 Instrument information

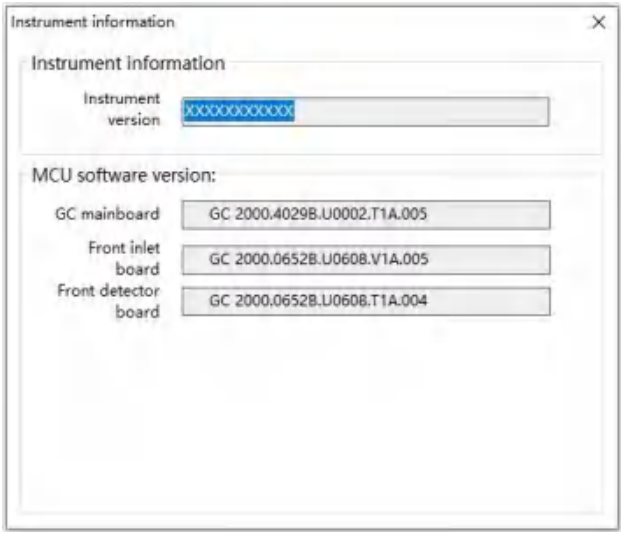


Figure 3-39 Instrument Information Window

Click [Help/Instrument Information], and click Read to view the instrument version and MCU software version information.

3.2.7.4 Alarm query

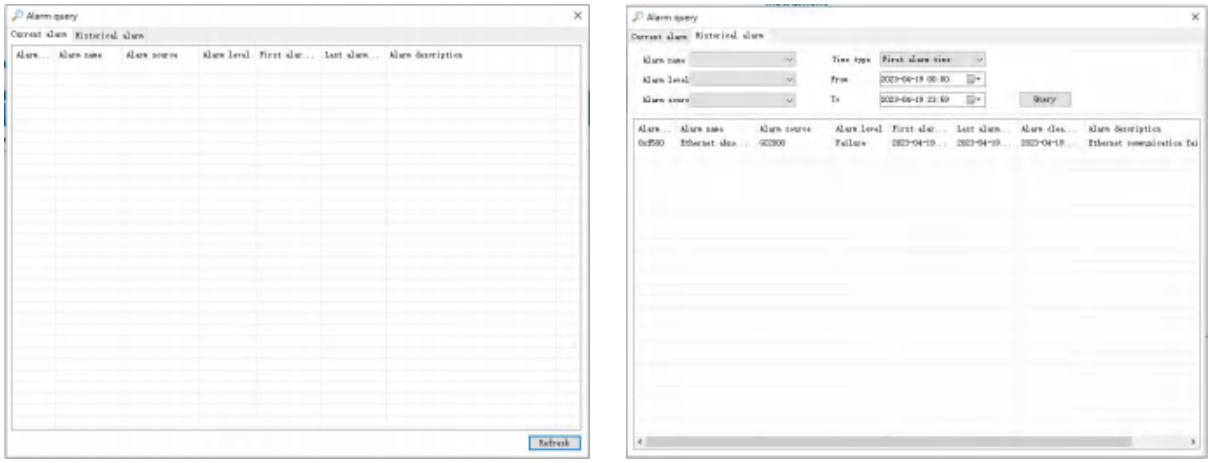


Figure 3-40 Alarm query window (current alarm - left, historical alarm - right)

Click [Help/Alarm Query] to view the current alarm information and historical alarm information. This information is used to prompt the current or historical problems of the instrument, which is convenient for troubleshooting and locating the cause. In the current alarm window, click "Refresh" to view the current latest alarm information. Historical alarms can be filtered and queried by alarm name, alarm level, alarm source, time type and time range.

3.3 Data analysis software operation

Double-click the icon of the GC 2000 analysis software to enter the main interface.

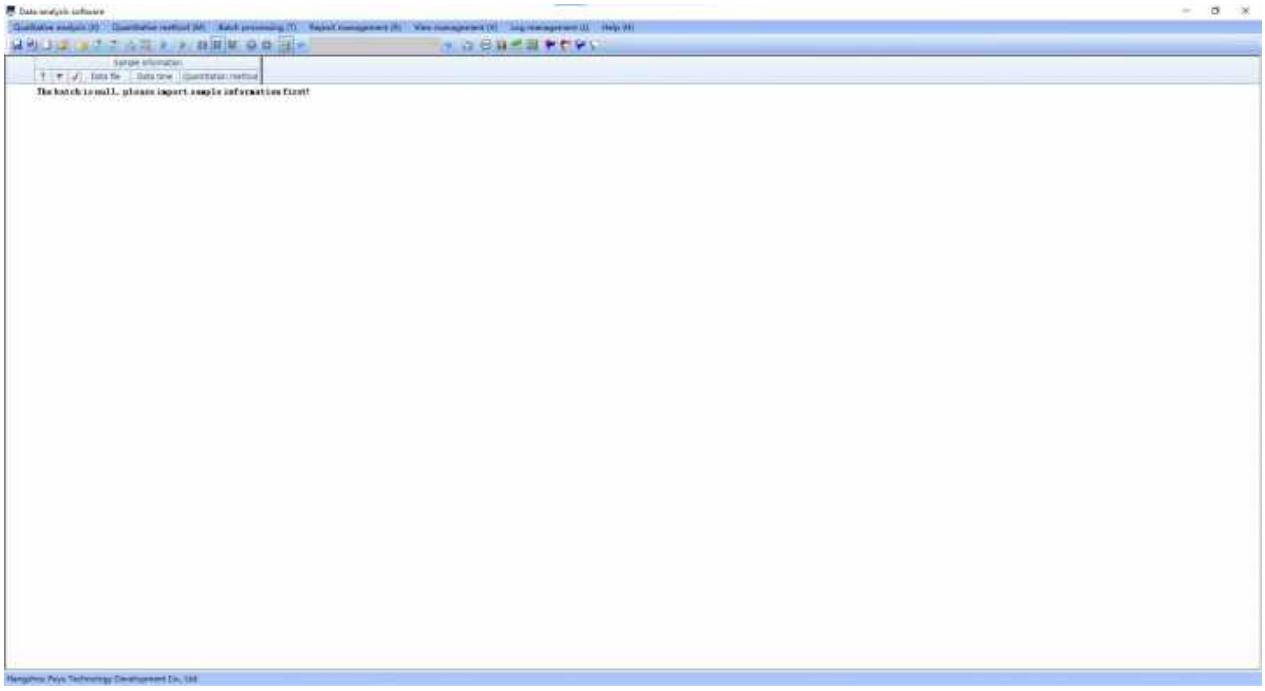


Figure 3-41 Main interface of GC 2000 analysis software

3.3.1 Introduction of function bars

3.3.1.1 Qualitative analysis

Click to enter the qualitative analysis interface, so as to perform qualitative analysis on the spectrum.

3.3.1.2 Quantitative method

Click to enter the quantitative method edit interface so as to create, open or edit a method.

3.3.1.3 Batch processing

Batch processing edit interface, so as to create, open, save or save a batch table.

3.3.1.4 Report management

Click to enter the report template management interface, so as to edit the elements that need to be generated in the report.

3.3.1.5 View management

It is possible to edit, display or hidden the sample information and compound information display windows of the current interface.

3.3.1.6 Help

(1) About

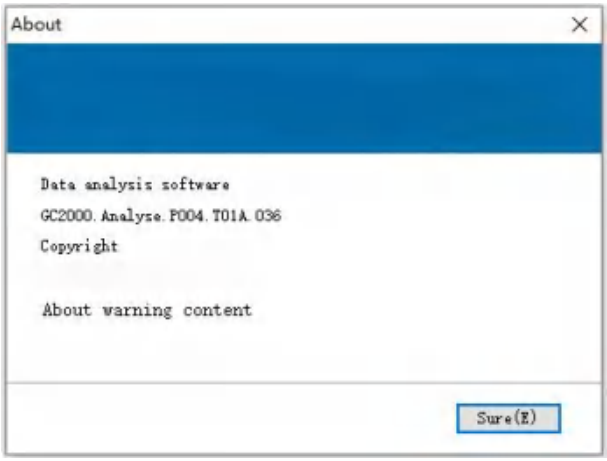


Figure 3-42 About the view interface

Click [Help/About] to view the GC 2000 analysis software version and company website and other related information.

(2) System help

Click [Help/System Help] to view the GC 2000 Analysis Software User Manual.

(3) Gadgets

Click Calculator, Notepad, Screenshot Tool, and Molecular Weight Calculator to use the corresponding functions.

3.3.2 Introduction of shortcut bars

New Sample List: Click the New Sample List button to create a new batch table sample list;

Open Sample List: Click the Open Sample List button to open the existing sample list;

Save sample list: Click Save Sample List to save the current sample list;

Save Sample List as: Click Save Sample List As to save the current sample list;

Import Samples from Folder: Click the Import Samples from Folder button to import all samples in the folder;

Import Samples: Click the Import Samples button to select single or multiple samples to import into the sample list;

Delete Sample: Click the Delete Sample button to delete the selected single sample in the sample list;

Sample Information: Click the Sample Information button to view the sample information of the currently selected sample;

Compound Information: Click the Compound Information button to view the compound information of the currently selected sample;

Analysis Batch: Click the Analysis Batch button to automatically analyze all samples in the batch;

Quantitative batch processing: Click the Analyze Batch button to automatically analyze all samples in the

batch;

Portrait view: Click the Portrait view button  to change the result list after batch processing into vertical display;

Horizontal compound: Click the horizontal compound button  to display the batch result according to the horizontal compound;

Horizontal sample: Click the horizontal sample button  to change the list of results after batch processing into horizontal display;

Previous Sample: Click the Previous Sample button  to move the selected bar up one row, that is, select the previous row of samples;

Next Sample: Click the Next Sample button  to move the selected column down one row, that is, select the next row of samples;

All Compounds: Click the all Compounds button  to display all compound results defined in the processing method in a batch table;

Previous Compound: Click the Previous Compound button  to display the calculation result of the previous compound;

Next Compound: Click the Next Compound button  to display the calculation result of the next compound;

Generate Report: Click the Generate Report button  to generate a result report;

Compound Expected Concentration: Click on Compound Expected Concentration  to set the expected concentration of each compound;

Show Statistics: Click on Show Statistics  to automatically calculate the maximum, minimum, average, RSD and other information of each result;

Trend Statistics: Click the Trend Statistics button  to show the trend of the treatment results of the compound;

Export to Excel: Click the Export to Excel button  to export the results to an excel file;

Show Samples Above/Below Outliers: Click the Show Samples Above/Below Outliers button  to filter out sample results above/below outliers;

Show Samples Above Outliers: Click the Show Samples Above Outliers  to filter out sample results above outliers;

Show Samples Below Outliers: Click the Show Samples Below Outliers button  to filter out sample results below outliers;

Show Samples Without Outliers: Click the Samples Without Outliers button  to filter out sample results without outliers.

3.3.3 Qualitative analysis

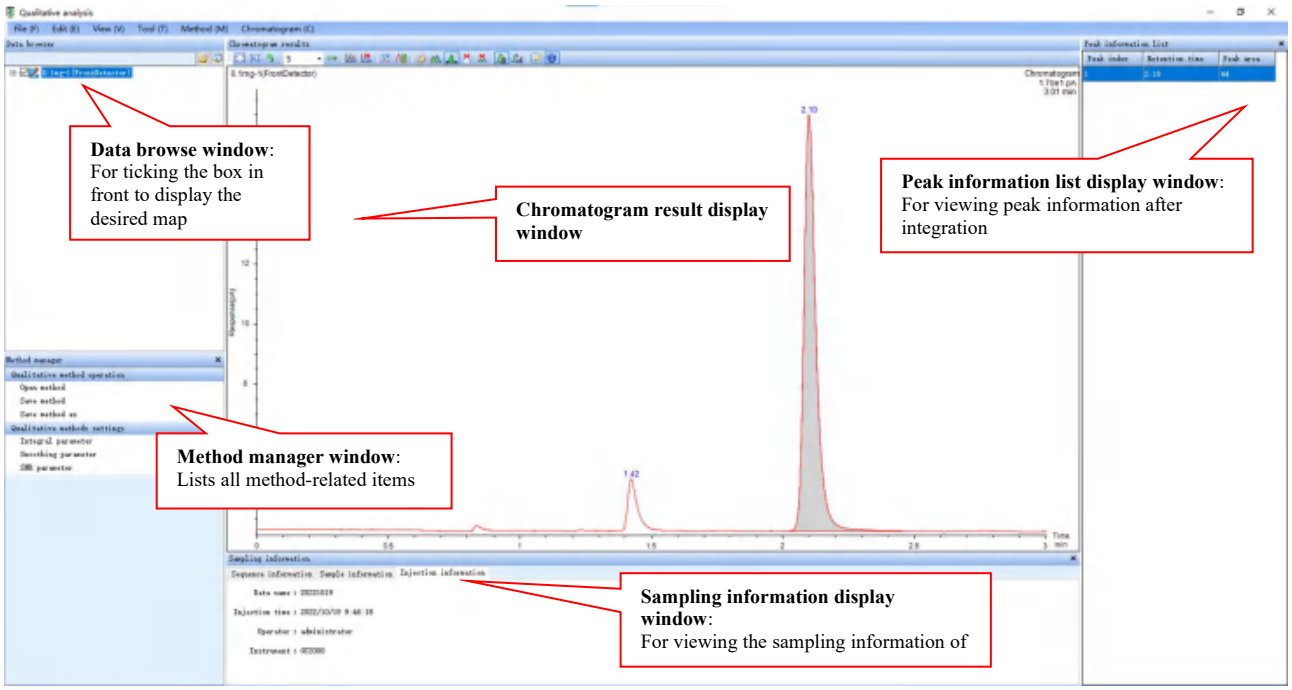


Figure 3-43 Qualitative analysis window

3.3.3.1 Data browse window

The called data files are listed here. A dialog box that can select/deselect a file or a graph, optionally displaying data files and associated spectra. Right-click on a data file to close the selected data or all data files.

