thermo scientific

Modular Gas System

USER GUIDE

269-346400A

November 2021

ThermoFisher SCIENTIFIC

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For Research Use Only. This instrument or accessory is not a medical device and is not intended to be used for the prevention, diagnosis, treatment or cure of disease.

WARNING

Avoid an explosion or fire hazard. This instrument or accessory is not designed for use in an explosive atmosphere.

Contents

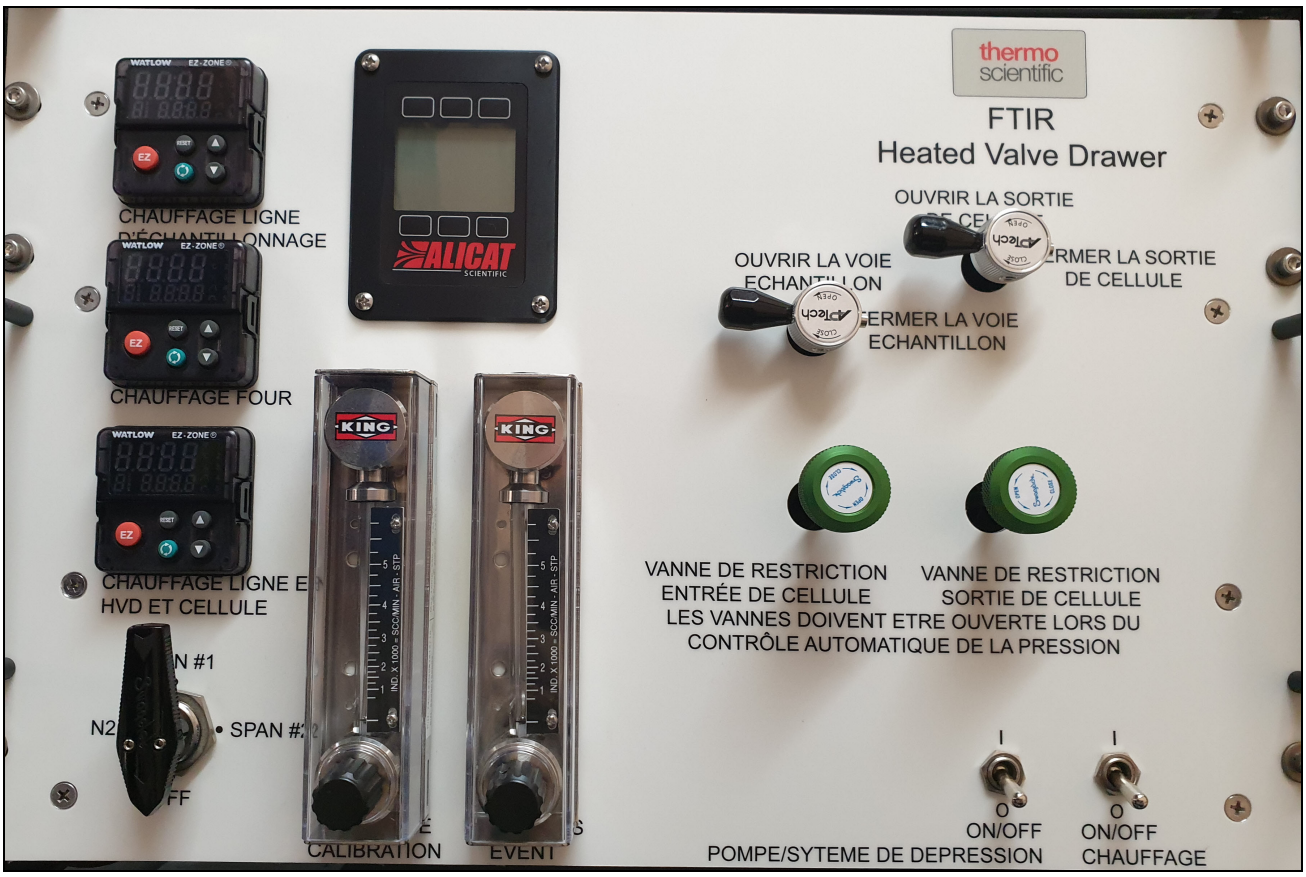
Chapter 1

Introduction

The Thermo Scientific™ Modular Gas System includes the FTIR Heated Valve Drawer for convenient gas selection and gas cell isolation. With the Heated Valve Drawer, you can monitor and control the temperature, pressure, and flow rate of your gas sample from sample point through the heated gas cell.

The Modular Gas System is intended to be used with non-flammable and non-oxidizing gases that are compatible with PTFE, PFA, glass, and stainless steel.

Figure 1-1: The Automated Pressure configuration of the Heated Valve Drawer.



The Modular Gas System includes an open 19” rack mounted system and is designed to be used with the Thermo Scientific Antaris™ IGS analyzer, or the Nicolet™ iG™50, Nicolet iS™50, Nicolet iS10, or Nicolet iS20 spectrometers.

SYSTEM OPTIONS

The system accommodates a variety of configurations, including the following options:

- Compatible with Antaris IGS analyzer or a Nicolet spectrometer
- Installs in a full or half height 19-inch standard rack or table mounted system
- Suitable for open or enclosed racks

The Heated Valve Drawer also supports a variety of configurations of valves, controls, and gas fittings. This manual describes each of the components available, but your Heated Valve Drawer may be configured differently to suit your site and sampling requirements.

For additional information about available configurations, contact www.thermofisher.com.

Be sure that all persons operating this system read the site and safety manual first.

The site and safety guide that came with your analyzer or spectrometer contains important safety information. Before you use the system, read the entire guide. To prevent personal injury and damage to equipment, follow the safety precautions contained in the guide whenever you use the system.

Using this document

This document describes setting up, operating, and maintaining the FTIR Heated Valve Drawer as a component of the Modular Gas System. Read this manual before you attempt to install or use the system.

Before using this system, review the Site and Safety information that came with your spectrometer. See the user guides for your spectrometer and other accessories for additional information.

If you have any questions or concerns after reading this manual, refer to www.thermofisher.com.

Conventions used

Safety precautions and other important information use the following format:

DANGER

Avoid hazard. Indicates a hazardous situation which, if not avoided, will result in serious injury or death.

WARNING

Avoid hazard. Indicates a hazardous situation which, if not avoided, could result in serious injury or death.

CAUTION

Avoid hazard. Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

Follow instructions with this label to avoid damaging the system hardware or losing data.

Note Contains helpful supplementary information.

Chapter 2

Site requirements and safety information

This chapter contains a summary of safety precautions for using the system. The information in this guide is a supplement to the site and safety information that came with your instrument and to the user guide that came with your gas cell, spectrometer or analyzer, and other system components. See the site and safety guide that came with your system components for additional site requirements and safety information.

Each person who will be using this device should read this chapter as well as the site and safety information that came with your other system components.

Operating environment

Consider the following environmental factors when planning your work space.

Lifting and carrying

The FTIR Heated Valve Drawer weighs approximately 23 kgs (51 lbs). To avoid risk of injury, use proper lifting techniques when lifting or moving the Heated Valve Drawer or other system components.

CAUTION

Avoid risk of personal injury. Your Heated Valve Drawer cannot be lifted safely by a single person. Lifting or moving the drawer requires two people. Use proper lifting techniques when lifting or moving the drawer or other system components.

Workspace considerations

The Heated Valve Drawer is measures approximately 48.26 cm wide, 30.5 cm high, and 38 cm deep (19 in. wide, 12 in. high, and 15 in. deep). With the optional heated filter, the drawer is approximately 48.26 cm deep (19 in.)

The FTIR Heated Valve Drawer is designed to fit a standard open 19” rack

CAUTION

Do not position the FTIR Heated Valve Drawer so that it is difficult to reach the cable connections and power switch on the rear panel.

Electrical service specification

CAUTION

Avoid shock hazard. Each wall outlet used must be equipped with a ground. The ground must be a noncurrent-carrying wire connected to earth ground at the main distribution box.

The following table lists the specifications for electrical service. Contact our service representative in your area if you have questions about the requirements.

Requirements	Specifications
Input current	10 A (max.)
Input voltage	230 Vac
Line frequency	50 to 60 Hz
Line disturbances	Sags, surges or other line disturbances must not exceed 10% of input voltage (even for a half cycle).
Noise	< 2 V (common mode) < 20 V (normal mode)

Power cords

Use an appropriate power cord for the electrical service. The power cord supplied with the spectrometer is a 3-wire, grounded power cord, appropriate for use in the country listed as the shipping destination for the system. The main power supply cord can be replaced only by an equivalent cable. If the power cord you received is not appropriate for the electrical system in your location or if the power cord becomes damaged, contact us to order a new power cord.

A 10 A rated power cord must be used for each power cord.

Temperature and humidity

The FTIR Heated Valve Drawer is designed for indoor use at altitudes up to 2,000 M (6,500 ft). The drawer itself operates reliably at temperatures between 16 °C and 27 °C (60 °F and 80 °F).

Maintain humidity at 20% to 80% non-condensing.

The safe environmental operating temperatures of the gas analysis system at your location may be restricted by the safe operating parameters for the gas cell(s) used with your analyzer or spectrometer.

Gas Cell	Safe Operating Temperature Range
10-meter	25 °C to 185 °C (77 °F to 365 °F)
2-meter	20 °C to 185 °C (68 °F to 365 °F)
Other cells	See the documentation that came with the gas cell

Ventilation of sample gases

The FTIR Heated Valve Drawer includes a gas vent on the rear panel of the drawer. Ensure that the sample gases are vented to a safe and suitable location.

This system is designed for vacuum use only. If you are sampling toxic or hazardous gases, the gas vent outlet must be connected to a vacuum exhaust vent system designed to safely remove these toxic or hazardous gases.

If the vent port is blocked or connected to a source of pressure, toxic or hazardous gas could enter the work area and break the gas cell windows. Never block or plug the vent port or connect it to a source of pressure.

The pressure relief valve is set to 25 PSI to protect the 2M or 10M gas cell with ZnSe windows. The relief valve is connected to the vent port.