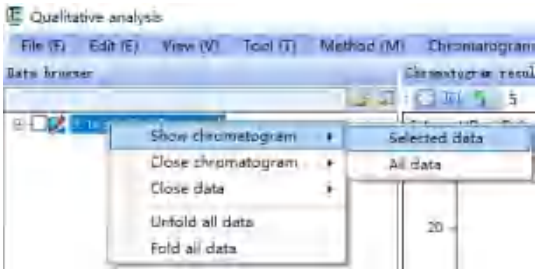


Figure 3-44 Data browse window

3.3.3.2 Method manager window

The parameters of the data processing of the current method are displayed here. Under the qualitative method operation item, users may create a new method, and open, save or save as the edited method. Integral parameters, smoothing parameters and signal-to-noise ratio parameters can be set under the qualitative method settings.

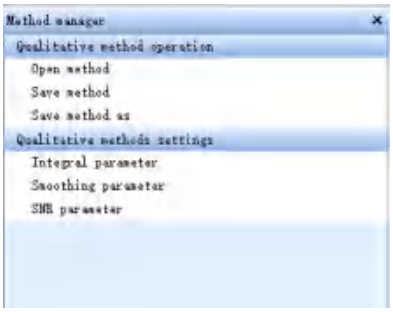


Figure 3-45 Method manager window

Click any parameter in the optional method settings to pop up the parameter editor window. These parameters can be modified, applied and saved.

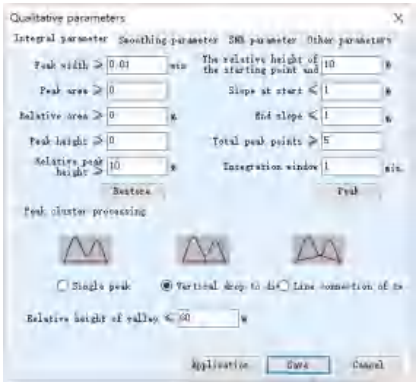


Figure 3-46 Qualitative parameter edit window

3.3.3.3 Chromatogram result window

Hold down the right mouse button and pull out a rectangle to zoom in on the selected spectrum. Click the tool bar icon in the chromatogram window to restore the full scale display.

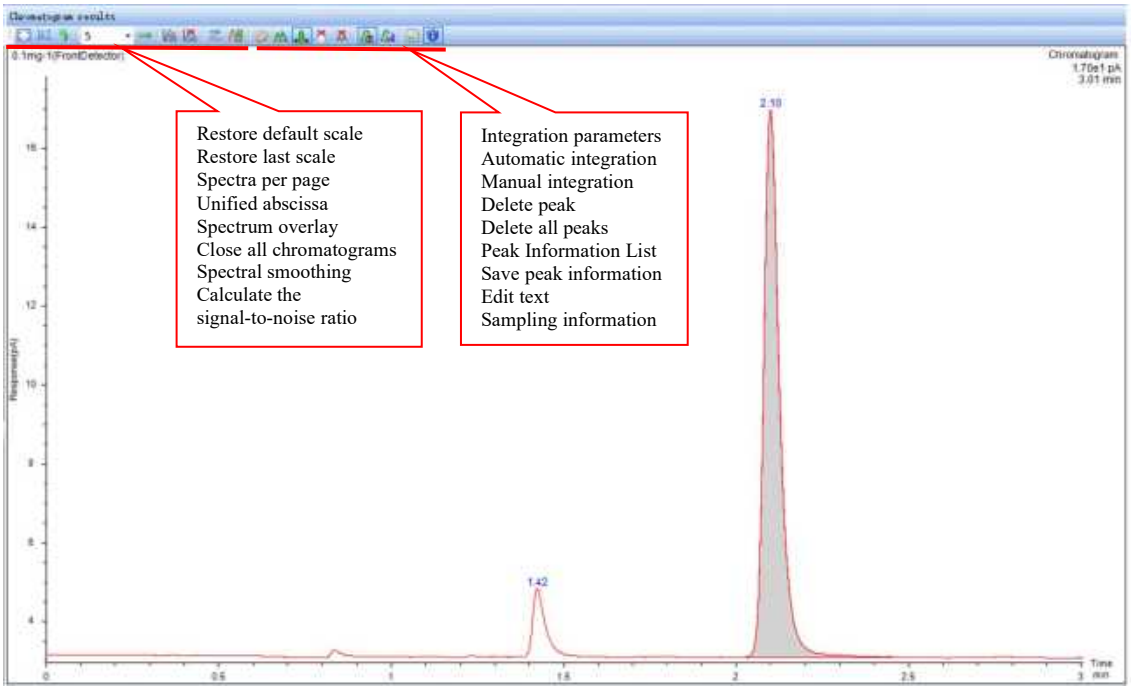


Figure 3-47 Chromatogram result window

3.3.3.4 Peak information list window

Click the Peak Information List button in the chromatogram result to display the peak information list, and display each peak information one by one according to the retention time. Right-click anywhere in this window to edit the list information.

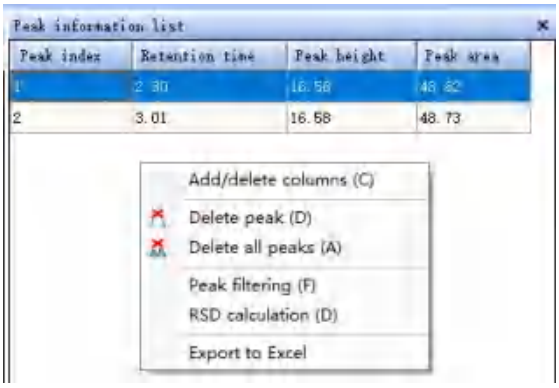


Figure 3-48 Peak information list window

3.3.3.5 Chromatogram integration

Click the integration parameter in the method manager or the integration parameter in the chromatogram result to pop up the integration parameter edit window, and set the following parameters to filter the unwanted impurity peaks. After editing the integration parameters, click Apply to complete the automatic integration, and the integrated results are displayed in the peak information list display window.

If manual integration is required, click the Manual Integration button on the top of the chromatogram window to show rectangular black dots in the chromatogram, and hold the left button of the mouse to drag the position of the black dots, and draw a line to outline the chromatographic peak that needs to be integrated. The chromatographic peak will appear with the parameters of the peak displayed.

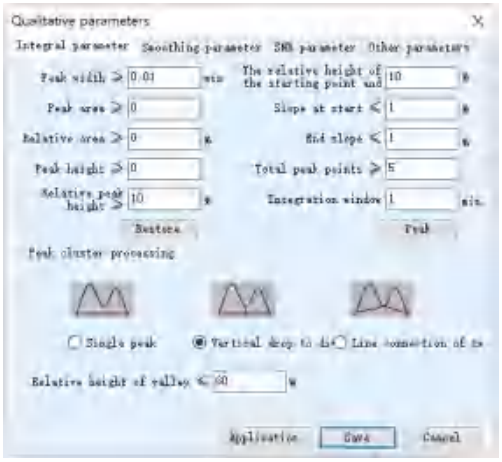


Figure 3-49 Qualitative parameter edit window

3.3.4 Quantitative analysis

3.3.4.1 New batch table

Click Batch Table/New Batch, or click the New Sample List icon to create a new batch table;

Click Batch Table/Open Batch, or click the Open Sample List icon, find the storage path of the previously saved batch table, select the batch table file, and click Open to open the saved batch table;

Click Batch Table/Save Batch, or click the Save Sample List icon, select the storage path, edit the name of the sample batch table, and click Save to save the current batch table;

Click Batch Table/Save Batch As, or click the Save Sample List icon, select the storage path, edit the

name of the sample batch table, and click Save to save the batch table.

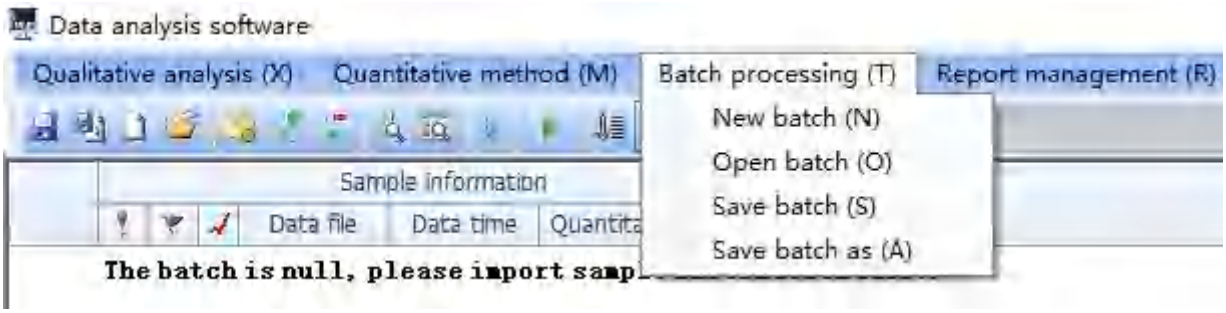


Figure 3-50 Batch table - new batch/open batch/save batch/save batch as

3.3.4.2 Import data file

Click the sample icon in the import folder, find the folder where the data is located, select it and click OK to import all data files in a folder. Or click the import sample icon, find the data file to be imported, and import one or more data files.

If there is a quantitative method, users may right-click on the blank space in the theorem method column in batch processing to select the loading method, and select the quantitative method file in the pop-up window to load it. Users can also choose to fill down the quantitative methods of other data files. If it is necessary to edit the quantitative method, users may select the editing method and enter the quantitative method to edit the method.

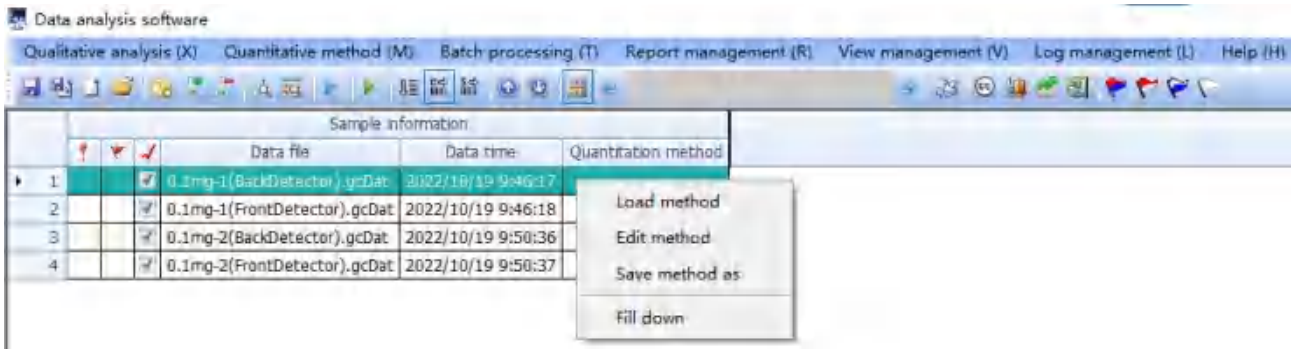


Figure 3-51 Batch table - Import data file

3.3.4.3 New quantitative method

Click quantitative method to enter the quantitative method interface, click save method button or save method as button to customize the storage path and enter the quantitative method name.

Click the new method button to create a quantitative method and edit or modify it.

Click the open method button to find the path of the previously saved quantitative method, select the quantitative method file, and click Open to open the saved quantitative method.

(1) New/add compound

Click Add Compound from Data under New/Add Compound on the left, and select single or multiple data files (preferably the data file with the best signal and the most representative data file). If there is an existing method, click Add compound from method. After opening the data, the data file can be displayed in the right sample data column.

Click New Compound, enter the compound name and retention time in the compound list on the right to

complete, as shown in the figure below. Click Delete Compound or Delete All Compounds to delete the selected compound or all compounds.