WARNING

Avoid toxic inhalation. If you are sampling noxious, toxic, reactive, asphyxiant, or otherwise hazardous gases, you must provide an active venting system to vent the gases to a safe and suitable location.

DANGER

Avoid fire and explosion hazard. The infrared source inside the adjacent FTIR instrument is an ignition source. If you are sampling flammable gases, vent the gases away from the instrument. Provide a fume hood or other active venting system that is free of spark and other ignition sources and that prevents flammable vapors from collecting in the atmosphere surrounding these instruments.

Fire safety and burn hazards

Components of the FTIR Heated Valve Drawer become quite hot during normal operation, including the heated filter, sample gas line, gas fittings, and valves.

CAUTION

Avoid burn hazard. The optional heated filter becomes very hot during normal operation. Turn off power to the heaters and allow the filter to come to room temperature before handing the heated filter assembly.

To avoid a burn injury, turn off the FTIR Heated Valve Drawer and allow to cool to room temperature before replacing any components.

Tip hazard

The rack mounted system can pose a tip hazard unless appropriate anti-tip extensions, feet, or anchors are in place. Use anti-tip devices that were designed by your rack manufacturer or by a qualified structural engineer.

Rack enclosure hazards

If your gas system is installed in an enclosed rack, ensure that the rack is properly ventilated to prevent gases from accumulating inside the rack and internal rack temperatures from exceeding the operating temperatures of the enclosed components.

DANGER

Avoid fire and explosion hazard. The infrared source inside the adjacent FTIR instrument is an ignition source. If you are sampling flammable gases, vent the gases away from the instrument. Provide a fume hood or other active venting system that is free of spark and other ignition sources and that prevents flammable vapors from collecting in the atmosphere surrounding these instruments.

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Chapter 3

Installation

This chapter describes setting up components of the Modular Gas System and connecting and turning on the Heated Valve Drawer.

The installation steps depend on whether you have a manual or Automatic Pressure Control system.

Your system may be configured with different connections and components. See the plumbing diagram for your system in the Appendix before connecting gas lines.

Assemble the rack

You can install the FTIR Heated Valve Drawer and your other system components on a standard open 19-inch rack. The optional rack accommodates the heated valve drawer, pumps and filters, and a spectrometer or analyzer.

Depending on your configuration, your system may look different than the one shown.

Figure 3-1: Two possible configurations for the rack-mounted system

CAUTION

Avoid risk of personal injury. Your Heated Valve Drawer and the spectrometer or analyzer cannot be lifted safely by a single person. Lifting or moving the drawer requires two people. Use proper lifting techniques when lifting or moving the drawer or other system components.

Required Materials

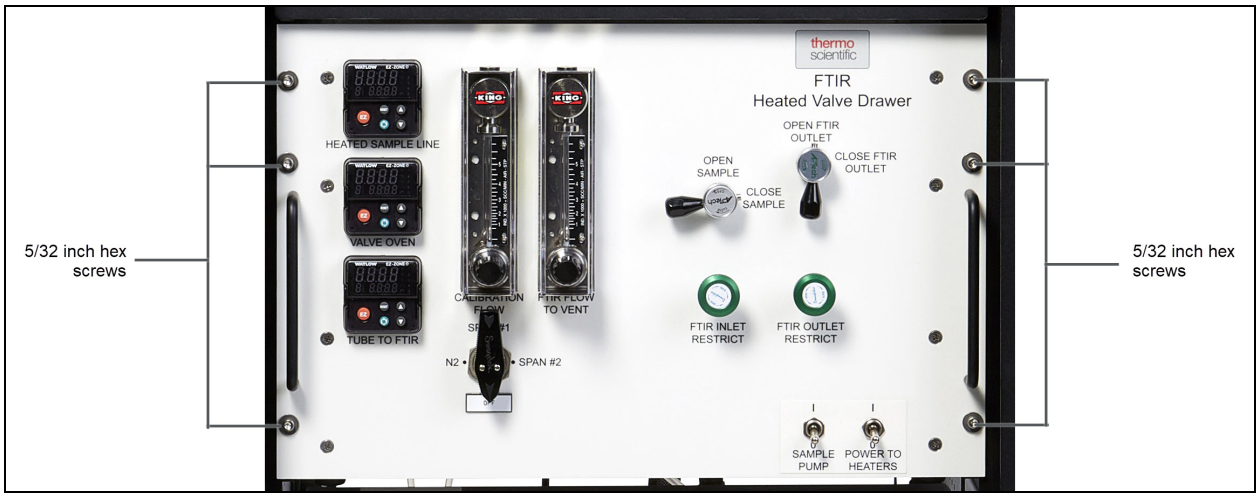
- 5/32 inch hex wrench
- Two or more people are required for the installation

❖ To install system components on the optional rack

Step 1: Install the Heated Valve Drawer

Note If the rack is empty when you begin, you may want to carefully lay the rack flat on its back side so that you can lower the drawer into position. The vacuum pump is also easier to install in this postion. If there are already components on the rack, one person will need to support the weight of the heated valve drawer while the other fastens the screws.

1. Insert the drawer into the front of the rack, aligning the holes on the front of the drawer with the cage nut clips.
2. With one person supporting the weight of the drawer, use the six (6) hex screws and washers to fasten the front panel of the drawer to the rack.



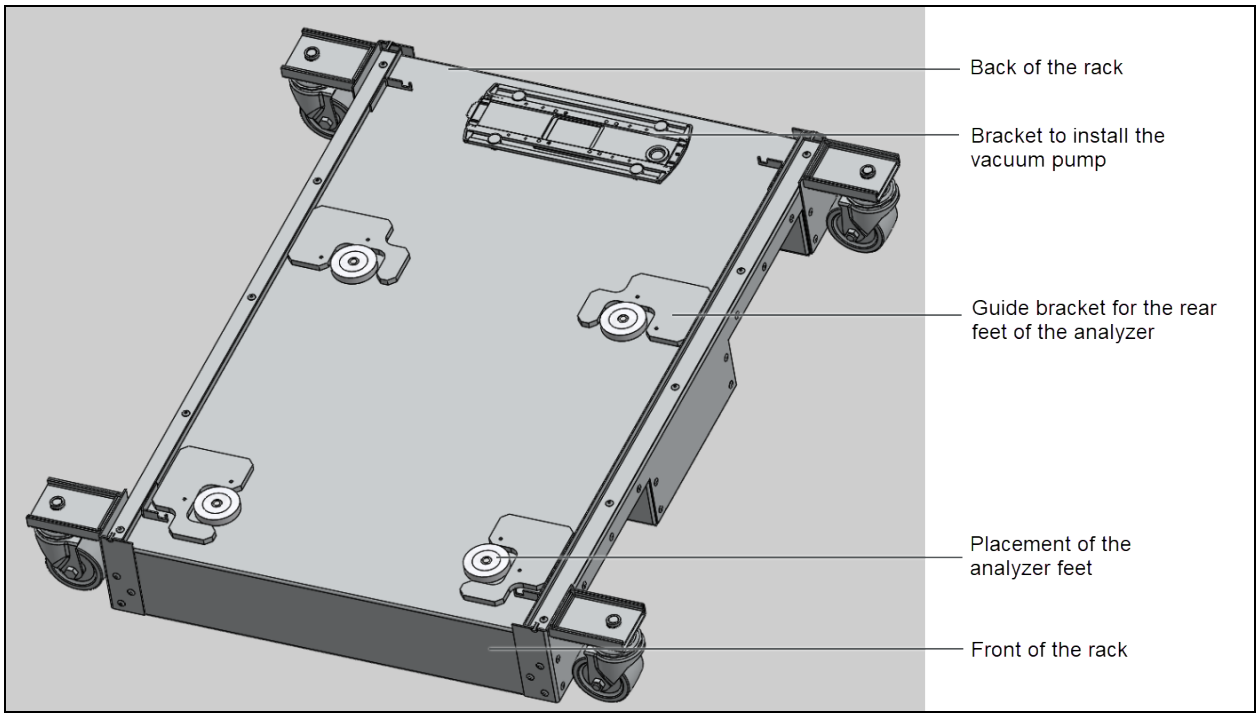
3. Completely tighten each of the screws.

Step 2: Position the instrument

The system supports the IGS Analyzer on the bottom shelf of the rack or the iG50 FTIR Spectrometer on the top of the rack.

- **To install the IGS Analyzer on the bottom shelf of the rack**

1. Slide the back feet of the anlyzer into the rear brackets to center the analyzer, and then lower the front feet into the brackets.