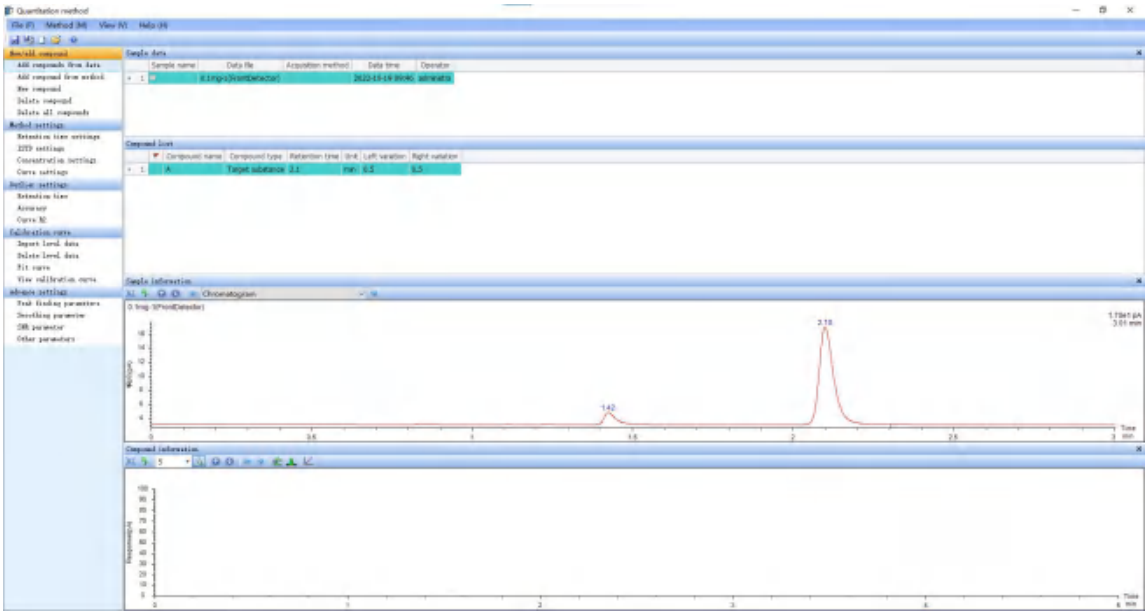


Figure 3-52 Quantitative method edit interface

(2) Method settings

- Retention time settings

Click Retention time setting to check and confirm the imported parameters (preferably group samples by retention time as much as possible to avoid interference);

Checking whether the retention time corresponds to the left and right changes may set the retention time range. When the retention time drifts a lot, users can appropriately widen the range to ensure that the target peak is found. In this example, it is set to be 0.5 min. The offset unit can also be set as a percentage, which can be selected according to actual needs.

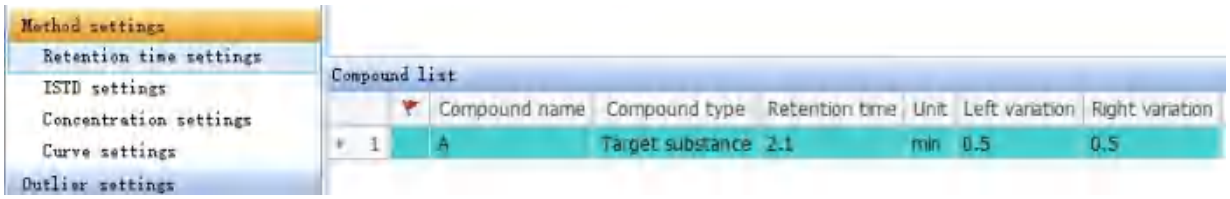


Figure 3-53 Method settings - Retention time settings

- ISTD settings

If using the internal standard method, click ISTD Settings, check the Use ISTD box in the row of the target compound, and select the corresponding internal standard name.

This step should be ignored if quantification is performed with external standard method. Different target compounds can be quantified by matching different internal standards, and compounds without internal standards are automatically processed by the external standard method.

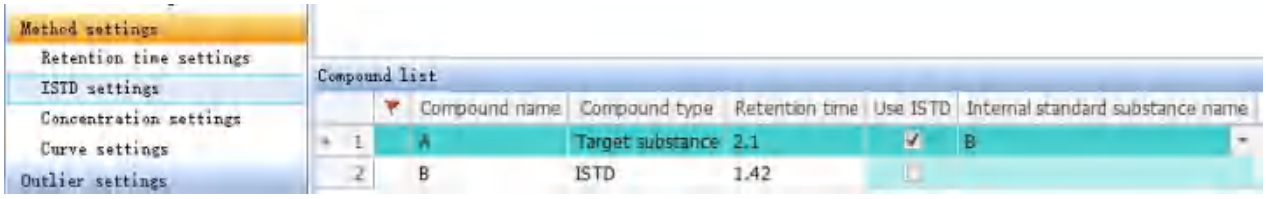


Figure 3-54 Method settings - ISTD settings

- Density setting

Click Concentration Settings to change the maximum concentration, dilution mode, concentration unit and multiplier. If the standard concentration is 100 ng/mL, 500 ng/mL, 1000 ng/mL, 5000 ng/mL, 10000 ng/mL and 50000 ng/mL, the highest concentration is 50000 ppb, and the dilution mode is 1:5: 2:5:2:5, concentration in ng/mL. There are 3 options for concentration units: ng/mL, μg/mL and μg/kg.

Figure 3-55 Method settings - Concentration settings

- Calibration curve settings

Click Calibration Curve Settings to set parameters such as calibration curve fitting type, fitting origin and weight type.

Fit types: linear, square, power of 3, and average factor. Generally select linear or squared curve as the calibration curve fitting type.

Fit origin: ignore, include, force, blank offset, blank subtract. In case of a single-point legal quantity which cannot be ignored, Include or Force should be chosen.

The fit type of the calibration curve and the fit origin will affect the final quantitative results.

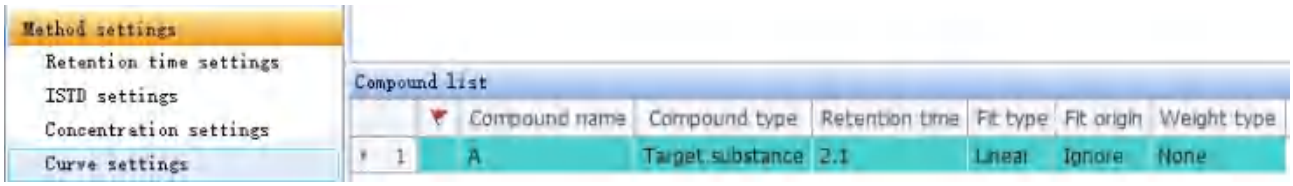


Figure 3-56 Method settings - Calibration curve settings

(3) Outlier settings

Using the range of outlier data can quickly and effectively help determine unreasonable data.

For the configuration of upper and lower limits of outliers, users may set the retention time, accuracy and curve R^2. When the corresponding result exceeds the set value, it is regarded as an outlier.

- Retention time settings

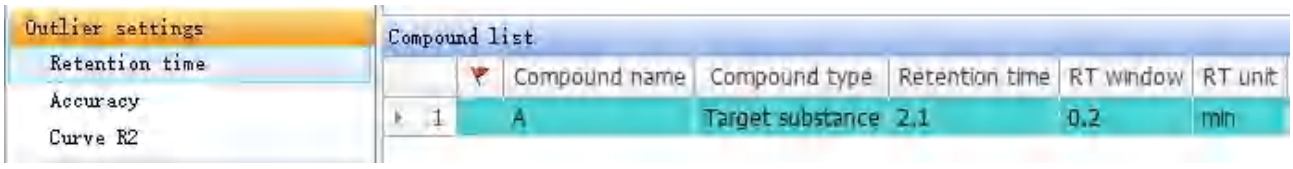


Figure 3-57 Outlier settings - Retention time settings

- Accuracy settings

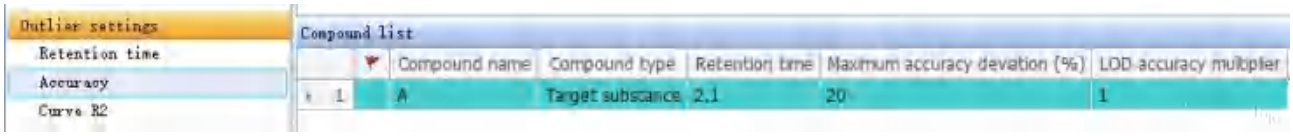


Figure 3-58 Outlier settings - Accuracy settings

- Curve R^2 Settings

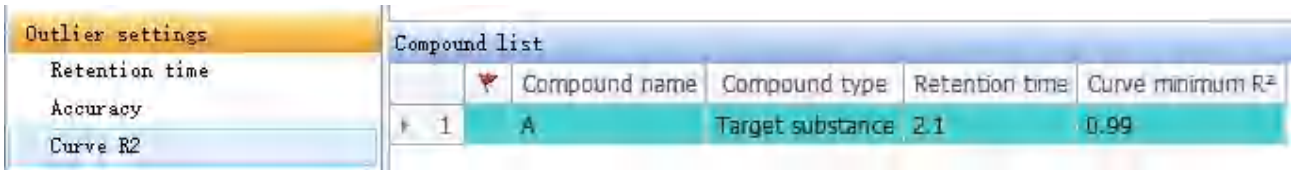


Figure 3-59 Outlier settings – Curve R^2 settings

(4) Calibration curve

- Import level data

If it is necessary to establish a calibration curve, users need to click Import Level Data, select data from the pop-up window, modify the level of each data after importing, number them in order of concentration, and enter the order of concentration in turn in the dilution mode of the concentration setting in the method setting.

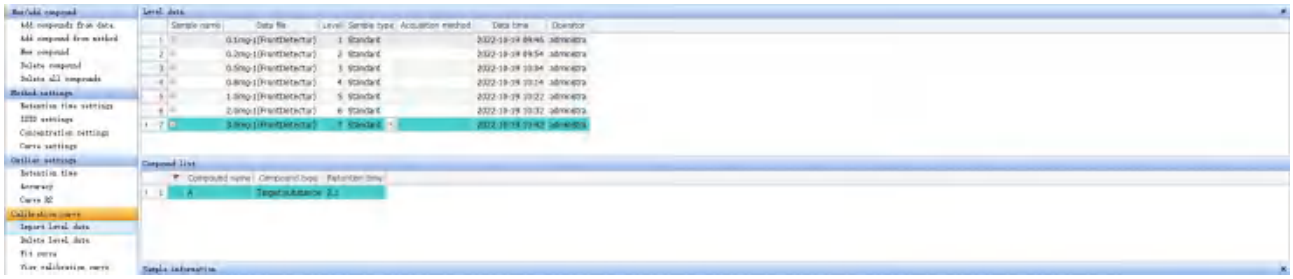


Figure 3-60 Calibration curve - Import level data

- Delete level data

Users may select a certain level of data and click Delete Level Data to delete it.

- Fitted curve

Click the fitted curve to view the fitted calibration curve.

- View calibration curve

Click View Calibration Curve to view the Quantitative Curves window.

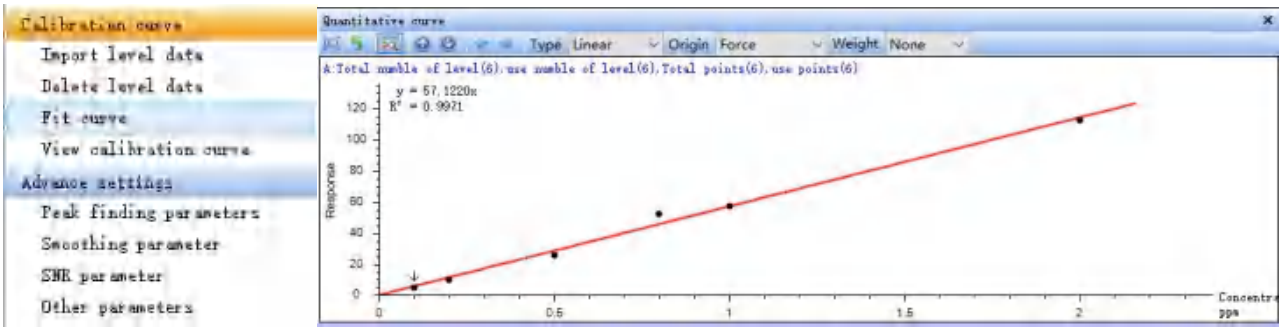


Figure 3-61 Quantitative curve window

(5) Advanced settings

- Peak finding parameters

Click the peak search parameter in the advanced settings to pop up the integration parameter editing interface. For specific functions, see 3.3.3.5 Chromatogram integration.

- Smoothing parameter

Click the smoothing parameter in the advanced settings to pop up the smoothing parameter editing interface, and modify the window size, fitting times and smoothing times as required.

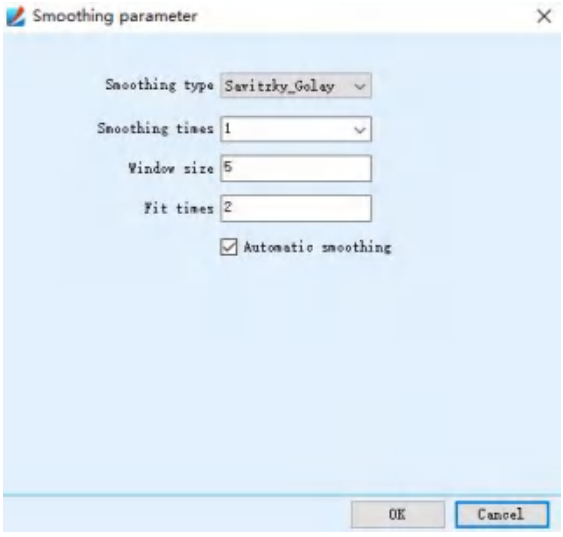


Figure 3-62 Smoothing settings window

- Signal-to-noise ratio (SNR) parameter

Click the SNR parameter in the advanced settings to pop up the SNR parameter editing interface, and modify the SNR type, noise width and SNR calculation method as needed.

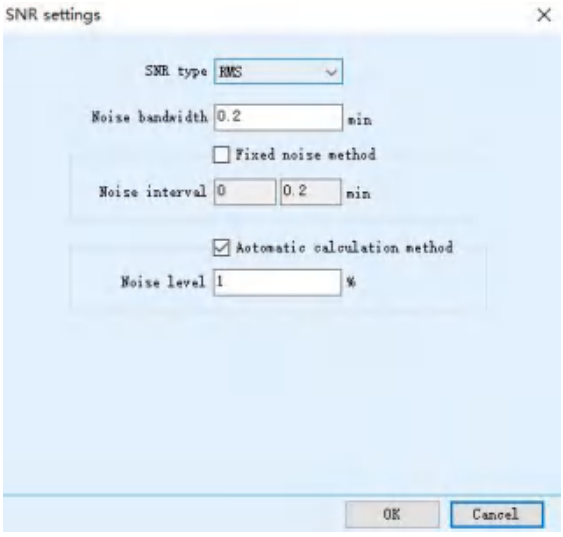


Figure 3-63 Signal-to-noise ratio settings window

3.3.4.4 Exit and save the quantitative method

Click the save method in the file or click the icon to save the quantitative method.

Click Exit in the file or close directly in the upper right corner to exit the quantitative method editing interface.

Users may also save a quantitative method before exiting quantitative method editing. In this way, when quantifying other data of the same project in the future, this quantitative method can be directly called for quantification without re-establishing the quantitative method.

3.3.5 Data analysis

3.3.5.1 Quantitative batch

Right-click on the blank space under the Quantitative Method column of the batch table, select Load Method, and fill it down. Click Quantitative Batch  icon, and the data can be analyzed in batches. After the analysis is completed, the interface consists of the target data results, the target spectrum results and the calibration curve.

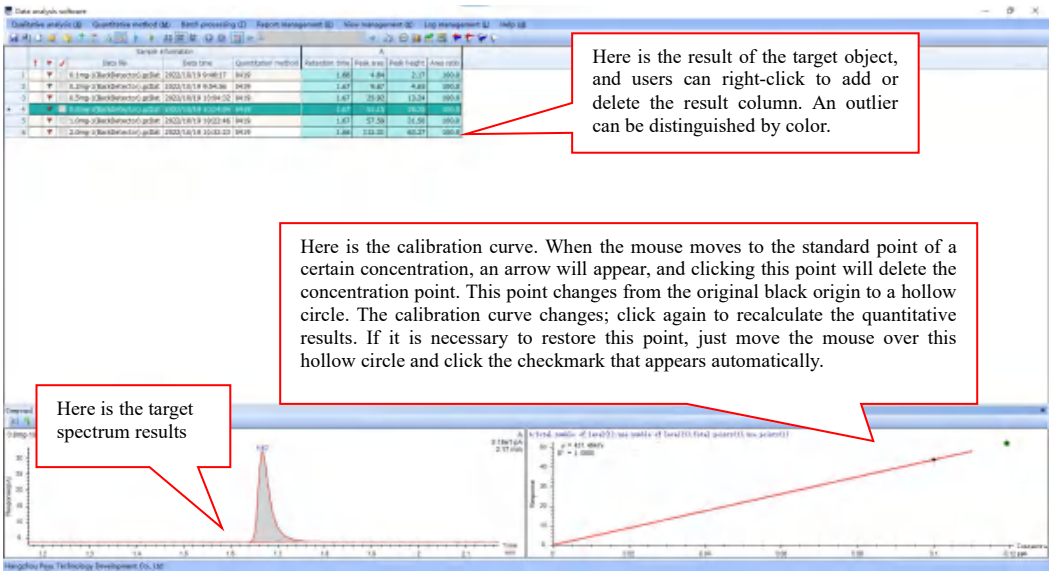


Figure 3-64 Quantitative batch results

See 3.3.1 and 3.3.2 for the function introduction of the upper function bar and shortcut keys.

3.3.5.2 Save batch table

Click the save button to save the current batch table.

3.3.6 Report generation

3.3.6.1 Report configuration

Click the report configuration under the report management button to pop up the report configuration window, including basic information and report column configuration. The report column configuration includes sample information, compound information and quantitative curve information. After the configuration is complete, click OK in the lower right corner.

1. Basic information configuration

Tick the small box in front of the content that needs to be displayed in the report.

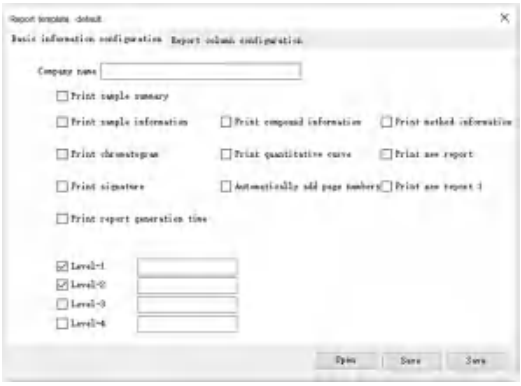


Figure 3-65 Report configuration - Basic information

2. Report column configuration

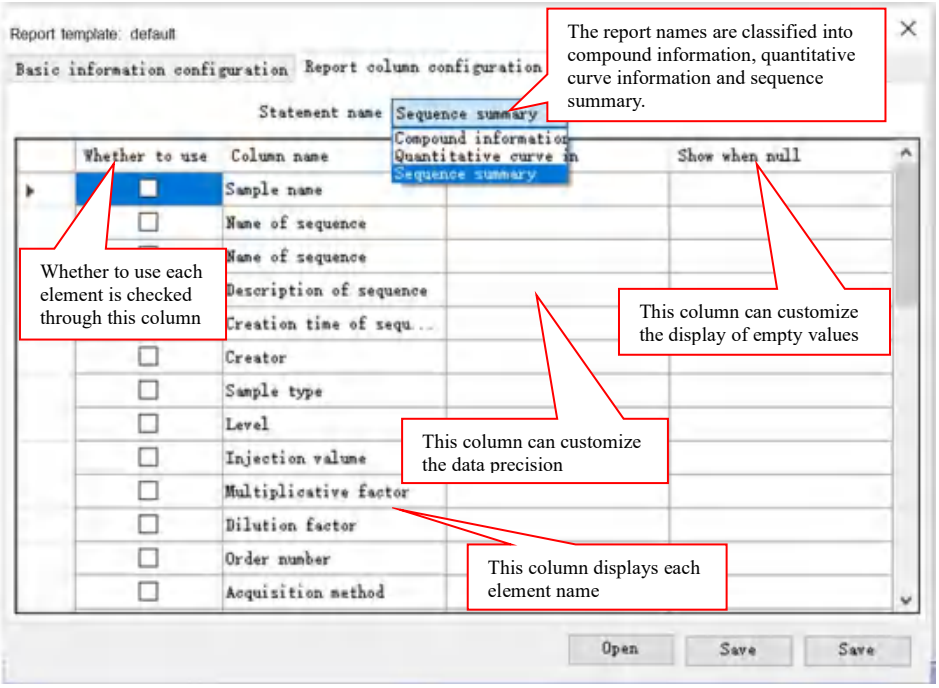


Figure 3-66 Report configuration - report column configuration

3.3.6.2 Generate report

Click the Generate Report icon, select the compounds to be printed in the pop-up window, and click OK to generate the preview report.

Figure 3-67 Print compound selection window

4 Instrument operation and maintenance

4.1 About instrument operation

4.1.1 chromatographic column installation

Take the installation of a capillary column as an example.

Note:

Chromatographic column installation and maintenance requires turning off the oven heating.

A. Install the chromatographic column holder

On the top of the inside of the GC 2000 oven, there is a pair of bracket holes in each of the front, middle, and rear parts, for mounting brackets. Insert the squeezable bracket into the bracket hole.

B. Install the column fitting

1. Select the ferrule

When connecting both ends of the chromatographic column to the injector and detector, a vespel and graphite hybrid ferrule is required. Table 4-1 lists the hybrid pressure rings corresponding to different chromatographic column sizes. During use, the same or similar retaining rings should be used; otherwise it will cause leakage or pollution.

Table 4-1 Chromatographic column and corresponding pressure ring size

Chromatographic column outer diameter (mm)	Inner diameter of the ferrule (mm)
0.10	0.4
0.25	0.4
0.32	0.5
0.53	0.8

2. Install marker pad, nut and ferrule, cut the chromatographic column

Install the corresponding marking pad, chromatographic column nut and pressure ring on one end of the chromatographic column in sequence, make a mark 3-4 cm from the opening with a capillary column cutter, and knock it off. Check the cutting surface to make sure it is flat and vertical. If there is any problem, it must be cut again.

3. Connect the chromatographic column to the split/splitless inlet.

Adjust the length of the chromatographic column so that it is smoothly connected to the inlet, and adjust the position of the marking pad to keep the nut in a certain position. At this time, the distance between the chromatographic column port and the ferrule should be about 4~6 mm. Always hold the chromatographic column with one hand so that the marking pad is always in contact with the nut and will not slide down. Hold the fixing nut with the other hand and insert the chromatographic column into the inlet, screw on the nut counterclockwise, then turn it another 1/4" turn with a wrench after tightening. If the column is still loose, use the wrench to rotate it for another 1/4" circle.

Note:

An over-tightened pressure ring causes air leak at the connection point.

4. Connect the chromatographic column to the FID

Repeat Step 2. Insert the chromatographic column port into the FID until reaching the bottom, and the length of the chromatographic column extending beyond the column nut is 78.5 ± 0.5 mm. Hold the column in one hand securely, screw the nut with the other hand, and move the marker pad to fit against the nut after tightening. Retract the chromatographic column by 1~2 mm. At this time, there is a slight gap between the marking washer and the nut. Use a wrench to rotate the nut for 1/4" circle; if it is loose, rotate it another for 1/4" circle.

5. Connect the chromatographic column to the FPD

Repeat Step 2. Extend the chromatographic column port into the FPD; the chromatographic column should be flush with the FPD nozzle, and the length of the chromatographic column extending beyond the column nut should be 82 mm. Hold the column in one hand securely, screw the nut with the other hand, and move the marker pad to fit against the nut after tightening. Retract the chromatographic column by 1~2 mm. At this time, there is a slight gap between the marking washer and the nut. Use a wrench to rotate the nut for 1/4" circle; if it is loose, rotate it another for 1/4" circle.

4.2 About maintaining GC

4.2.1 Maintenance content

This manual describes how to maintain the following GC components:

Split/Splitless inlet (SSL)

Capillary column

Flame ionization detector (FID)

Electron capture detector (ECD)

Flame photometric detector (FPD)

4.2.2 Maintenance preparations

Before performing routine maintenance procedures, necessary preparations for GC must be made as follows:

(1) Set a low temperature (50°C) to avoid burns, and cool all heating zones in the GC, including auxiliary heaters or other heating equipment that may be touched during maintenance, including injection ports, column ovens, and detectors;

(2) Shut off the flow to prevent any danger or damage to the instrument;

(3) Turn off the GC and disconnect the power;

(4) Remove the covers, including the air control assembly cover, and the detector cover.

4.3 Split/Splitless inlet maintenance

4.3.1 Split/Splitless inlet configuration

The inlet is composed of main body, flow path adapter block, septum nut, septum pressure block, heating

block, stop nut, adapter nut, heating rod and PT100.The septum, liner and seal, and splitter plate of the inlet require regular maintenance.