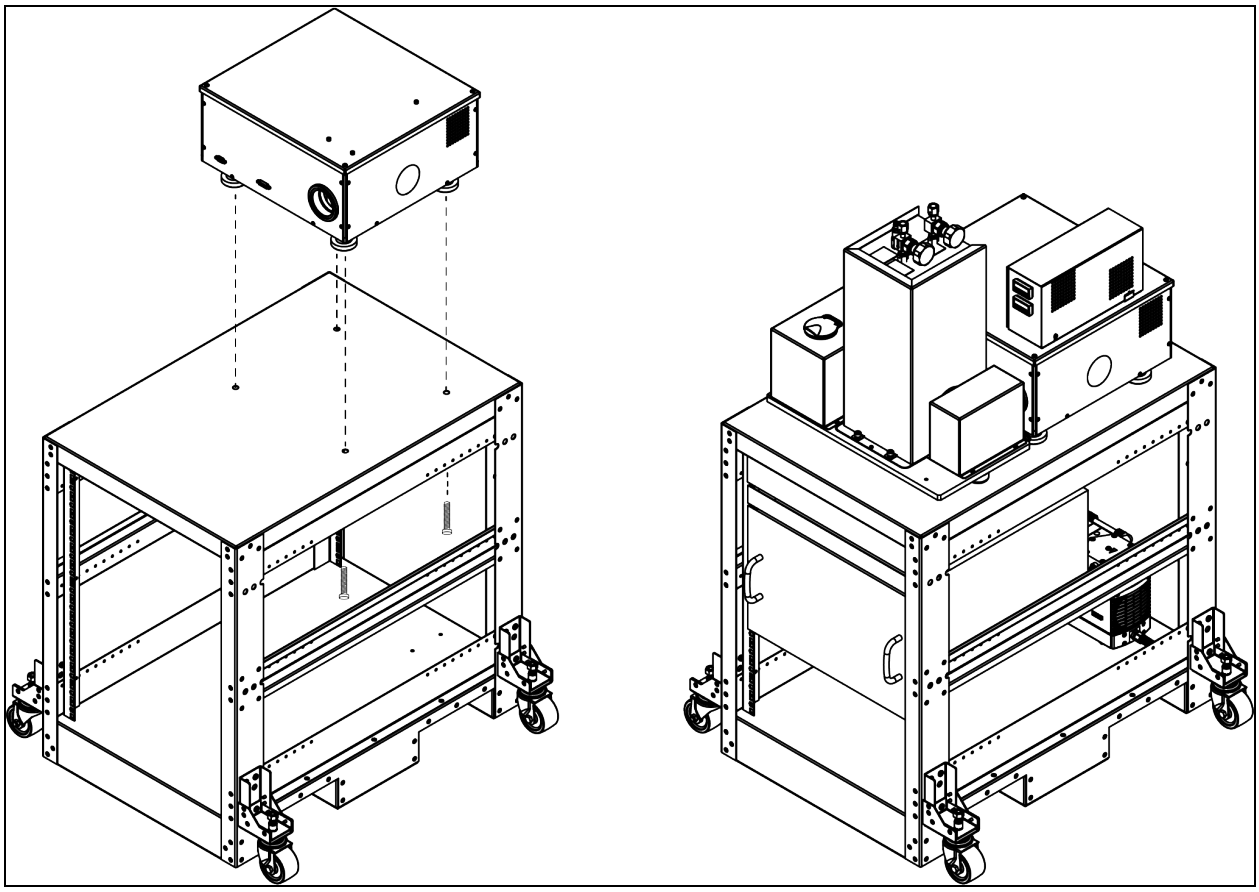


When removing the analyzer, lift the front feet over the bracket and slide the analyzer forward.

- **To install the Nicolet iG50 FTIR Spectrometer on the top of the rack**

The spectrometer is held in place by four screws installed from below the top of the rack upward into the feet of the iG50

1. Carefully position the spectrometer on top of the rack with the feet aligned over the drilled holes.



2. Insert the four (4) screws upward from underneath the top of the rack into the four feet of the spectrometer.
3. Tighten each of the screws completely.
4. Complete the assembly according to the installation guide that came with your spectrometer.

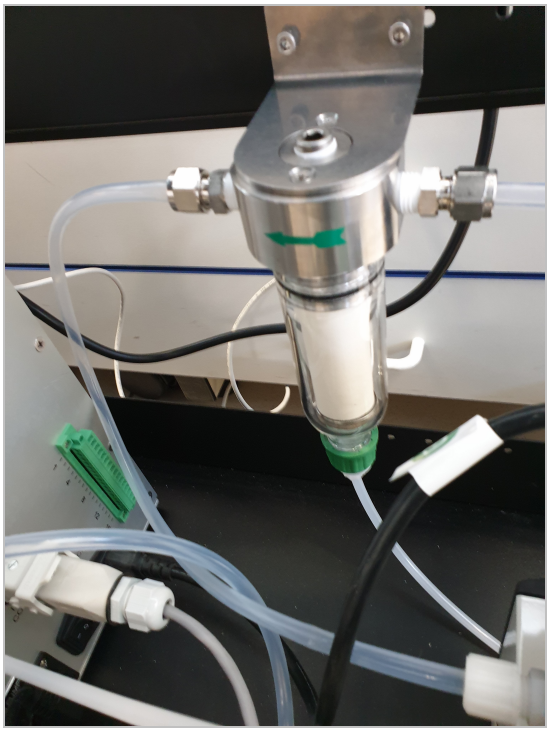
If your system uses a Manual Pressure Control system, proceed to step 3: install the pumps and additional filters.

If your system uses an automatic pressure control system, turn to "The Automatic Pressure Control System"

Step 3: Install the pumps and additional filters

The system may include a vacuum sample pump, a condensate pump, and a water catch filter, which should also be installed on the rack.

1. Install the vacuum pump.
   a. With the gas inlet and outlet valves facing inside the rack, toward the analyzer or heated valve drawer, place the vacuum pump on the pump bracket with the feet aligned over the screw holes.
   b. To fasten the pump to the rack, reach under the rack and insert each of the four (4) M4 screws into the holes. Tighten the screws.
2. Install the peristaltic drain pump and water catch.
   a. Install the water catch filter behind the heated valve drawer.



b. Connect the water catch drain to the peristaltic pump.

If you are installing other components, such as a computer, on the shorter rack with the iG50 spectrometer, you can move the power strip to the space directly above the heated valve drawer, which will free additional space below the drawer. This will require you to route power cables over the top of the heated valve drawer.

After installing each of the components, you are ready to connect the gas lines . See "Connect the Heated Valve Drawer and pressure control system" for details.

Replace gas cell fittings

The gas cell uses 1/4 in. standard Swagelok fittings on the gas inlet and outlets. The fittings may need to be adapted to 6 mm if you are using metric fittings.