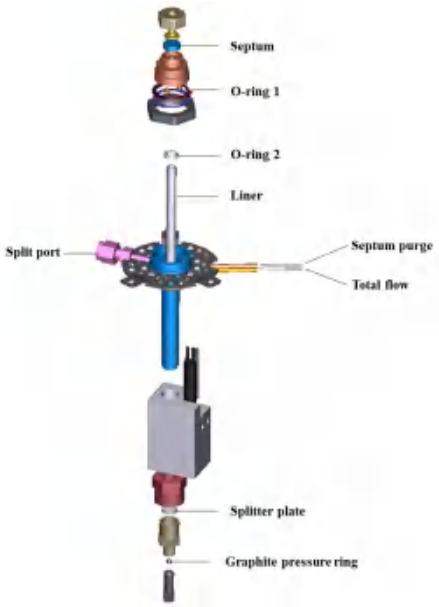


Figure 4-1 Inlet structure diagram

4.3.2 Inlet maintenance

4.3.2.1 Replace the septum

The septum is one of the key components of the inlet, whose function is to keep the chromatographic system in a sealed state. It is generally made of inert silica gel material with high temperature resistance and good air tightness. The septum is a consumable that needs to be inspected regularly and replaced as needed to prevent air leakage or contamination and decomposition due to long-term use, which may interfere with analysis.

The septum may leak after multiple injections. Generally, the septum needs to be replaced for more than 100 injections, and the specific situation can be adjusted according to the injection frequency.

According to the type of inlet and analysis requirements, there are many kinds of injection septa, which are made of different materials, generally divided into two categories: low temperature septum and high temperature septum. The low temperature septum is soft and provides good sealing performance. Compared with the high temperature septum, it has better puncture resistance and can be injected more frequently. The septum is usually used at the maximum operating temperature specified by the manufacturer. If it is used above the maximum temperature, gas leakage or decomposition will occur, resulting in sample loss, less column carrier gas flow, shorter column life, and ghost peaks.

To replace the injection septum, users should loosen the inlet septum nut by hand, take out the septum with tweezers, and check whether the septum is damaged. If damaged, replace it with a new one. After installing the septum, check whether it is fully embedded in the inlet, and then tighten the nut of the inlet septum by hand securely.

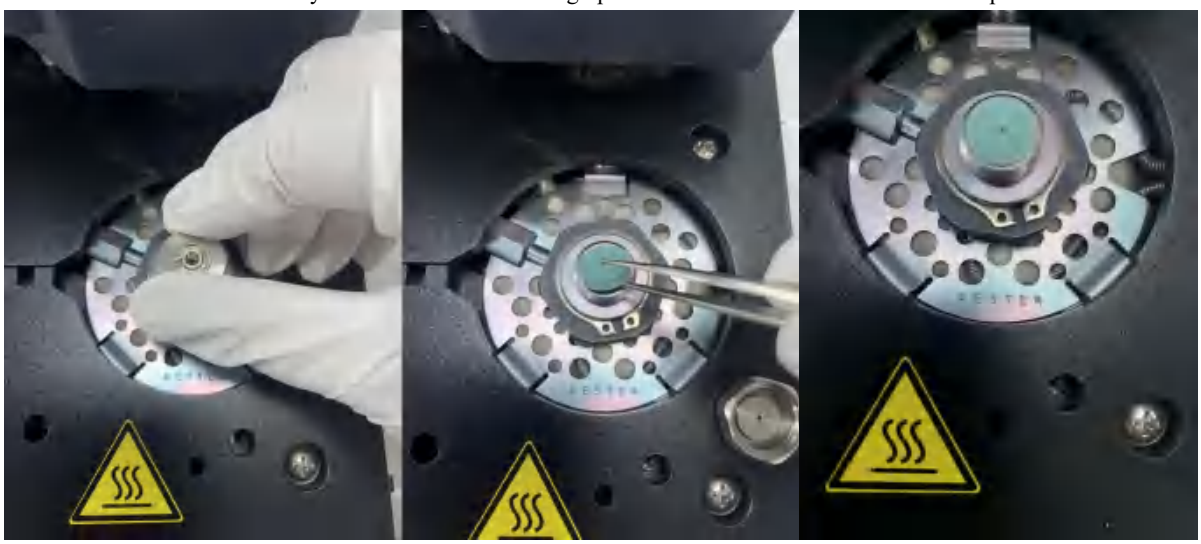


Figure 4-2 To replace the septum, users should unscrew the septum nut by hand, remove the septum with tweezers, and insert the new septum into the inlet

Warning:

The inlet septum nut and assembly may be hot during instrument operation and should not be touched without protection.

Note:

Before changing the septum, turn off the inlet carrier gas flow and pressure.

4.3.2.2 Replace the liner

The liner is the central component in the inlet, where the sample is vaporized into gas at high temperatures. The role of the inlet is to introduce the sample into the chromatographic system accurately and reproducibly. At high temperature, the liquid sample vaporized at the inlet becomes gaseous and enters the head of the column, while the sample volume increases significantly. Because the sample vaporizes at the liner, if the sample is dirty and contains many impurities, it is easy to contaminate the liner and interfere with the test results. Thus, the liner needs to be replaced regularly.

Typically, the sample will expand after vaporizing in the liner, and the volume of gas produced by vaporizing the liner must be within the volume of the liner. If the volume is larger than the liner, sample loss due to sample backflushing into the septum purge or split line can affect peak reproducibility and sensitivity, and often lead to sample carryover. Therefore, it is necessary to select a suitable liner during the analysis. In the case of split flow, the split liner is usually selected. For splitless injection and some special applications, the appropriate liner should be selected according to the actual application.

To replace the liner, users should unscrew the flow path adapter block counterclockwise with a socket wrench, and take out the liner with tweezers. Check the glass wool in the liner. If the liner is too dirty (a lot of black particles or septum debris on the glass wool), users need to replace the liner with a new one. After placing

the new liner in the inlet, use tweezers to push the liner until the bottom stops moving.

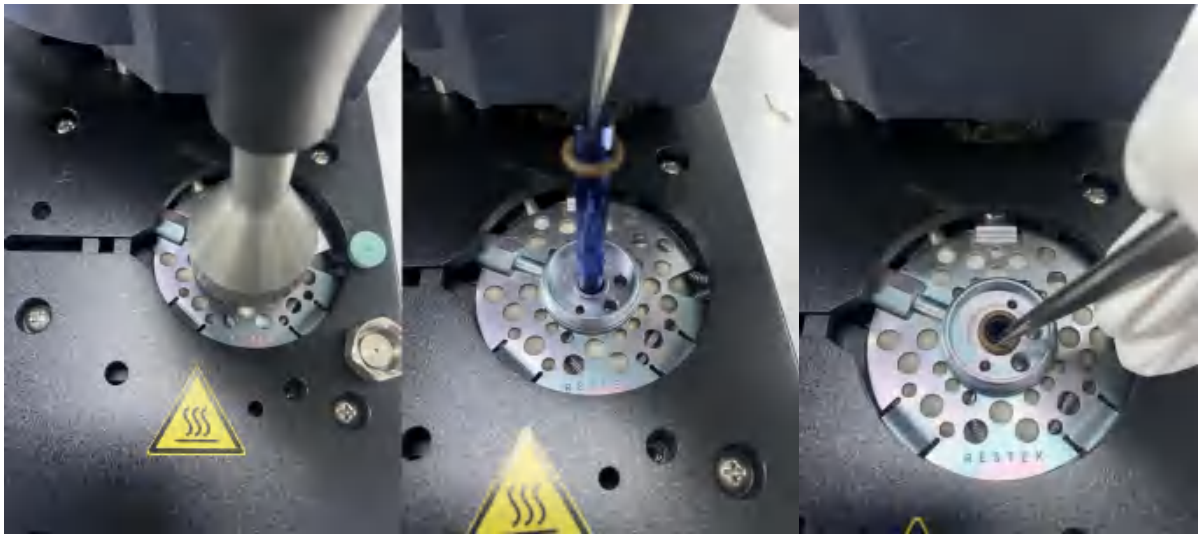


Figure 4-3 To replace the liner, users should unscrew the flow adapter block with a socket wrench, remove the liner with tweezers, place a new liner in the inlet, and push on the bottom

4.3.2.3 Replace the sealing O-ring

The inlet needs to be sealed with a sealing O-ring. Because the inlet is often used at high temperature, the requirements for the sealing ring are higher, and different sealing rings are selected according to different application needs. O-rings are consumables that need to be inspected regularly and replaced as needed.

The steps for replacing the sealing ring are as follows:

Use a socket wrench to remove the flow path adapter block, and check whether the two sealing O-rings 1 are damaged. If damaged, a new O-ring needs to be replaced.

The sealing O-ring 2 is applied to separate the entire injection chamber. Usually, when replacing the liner, if the sealing O-ring 2 has been used for a long time or is damaged, the sealing O-ring can be replaced as well. Remove the damaged sealing ring, fix the new sealing ring at the top 10 mm of the liner, put the liner into the injection port, and use tweezers to push the liner until the bottom cannot move.

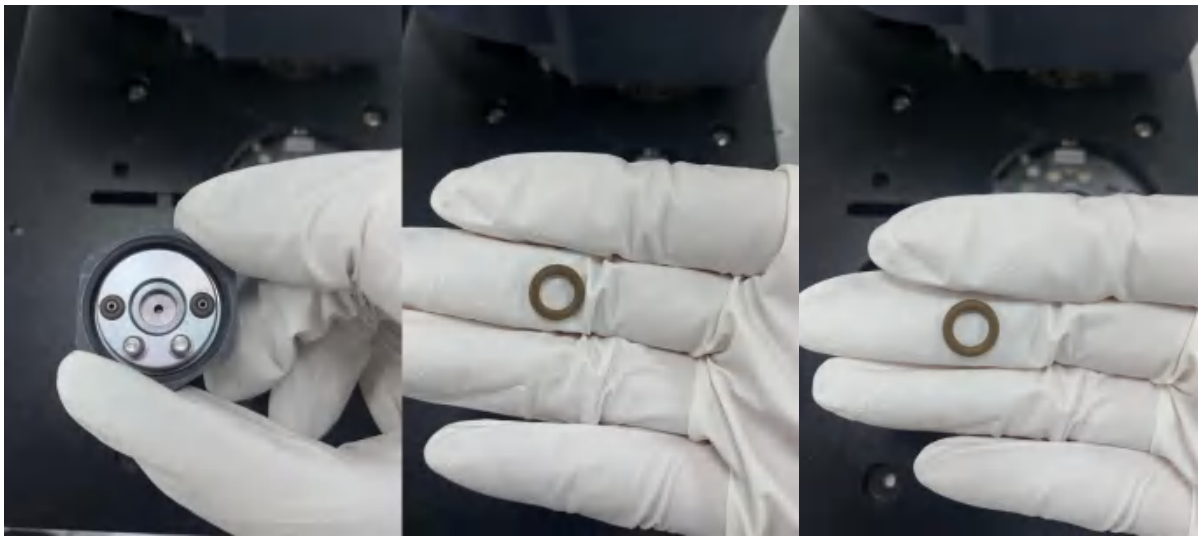


Figure 4-4 To replace the sealing ring, users should check two sealing rings 1, damaged sealing ring 2, and intact sealing ring 2

4.3.2.4 Replace the pressure ring

To replace the pressure ring, users should loosen the chromatographic column nut with an inch 1/4” fixed wrench, and check whether the polyimide/graphite mixed pressure ring is damaged. If damaged, it needs to be replaced with a new mixed pressure ring (0.25 mm column with 0.4 mm outer diameter, 0.32 mm column with 0.50 mm outer diameter).

4.3.2.5 Replace the splitter plate

The splitter plate supports the liner and guides the carrier gas flow, and generally does not need to be replaced.

To replace the splitter plate, users should loosen the two M3 screws with a Phillips screwdriver, remove the inlet insulation cover, use an adjustable wrench to remove the adapter nut at the splitter plate, remove the splitter plate and check the splitter plate; if there is dirt on the surface, clean the splitter plate; if the sealing ring is worn, it needs to be replaced with a new one. After placing the splitter plate flat in the adapter nut (the flat surface is facing up), use a wrench to tighten it securely.

Figure 4-5 Splitter plate

4.4 Capillary column maintenance

4.4.1 Replace the chromatographic column

The chromatographic column needs to be replaced when measuring different samples.

When replacing the chromatographic column, use a 1/4” wrench to loosen the chromatographic column nut connecting the inlet and the detector counterclockwise and then remove it. The inlet end and detector end column headers need to be cut flat with a column cutter.

When installing the chromatographic column, pay attention to the length of the chromatographic column extending into the inlet at the inlet end. Generally, the chromatographic column can be 4~6 mm higher than the chromatographic column nut, as shown in Figure 4-6, and then use a 1/4" wrench to tighten it securely.

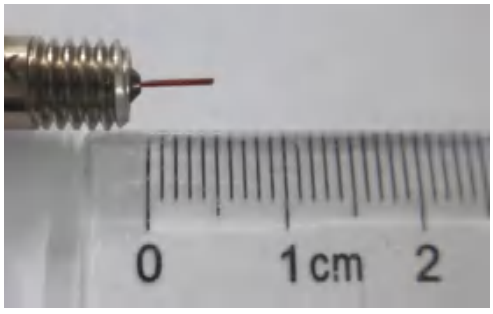


Figure 4-6 Schematic diagram of chromatographic column and inlet installation

If the detector end is connected to the FID, generally extend the chromatographic column into the detector, and after inserting it to the bottom, pull it back about 1 mm, and then tighten it with a 1/4" wrench.

For detailed operation, see 4.1.1 Chromatographic column installation.

4.4.2 Chromatographic column conditioning

Usually new chromatographic columns need to be conditioned before use. For specific conditioning steps, please refer to the chromatographic column's operation manual. Analytical columns should be conditioned according to the manufacturer's recommended conditions.

Long-term use of the chromatographic column may cause high-boiling impurities in the sample to remain in the chromatographic column, resulting in lower column efficiency and higher baseline. For the conditioning temperature, refer to the analysis conditions to be carried out, and 20°C can be added to the maximum temperature of the method for conditioning, but it must not exceed the upper temperature limit of the chromatographic column.

To conduct the conditioning method of universal chromatographic column, if there is no analytical method, the conditioning should be performed at the upper limit of the constant temperature of the chromatographic column minus 20°C.Generally, the chromatographic column gradually increases from low temperature to high temperature during conditioning, and keeps it in the high temperature section for 1~2 h, and then repeats the heating process.

To determining if a chromatographic column is sufficiently conditioned, a bleed curve (a chromatogram obtained by running a temperature program without injection) can be used to check for adequate conditioning after a chromatographic column is conditioned. The normal bleed curve rises smoothly with increasing temperature and exhibits no obvious spurious peaks.

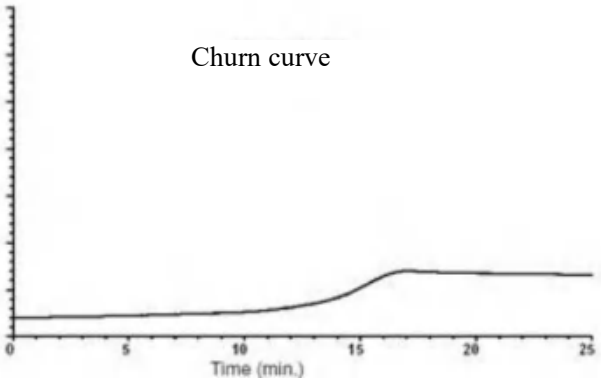


Figure 4-7 Churn curve

Usually the chromatographic column is connected to the detector for chromatographic column conditioning without contaminating the detector, but for a high sensitivity detector (ECD), it is recommended that the chromatographic column outlet should not be connected to the detector during conditioning.

Note: The maximum temperature cannot exceed its maximum operating temperature (refer to the chromatographic column temperature requirements for details). As the chromatographic column conditions, the column flow can be appropriately increased.

4.5 Detector maintenance

GC 2000 detectors include three commonly used detectors, as shown below.

Table 4-2 Detector type

Detector type	Column type	Remarks
Hydrogen flame ionization detector (FID)	Capillary column or packed column	Mass detector for most organics detection
Electron capture detector (ECD)	Capillary column	Selective detector, commonly used for halogenated hydrocarbon detection
Flame photometric detector (FPD)	Capillary column	Selective detector, often used for the detection of sulfur or phosphorus containing organics

Warning:

When using hydrogen as a carrier gas, it should be known that hydrogen is a flammable gas. Any leaked hydrogen in a closed space, e.g., a column oven, may cause combustion and explosion. Wherever hydrogen is required, all connections, lines, and valves should be leak-tested before using the instrument.

Before the instrument uses hydrogen, the hydrogen source should be turned off. When hydrogen is supplied to the instrument, make sure that the interface between the inlet and the detector column are connected to the chromatographic column, or sealed with caps.

4.5.1 FID maintenance

4.5.1.1 FID structure

Figure 4-8 Schematic diagram of the structure of FID

4.5.1.2 Cool down and power off the detector

On the GC 2000 acquisition software, click Flameout to extinguish the FID flame, lower the temperature of the oven, inlet, and detector. Wait until it cools to the set value, and set the flow rate of the gases (nitrogen, hydrogen, and air) used by the FID to 0, then power off the GC.

4.5.1.3 Replace or clean nozzles

Nozzles need to be cleaned or replaced regularly. Even with normal operation, deposits (usually white silica and black carbonaceous carbon black from column bleed) can develop inside the nozzle. These deposits reduce sensitivity and cause chromatographic noise and spikes. If cleaning the nozzle, be careful not to damage the nozzle.

When changing the column or analyte, it may also be necessary to change the nozzle. For example, a packed column uses a different nozzle than a capillary column. Users must install the appropriate nozzle before replacing the column.

To replace the nozzle, the FID housing assembly must first be removed. There are three steps: remove and inspect the nozzle, clean or replace the nozzle, and install the nozzle.

- Disassemble and inspect the nozzle

(1) Properly turn off the power of the instrument as described in 4.5.1.2 Cool down and power off the detector;

(2) Loosen the four screws that fix the detector on the surface of the oven, take out the detector, and remove the detector heating block;

(3) Remove the three screws on the back of the detector holder, and the detector shell;

(4) Loosen the tightening nut with a wrench, and take out the nozzle assembly;

(5) Bring the nozzle to the front of the lamp, and check through the hole for contamination. The tube should be clean if there is no contamination or column debris.

Figure 4-9 Take out the detector and remove the detector heating block

Figure 4-10 Remove the detector housing

Figure 4-11 Remove the nozzle assembly

- Clean the nozzle

Often, it is much more convenient to replace a new nozzle than to clean a dirty nozzle, especially if the nozzle is already heavily soiled.

(1) Put the nozzle into the beaker, add acetone solution (GC grade) that can cover the nozzle, put the beaker into the ultrasonic cleaner, and use ultrasonic waves for 5 min;

(2) Take out the nozzle, rinse it with clean water, put it into a beaker with methanol solution (GC grade), then into an ultrasonic cleaner for 5 min;

(3) Take out the nozzle with tweezers, rinse it with water, put it in a clean beaker, and dry it at 100°C in the oven.

- Install the nozzle

(1) Referring to Figure 4-11, install the graphite ferrule, washer and tightening nut on the nozzle in sequence.

(2) Referring to Figure 4-10, put the nozzle assembly back into the detector fixing bracket, and use a wrench to tighten the fastening nut (do not over-tighten it).

(3) Referring to Figure 4-9, reinstall the detector housing and tighten the three screws at the bottom.

(4) Reinstall the detector in the fixed position of the instrument oven, and reconnect the chromatographic column and detector, so that normal operating conditions can be restored.

4.5.1.4 Replace the ignition wire assembly

Materials needed: new ignition wire assembly.

Figure 4-12 Ignition wire assembly

Step 1. Allow the detector to cool to room temperature. When the detector has cooled down, turn off the

instrument.

Step 2. Use a wrench to loosen the ignition wire nut from the top of the detector.

Step 3. Connect the other end of the ignition cable connected to the ignition electrode to the detector signal board, and the connector can be easily found along the cable.

Step 4. Grab both sides of the cable connector and gently pull out the connector. Insert the new ignition cable into the slot in the same way.

Step 5. On the other end of the ignition cable, connect the new ignition wire assembly nut to the top of the detector and tighten with a wrench.

Step 6. Turn on the instrument and return to normal operating conditions.

4.5.1.5 FID hardware troubleshooting

The following lists some frequently encountered faults, fault causes and countermeasures in the use of FID.

If the fault cannot be solved through the methods suggested by us, or it is not within the scope listed here, please contact Drawell Technology Co., Ltd.

Table 4-3 Common FID faults and solutions

Fault	Reason	Solution
No ignition or flame easily extinguished	Not connected to the chromatographic column	Connect the chromatographic column
	Hydrogen/air not supplied, or hydrogen flow is too low or air flow is excessive	Ensure hydrogen/air supply, and appropriately increase hydrogen flow or reduce air flow
	Ignition wire failure (blowout)	Replace the ignition wire
	Detector temperature is too low	Increase the detector temperature, wait for the temperature to stabilize for a period of time before igniting
	Hydrogen/air EPC fault	Contact our Technical Support to replace EPC
Excessive baseline noise/severe baseline drift	The signal line is not properly connected	Check signal connection and adjust it to normal
	Gas leak	Check for leaks and repair leaks
	Accumulation of water vapor in the exhaust port	Purge the exhaust port with a high flow of gas to remove adsorbed water
	Hydrogen/air EPC fault	Contact our Technical Support
	Inlet or column contamination	Clean or replace glass liners Condition the column, cut the column head
	Unstable FID temperature	Investigate the temperature change of each part of the FID, if it is unstable, contact our Technical Support
No chromatographic peaks	Flameout	Reignite
	Quenching	Adjust analytical conditions to use aromatic-free solvents
	Signal cable not connected properly	Check electrical connections and repair

4.5.2 ECD maintenance

4.5.2.1 ECD structure

Figure 4-13 Schematic diagram of ECD structure

4.5.2.2 Note on the use of ECD

ECD has a wide range of applications in the field of analysis, and has become a problem that cannot be ignored in practical applications due to its high sensitivity and easy contamination. ECD can become contaminated by elevated temperatures when the gas is not flowing. When using an ECD, make sure that the carrier gas and makeup gas flow at the exhaust port before heating up.

Contamination of electron capture detectors generally occurs in two ways:

1) The impurities in the measured component directly capture the electrons in the ECD, which reduces the base current of the detector or increases the fundamental frequency in the galvanostatic mode, leading to louder noise and less signal-to-noise ratio;

2) The surface of the radioactive source is polluted by impurities in the measured components, which weakens the ionization ability of the radioactive source, thereby reducing the base current of ECD in DC voltage and frequency mode, or increasing the fundamental frequency in constant current mode.

Therefore, overloading of ECD should be strictly prevented during the use of ECD. In chromatographic analysis, column overload or detector overload may occur due to large injection volume (or large sample concentration). When ECD is used for the analysis of trace contaminants in environmental samples, the sample amount per peak is (10^{-8}~10^{-13}) g. This of course does not cause column overload, but for an ECD with a narrow linear range (approximately 10^4), it is easy to reach response saturation. When the ECD is saturated, the peak height no longer increases (or the increase is small), and the half-peak width is expanded. Therefore, when ECD is generally used, split injection is often used or the sample is diluted with a solvent to within the linear range of ECD, and then measured.

Because ECD is very sensitive, contamination of any part of the system can intensify background and noise. To ensure a clean system, both the inlet and the column should be cleaned and conditioned before use. When conditioning the column, it is necessary to use clean packing and filtered gas. In addition, users should use as less

PTFE pipes as possible to connect the ECD, so as to prevent a serious drop in the base flow.

Note:

Since the ECD is a highly sensitive detector, we strongly recommend the use of water, hydrocarbon, and oxygen scavengers for carrier gas, makeup, hydrogen, and air.

Whenever the column is disconnected from the ECD, users must first cool the ECD to avoid oxidation of the nickel source and block the inlet and vent of the ECD.

4.5.2.3 Daily maintenance of ECD

If the ECD is not used for a long time, the chromatographic column should be disconnected and the vent should be blocked to prevent oxidation of the nickel source. The operation is as follows:

(1) Lower the temperature of the ECD until the pool is cooled to room temperature, and then turn off the makeup gas;

(2) Unscrew the connecting screws of the ECD and the chromatographic column counterclockwise, and disconnect the chromatographic column;

(3) Use a chromatographic column plug to block the connection between the ECD and the chromatographic column, as well as the ECD vent with a plug.

4.5.2.4 Troubleshooting

Table 4-4 Common ECD faults and solutions

Fault	Reason	Solution
The control software cannot be zeroed	1 The recorder does not enter the normal working state 2 ECD controller is abnormal 3 The signal cable is not connected properly 4 The signal cable is broken, dropped or short-circuited 5 Detector has no base current	1 Check the status of the recorder and whether the signal connection is correct 2 Check the input voltage of the ECD controller and related working states 3 Check the cable connection 4 Check and measure the condition of the cable with a multimeter 5 Detector contamination, conditioning at high temperature and large flow; radioactive source failure, send it to the factory for maintenance
High baseline noise	1 The airflow is unstable; any leaks occur; or the purity is too low 2 The column is not conditioned or has residue overflow 3 ECD contamination 4 ECD controller is broken or the base voltage is unstable	1 Check the gas source, detect leaks, improve the purity of the gas source or add a deoxygenation tube 2 Reconditioning the column 3 Open high temperature and large flow activation or exchange 4 Replace AD515 or Zener diode
Severe baseline drift	1 Detector temperature changes too much 2 Carrier or makeup gas leaks 3 Silicone rubber leaks at the inlet	1 Monitor the temperature change of the detector 2 Leak detection 3 Replace the silicone rubber

Disclaimer: Private dismantling is prohibited, and the consequences without permission are at your own risk.