CAUTION

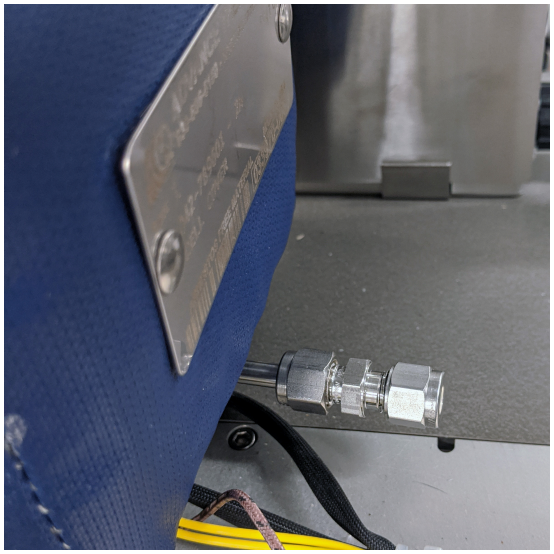
Avoid Leaks. Do not mix 1/4 inch and 6 mm ferrules and nuts. If they are mixed or if they are attached to the wrong end of the 1/4 inch to 6 mm adapter, the connection will leak.

Figure 3-2: The needle valves on the gas cell must be replaced with a standard fitting

❖ To replace the gas cell fittings

1. Using a 9/16” wrench or an adjustable wrench, loosen the nut closest to the gas cell to remove the valve.

2. Insert the standard Swagelok fitting into the nut as shown:



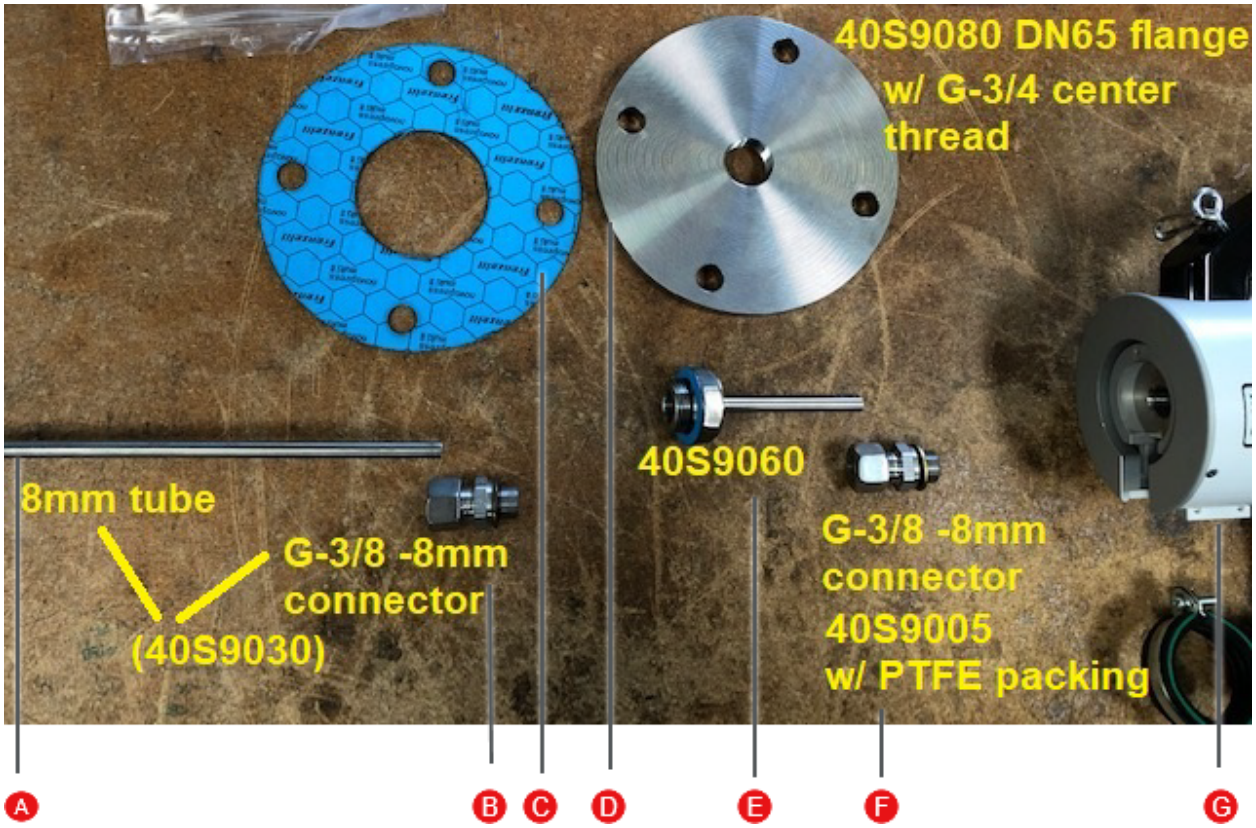
3. Using an adjustable wrench, tighten the nut. Be careful not to bend or damage the gas line.
4. Repeat for the second valve.