4.5.3 FPD maintenance

4.5.3.1 FPD structure

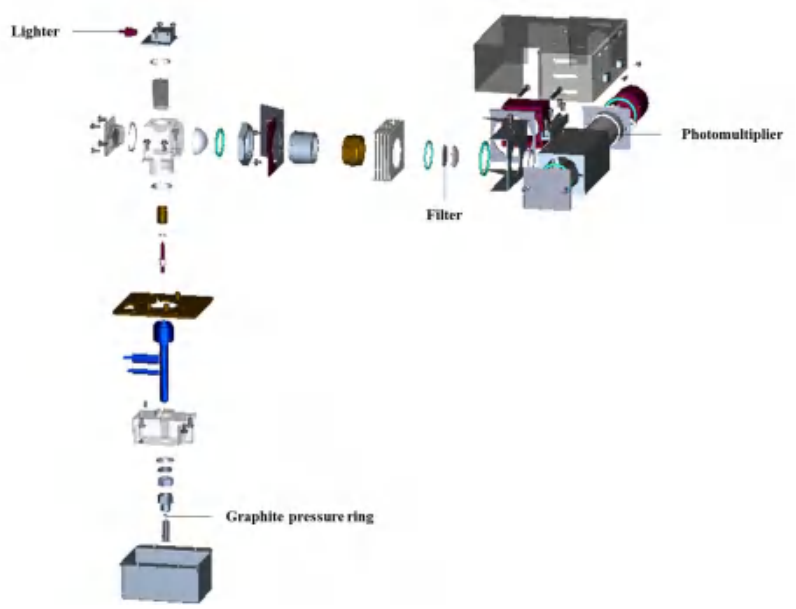


Figure 4-14 Schematic diagram of FPD structure

To ensure user safety and maintain system performance, the instrument's power switch needs to be turned off before any maintenance or inspection of the FPD is performed.

Warning:

The surface of the FPD is still hot when it is just turned off; make sure to cool it down to room temperature before performing maintenance operations.

Note:

When removing the PMT, please make sure that the FPD is powered off; if the PMT is exposed to light while it is charged, it is very likely to be damaged.

The fan on the FPD is to protect the filter and PMT. It will work only when the power supplies to the host. Therefore, in order to prolong the life of the filter and PMT, please do not turn it off when the temperature of the oven and FPD is still high. Turn off the power after the detector and column oven have cooled down sufficiently.

4.5.3.2 Cool down and power off the detector

On the GC 2000 acquisition software, click Flameout to extinguish the FPD flame, lower the temperature of the oven, inlet, and detector. Wait until it cools to the set value, and set the flow rate of the gas (hydrogen and air) used by the FPD to 0, then power off the GC.

4.5.3.3 Clean the quartz sleeve

If the quartz sleeve is contaminated with high boiling point substances or steam, the measurement sensitivity of the FPD will decrease. Please follow the steps below to clean or replace the quartz sleeve.

(1) Properly power off the instrument as described in 4.5.3.2 Cool down and power off the detector.

(2) Remove the FPD top cover.

(3) Unscrew the fixing screws on the upper cover of the FPD combustion chamber and remove the upper cover.

(4) At this point, the quartz sleeve can be seen; take it out with tweezers, and observe whether the surface is contaminated or damaged. In case of contamination, wash the sleeve with clean solvent, then dry and put it back into the FPD.

(5) If the quartz sleeve is damaged, replace it with a new one.

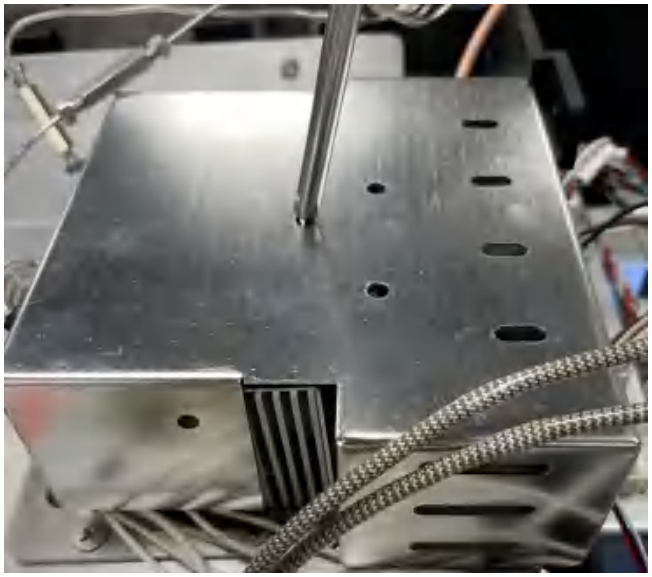


Figure 4-15 Top view, removing the top cover

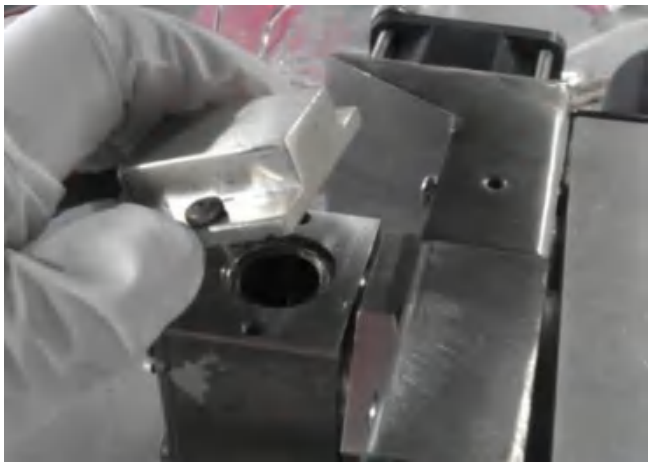


Figure 4-16 Open the top cover of the combustion chamber

Figure 4-17 Take out the quartz sleeve

4.5.3.4 Filter maintenance and replacement

FPD includes sulfur (S) type, phosphorus (P) type, and tin (Sn) type. The specific type is determined by the filter. If users wish to change the element type of the FPD-specific response, the filter needs to be replaced; in addition, the contamination of the filter will lead to a decrease in the sensitivity of the FPD measurement. If any of the above occurs, follow the steps below to replace or clean the filter.

(1) Properly power off the instrument as described in 4.5.3.2 Cool down and power off the detector.

(2) Remove the PMT (together with the outer sleeve). Hold the PMT outer sleeve with both hands and slowly pull it to the right to remove it. To prevent external light from entering through the opening of the PMT outer sleeve, block the opening with aluminum foil or similar shade.

(3) Rotate the filter holder counterclockwise to remove it.

(4) Unscrew the PEEK fixing screw on the side of the small lens, and then the small lens and filter can be poured out on a clean dust-free cloth. If the surface is contaminated, wipe it with a clean soft cloth. If it still cannot be removed, use an organic solvent to wash and dry it.

(5) If it remains around or there is obvious damage with the method in Step (4), please replace the filter.

(6) Put the cleaned or replaced filter with the mirror surface facing the flame direction into the bracket, and then put the small lens with the convex surface of the lens facing the PMT, then install the PEEK fixing nut and tighten it back to the FPD.

Note:

Do not touch the surface of the lens or filter with your hands during the above operations.

Figure 4-18 Remove the PMT outer sleeve

Figure 4-19 Front sectional view of filter position

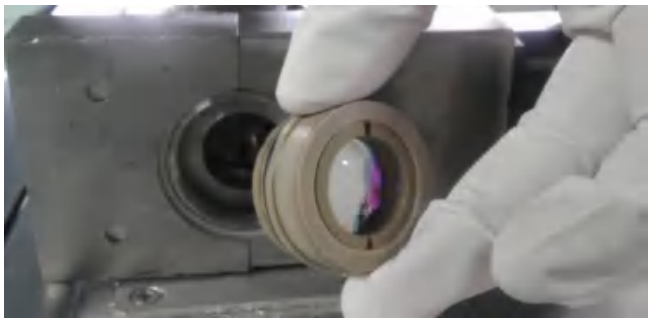


Figure 4-20 Remove the filter assembly

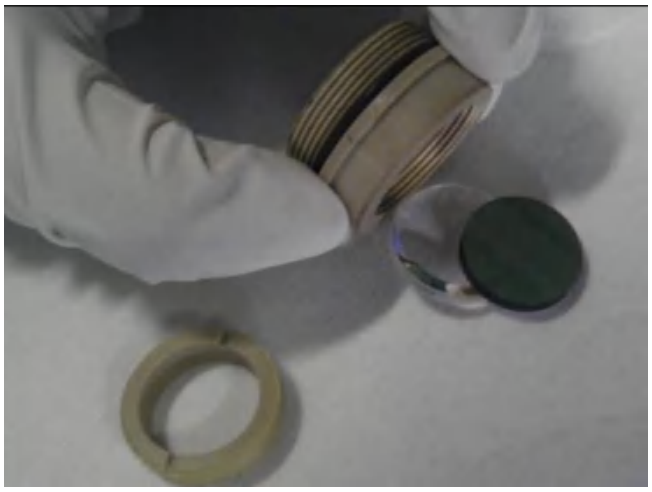


Figure 4-21 Remove the filter

4.5.3.5 Maintenance and replacement of the photomultiplier tube (PMT)

The performance degradation of the PMT after long-term use will lead to less sensitivity of the FPD. In this case, please follow the steps below to replace the PMT.

(1) Properly power off the instrument as described in 4.5.3.2 Cool down and power off the detector.

(2) Remove the PMT (together with the outer sleeve). Hold the PMT outer sleeve with both hands and slowly pull it to the right to remove it.

(3) Unscrew the fixing screws of the PMT and its metal sleeve, hold the PMT base, and slowly take out the base together with the PMT.

(4) Firmly and slowly unplug the old PMT from the base and insert the new PMT.

(5) Install the PMT into the sleeve and fix it according to the reverse steps, and install it on the FPD.

Note:

When installing a new PMT, the photocathode part of the PMT should be aligned with the opening of the outer sleeve, and do not install it backwards; be careful not to contaminate the light-receiving part of the PMT.

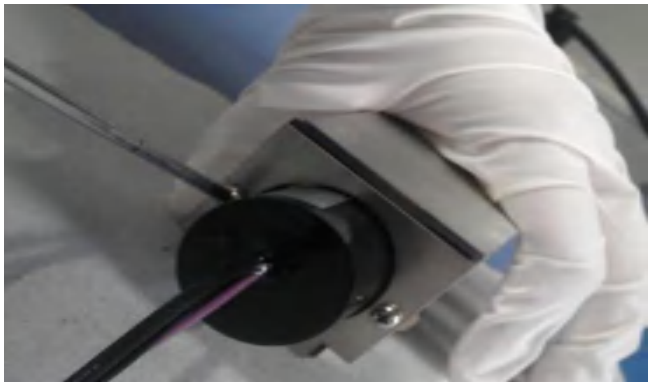


Figure 4-22 Remove the photomultiplier base

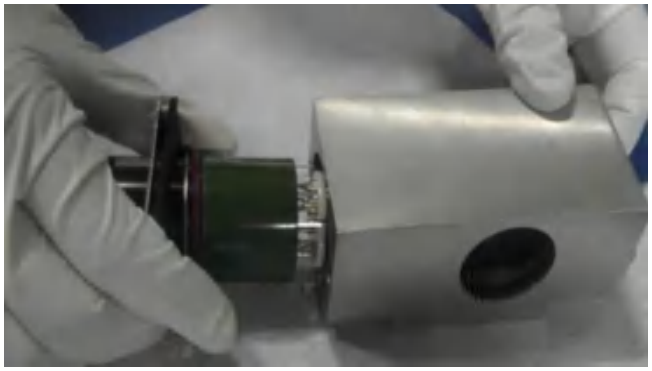


Figure 4-23 Take out the photomultiplier

Figure 4-24 Replace the Photomultiplier Tube

4.5.3.6 Troubleshooting

The following lists some common faults, fault causes and countermeasures encountered in the use of FPD.

If the fault cannot be solved through the methods suggested by us, or it is not within the scope listed here, please contact Drawell Technology Co., Ltd.

Table 4-5 Common FPD faults and solutions

Fault	Reason	Solution
No ignition or flame easily extinguished	Not connected to the chromatographic column	Connect the chromatographic column
	Hydrogen/air not supplied or incorrect hydrogen/air flow	Ensure hydrogen/air supply and adjust it to correct flow
	Ignition wire fault	Replace the ignition wire
	Detector temperature is too low	Increase the detector temperature, wait for the temperature to stabilize for a period of time before igniting
	Hydrogen/air EPC fault	Contact our Technical Support to replace EPC
Excessive baseline noise/severe baseline drift	The signal line is not properly connected	Check signal connection and adjust it to normal
	Gas leak	Check for leaks and repair leaks
	Light leakage	Find light leaks and block light with dark film
	Accumulation of water vapor in the exhaust port	Purge the exhaust port with a high flow of gas to remove adsorbed water
	Hydrogen/air EPC fault	Contact our Technical Support
	Inlet or column contamination	Clean or replace glass liners Condition the column, cut the column head
	Unstable FPD temperature	Investigate the temperature change of each part of the FPD; if it is unstable, contact our Technical Support
No chromatographic peaks	Flameout	Reignite
	Quenching	Adjust analytical conditions
	Wrong filter installation	Check and reinstall
	High-voltage wires or signal wires are not properly connected	Check electrical connections and repair

4.6 Purifier maintenance

When installing the purifier, be careful not to damage the purifier or deoxidizer, etc., during the installation process. The deoxygenation tube has a narrow capacity, and a small-sized deoxygenation tube has an oxygen capacity even of less than 30 mL. Therefore, the installation process is critical, and it is necessary to avoid the deactivation of the trap during the installation process which can shorten its service life.

If the purifier is pre-conditioned, it is not necessary to condition it before using. Nevertheless, all purifiers are subject to periodic regeneration, such as after one to four cylinders of gas are used, or when high-purity gas is not used.

To perform the regeneration method of the deoxygenation tube, users need to heat the deoxygenation tube to about 300°C under the condition of passing high-purity hydrogen, and stop heating until there is no water vapor (oxygen and hydrogen will generate water, which flows out of the deoxygenation tube in a gaseous state). After it cools down, it is necessary to reduce the hydrogen flow rate, and quickly close both ends of the deoxygenation tube under the condition of ventilation. When regenerating, users should pay attention to the safety of the use of hydrogen. If the chromatograph can be connected to a stainless steel packed column, the two ends of the deoxidizing tube are allowed to connected to a small section of stainless steel gas pipeline (the gaskets which need

to use graphite are 3 mm in outer diameter, and the joints at the two ends of the deoxidizing tube are generally connected to pipes with an outer diameter of 3 mm). Connect one end to the vaporization chamber and one end to the FID, then replace the carrier gas of the chromatograph with hydrogen, and check whether the excess carrier gas and makeup gas paths are closed (to prevent hydrogen from entering the oven after explode).Turn on the carrier gas again, the temperature of the column oven is raised to about 300°C, the temperature of the FID is raised to 300°C, and the vaporization chamber may not be heated. Good ventilation is required in the laboratory.

4.7 Tools and materials required for maintenance

Table 4-6 Tools and consumables for GC maintenance

Common tools	**Function**	**Article No.**
Toolkit	Adjustable wrench for unscrewing the adapter nut	1480100245
	Inch full-polished double open-end wrench 1/4"*5/16" for screwing the column nut at the inlet and detector end	
	Metric fully polished double open-end wrench 10*12mm for screwing the air source connection port	
	Socket wrench for unscrewing the flow path adapter block	
	Phillips screwdriver for unscrewing screws	
Routine maintenance consumables and parts	**Function**	**Article No.**
Inlet septum 11 mm	Seal the inlet. The inlet septum is a consumable that needs to be checked regularly and replaced as needed.	1440600371
Ultra-inert splitless liner	It is used when the splitless injection mode is selected, mainly for low concentration samples, such as water environment samples, food samples, and water purification plant samples. Compared with ordinary splitless liner, the ultra-inert splitless liner can effectively prevent adsorption, primarily for easily adsorbed samples, such as easily adsorbed pesticide residues.	1480300036
Split liner	It is used when the split injection mode is selected, mainly for high-concentration samples, such as leachate samples from waste treatment plants, and industrial wastewater samples.	1360400910
O-ring (for liner)	It is designed to divide the entire injection chamber for use on the liner. O-rings are consumables that need to be inspected regularly and replaced as needed.	1330900469
Splitter plate	It supports the liner and guides the carrier gas split, and generally the splitter plate does not need to be replaced. However, in the case of dirty samples, ghost peaks appear in the chromatogram, users may check whether the splitter plate is worn out or contaminated, and choose cleaning or replacement	1360300013
Vespel and graphite hybrid clamp ring (1/16" x 0.4mm)	Commonly used in the inlet/detector and column joints; and able to play a role in sealing thanks to its high temperature resistance. After cutting the column head or replacing other chromatographic columns, if the original pressure ring is deformed, it needs to be replaced. For 0.25 mm columns	1330900260
Vespel and graphite hybrid clamp ring (1/16" x 0.5mm)	For 0.32 mm columns	1330900060
Column ferrule fittings (metric)	It is used to fix the connection between the chromatographic column and the inlet, and generally does not need to be replaced.	1320300206
Syringe	It is placed in the autosampler for sampling and injection. Normally, it does not need to be replaced. If the injection needle is contaminated or blocked by impurities in the sample, choose cleaning. After cleaning, if it is still blocked, replace the syringe.	1440600188

5 Troubleshooting and analysis

5.1 Prompt information

The instrument regularly monitors the status of inlets, ovens, detectors, EPC modules, circuit boards and other components. If there is a fault, the running status and instrument status will display a fault prompt, which can be viewed in the alarm query. If a malfunction causes serious damage to the instrument or is dangerous to users, it will automatically stop the malfunctioning component from working.

5.1.1 Prompt information

Not ready: It occurs when some part of the instrument is not operating at normal operating conditions. When the instrument is not ready, the workstation software will have a corresponding prompt.

Alarm: The prompt means that there is a fault, and the instrument will have a corresponding alarm prompt at this time.

Fault: The prompt points out the hardware faults and other component faults that can cause great harm, which users should pay attention to. At this point, the instrument will stop all commands and actions being executed.

The fault can only disappear after the instrument clears the fault and activates the method twice.

5.2 Warnings and faults

See Table 5-1 for warnings and fault prompts. Users can maintain some problems by themselves, and some hardware problems need to be handled by the maintenance personnel of Drawell Technology Co., Ltd.

Table 5-1 introduces the common faults of the gas chromatograph and the corresponding treatment methods.

Table 5-1 GC 2000 Fault Prompts and Troubleshooting

	Alarm code	Fault prompt	Cause of fault	Troubleshooting
Main board Alarm code	0x01	Self-check indicates the main board 5V voltage is abnormal	Main board 5V voltage is abnormal	Contact the after-sales maintenance personnel to check the 5V power module
	0x02	Self-check indicates the main board 3.3V voltage is abnormal	Main board 3.3V voltage is abnormal	Contact the after-sales maintenance personnel to check the 3.3V power module
	0x05	Self-check indicates the off-chip EEPROM of the main board is abnormal	The off-chip EEPROM storage of the main board failed	Contact after-sales maintenance personnel to check the EEPROM chip
	0x06	Operating temperature of the main board is abnormal	Ambient temperature is too high	Check ambient temperature
	0x07	DAC124 is abnormal	DAC124 voltage is abnormal	Contact after-sales maintenance personnel to check the DAC124 chip
	0x08	Main board AD7124 sampling is abnormal	AD7124 acquisition failed	Contact the after-sales maintenance personnel to check the AD7124 chip
	0x10	Column oven out of temperature range	Column oven temperature range overrun	Contact the after-sales service personnel to check the oven PT100
	0x12	Column oven heating is abnormal	Slow heating rate	Contact after-sales service personnel to check the heating module

	0x14	The front door of the column oven is abnormal	The front door of the column oven is not closed	Check if the front door is closed
	0x20	Front inlet out of temperature range	Temperature sensor range overrun	Contact after-sales maintenance personnel to check PT100
	0x21	Front inlet heating is abnormal	Slow heating rate	Contact after-sales service personnel to check the heating module
	0x22	Rear inlet out of temperature range	Temperature sensor range overrun	Contact after-sales maintenance personnel to check PT100
	0x23	Rear inlet heating is abnormal	Slow heating rate	Slow heating rate
	0x24	Front detector out of temperature range	Temperature sensor range overrun	Contact after-sales maintenance personnel to check PT100
	0x25	Front detector heating is abnormal	Slow heating rate	Contact after-sales service personnel to check the heating module
	0x26	Rear detector out of temperature range	Temperature sensor range overrun	Contact after-sales maintenance personnel to check PT100
	0x27	Rear detector heating is abnormal	Slow heating rate	Contact after-sales service personnel to check the heating module
	0x30	Communication fault of the EPC board of the front inlet	Communication fault of the EPC/EFC board of the front inlet	Check EPC communication
	0x31	Communication fault of the EPC board of the rear inlet	Communication fault of the EPC/EFC board of the rear inlet	Check EPC communication
	0x32	Communication fault of the EPC board of the front detector	Communication fault of the flow control board of the front detector	Check EPC communication
	0x33	Communication fault of the EPC board of the rear detector	Communication fault of the flow control board of the rear detector	Check EPC communication
	0x34	Communication fault of Auxiliary 1 EPC board	Communication fault of Auxiliary module 1 flow control board	Check EPC communication
	0x35	Communication fault of Auxiliary 2 EPC board	Communication fault of Auxiliary module 2 flow control board	Check EPC communication
	0x38	Communication fault of the signal board of the front detector	Communication fault of the sub-board of the front detector	Check detector signal board communication
	0x39	Communication fault of the signal board of the rear detector	Communication fault of the sub-board of the rear detector	Check detector signal board communication
EPC Sub-board Alarm code	0x01	Front inlet/rear inlet/front detector/rear detector/auxiliary 1/auxiliary 2 VCC-FLOW is abnormal	Abnormal supply voltage	Contact the after-sales maintenance personnel to check the flow supply voltage
	0x02	Front inlet/rear inlet/front detector/rear detector/auxiliary 1/auxiliary 2 external DA/AD is abnormal	DA output voltage is abnormal	Contact after-sales service personnel to check DA output or AD sampling
	0x03	Front inlet/rear inlet/front detector/rear detector/auxiliary 1/auxiliary 2 off-chip EEPROM is abnormal	Off-chip EEPROM is abnormal	Contact the after-sales service personnel to check the off-chip EEPROM chip
	0x10	Front inlet/rear inlet Total	Inlet total flow range	Check gas circuit or sensor

		flow range overrun	overrun	
	0x11	Front inlet/rear inlet Total flow control is abnormal	The deviation between the actual value of the total flow and the set value exceeds the range	Check gas circuit or sensor
	0x12	Front inlet/rear inlet/aux 1/aux 2 pre-column pressure range overrun	Precolumn pressure range overrun	Check gas circuit or sensor
	0x13	Front inlet/rear inlet/auxiliary 1/auxiliary 2 column front pressure control is abnormal	The deviation between the actual value of pre-column pressure and the set value exceeds the range	Check gas circuit or sensor
	0x16	Front detector/rear detector hydrogen/reference gas flow range overrun	Detector hydrogen/reference gas flow range overrun	Check gas circuit or sensor
	0x17	Front detector/rear detector hydrogen/reference gas flow control is abnormal	The deviation between the actual value of hydrogen/reference gas flow and the set value exceeds the range	Check gas circuit or sensor
	0x18	Front detector/rear detector air flow range overrun	Detector air flow range overrun	Check gas circuit or sensor
	0x19	Front detector/rear detector air flow control is abnormal	The deviation between the actual value of the air flow of the detector and the set value exceeds the range	Check gas circuit or sensor
	0x1a	Front detector/rear detector makeup flow range overrun	Detector makeup flow range overrun	Check gas circuit or sensor
	0x1b	Front detector/rear detector makeup flow control is abnormal	The deviation between the actual value of the makeup flow of the detector and the set value exceeds the range	Check gas circuit or sensor
Detector sub-board Alarm code	0x01	Front detector/rear detector 5VA voltage is abnormal	Detector 5VA voltage is abnormal	Contact after-sales maintenance personnel to check the voltage chip module
	0x02	Front detector/rear detector 5VD voltage is abnormal	Detector 5VD voltage is abnormal	Contact after-sales maintenance personnel to check the voltage chip module
	0x03	Front detector/rear detector 10V voltage is abnormal	Detector 10V voltage is abnormal	Contact after-sales maintenance personnel to check the voltage chip module
	0x04	Front detector/rear detector 12V voltage is abnormal	Detector 12V voltage is abnormal	Contact after-sales maintenance personnel to check the voltage chip module
	0x05	Front detector/rear detector 24V voltage is abnormal	Detector 24V voltage is abnormal	Contact after-sales maintenance personnel to check the voltage chip module
	0x10	Front detector/rear detector HV voltage is abnormal	Detector HV voltage is abnormal	Contact after-sales maintenance personnel to check the HV power supply chip module
	0x11	Front detector/rear detector fan voltage is abnormal	Detector fan voltage is abnormal	Contact after-sales maintenance personnel to check the fan power supply chip module
	0x12	Front detector/rear detector ignition voltage is abnormal	Detector ignition voltage is abnormal	Contact after-sales service personnel to check the ignition system

	0x13	Front detector/rear detector EEPROM is abnormal	Write and read is abnormal	Contact the after-sales service personnel to check the off-chip EEPROM chip
	0x14	Front detector/rear detector ignition failure	Ignition failure	Check ignition system and gas circuit
	0x15	Front detector/rear detector flameout	Flameout	Check ignition system and gas circuit

Note: f5 represents the main board; 10 represents the front inlet EPC sub-board; 11 represents the rear inlet EPC sub-board; 12 represents the front detector EPC sub-board; 13 represents the rear detector EPC sub-board; 14 represents the auxiliary 1 EPC sub-board; 15 represents the auxiliary 2 EPC sub-board; 20 represents the front detector signal board; and 21 represents the rear detector signal board. For example: main board alarm code 0xf501; EPC sub-board alarm code 0x1012; detector sub-board alarm code 0x2014.

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