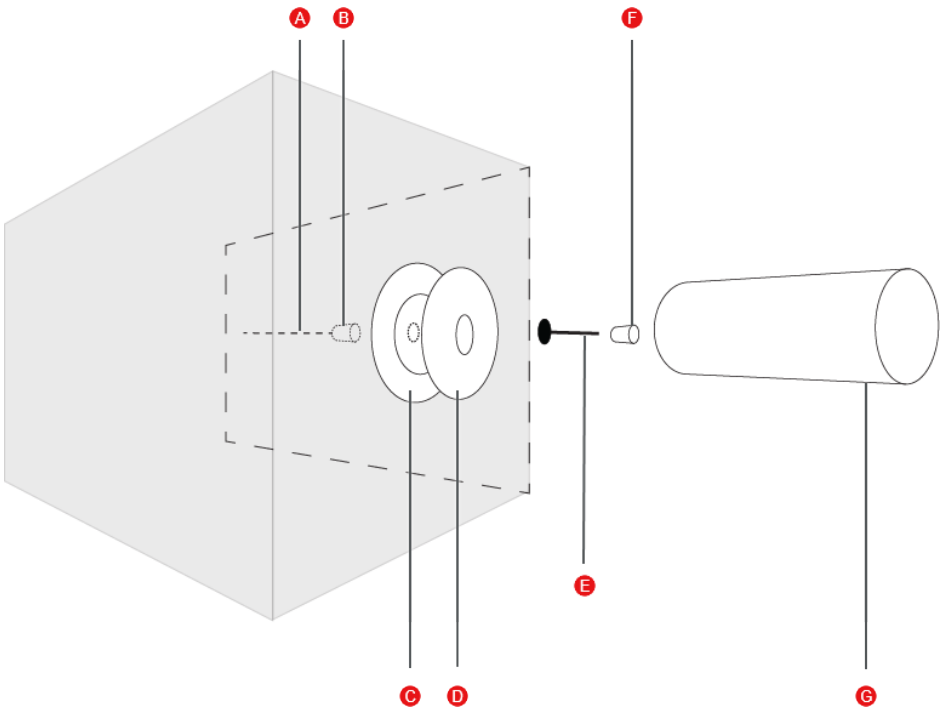
Mount the sample probe and particulate filter

The particulate filter connects to the sample source and filters the sample gas before it reaches the Heated Valve Drawer or the gas cell.

❖ To install the sample probe and particulate filter

1. Mount the flange to the outside of the sample source. The flange bolts to the sample wall using the 4 outer bolt holes.
2. Drill the hole in the center of the flange into the sample source.
3. Use the 3/8 8mm connector to connect the probe tube inside of the sample source with the sample tube on the outside of the source.





A	8mm probe tube (either solid or perforated), inside the sample source
B	3/8 8mm connector, inside the sample source
C	Blue gasket, outside of the sample source
D	DN65 flange
E	Sample tube
F	3/8 8mm connector with PTFE packing
G	PSP4000 particulate filter

4. Use the 3/8 8mm connector with PTFE packing to connect the sample tube to the PSP4000 particulate filter.

Connect the Heated Valve Drawer and pressure control system

The system is available in 2 basic configurations:

- **Manual Pressure Control:** Set the gas cell pressure and sample flow rate by manually adjusting the valves and flow meter positions. If you switch between Sample and Span gas inputs, you must reset pressure and flow values because of the different back pressures. You may also need to correct the pressure and flow occasionally when they naturally drift.
- **Automatic Pressure Control:** The gas cell pressure and sample flow rate are controlled automatically using a variable pressure control valve. Configure the set point with a pressure controller. The variable valve maintains the gas sample pressure at a constant value, even with changes in back pressure or between different input selections. With the Automatic Pressure Control option, you can use custom sampling manifolds with multiple streams and control the input sample selection through a programmable logic controller (PLC).

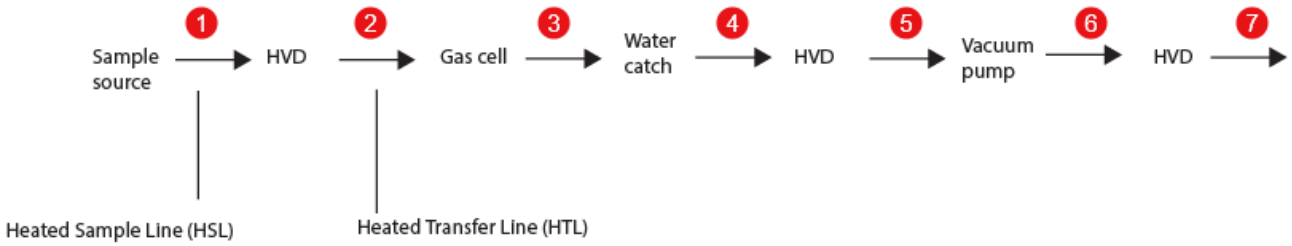
The Manual Pressure Control and Automatic Pressure Control configurations have different sample tubing connections on the rear panel of the Gas Control Panel. Verify the configuration of your system before installing the tubing connections.

Manual Pressure Control System

To complete the installation of your Manual Pressure Control system, connect the remaining gas lines and electrical components.

See the plumbing diagram for your system for a more complete flow diagram.

Figure 3-3: The flow path of the sample gas through the Manual Pressure Control system



1. Using the Heated Sample Line, connect the sample source to the SAMPLE IN fitting.

   The sample may pass through the optional probe and heated filter (not shown in Figure 3-3).

2. Using the Heated Transfer Line, connect the SAMPLE TO IGS fitting to the gas cell inlet.

3. Connect the gas cell outlet to the water catch and condensation filter. Connect the filter drain.

4. Connect the line from the condensation filter to the SAMPLE RETURN FROM FTIR fitting.

5. Connect TO VACUUM PUMP outlet to the inlet on the vacuum pump.

6. Connect the outlet on the pump back to the return from pump inlet on the HVD.

7. Finally, connect the VENT fitting to your fume hood.

❖ To connect the gas lines

Connect each of the gas lines to the rear panel of the drawer before connecting the electrical components.

The available gas inputs to the system include the following:

- Heated Sample Line from the sample point to the FTIR Heated Valve Drawer.
- Nitrogen (N2) used to clean the gas cell and collect a "zero" background sample. You may also use filtered, compressed air in place of nitrogen. If you are using filted, compressed air, use a filter that was designed for FTIR use.
- Optional Span 1 and Span 2 valve positions for span or calibration gas samples.

Gas lines are connected to the FTIR Heated Valve Drawer with Swagelok™ tube fittings.

1. Connect the Heated Sample Line (HSL)

   A heated sampling line (HSL) (typically 2 -3 meters in length) connects the sample site to the FTIR gas cell.Connect the HSL using the standard Swagelok fitting on the rear panel of the drawer.

   Figure 3-4: The Heated Sample Line (HSL) and control box.

   a. Fully insert the tubing into theSAMPLE IN fitting.
   b. Rotate the nut clockwise until finger tight.
   c. Using a wrench, tighten the nut 1¼ turns. Do not over tighten.
   d. Connect the round black cable from the HSL to the power control box.

e. Connect the power cable (not shown) from the power control box and power strip A.

f. Use the long gray cable to connect the power control box to the Heated Valve Drawer.

2. Connect the Heated Transfer Line (HTL).

   a. Connect the HTL between the IGS gas cell and the HVD. Place the end with the electrical connectors towards the HVD.

   > **Note** The line to the IGS is distinct from the Heated Sample Line from the sample source. The Heated Sample Line from the source to the Heated Valve Drawer is much longer, while the shorter Heated Transfer Line connects the HVD to the IGS gas cell.

   b. Connect the electrical round black cable from the HTL to the back of the Heated Valve Drawer.

3. Connect the remaining un-heated gas lines.

4. Connect the gas cell outlet to the condensate filter inlet.

5. Continue connecting each of the gas lines according to the plumbing diagram for your system. See "Automatic Pressure Control System"

6. Install the thermal insulation wrap on the bare tube connections of the HTL and HSL.

Ventilation

WARNING

Avoid toxic inhalation. If you are sampling noxious, toxic, reactive, asphyxiant, or otherwise hazardous gases, you must provide an active venting system to vent the gases to a safe and suitable location.

This system is designed for vacuum use only. If you are sampling toxic or hazardous gases, the vent outlet must be connected to a vacuum exhaust vent system designed to safely remove these toxic or hazardous gases.

If the vent port is blocked or connected to a source of pressure, toxic or hazardous gas could enter the work area and break the gas cell windows. Never block or plug the vent port or connect it to a source of pressure.

The pressure relief valve is set to 25 PSI to protect the 2M or 10M gas cell with ZnSe windows. The relief valve is connected to the vent port.

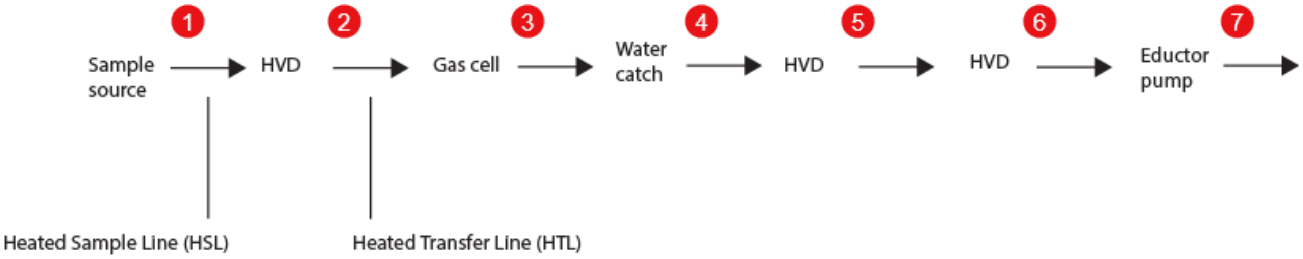
The Automatic Pressure Control System

To complete the installation of your Automatic Pressure Control System, connect the labeled gas lines and electrical components.

Figure 3-7shows the flow path the gas sample follows as it passes through the Modular Gas System and FTIR analyzer.

See the plumbing diagram for your system for a more complete flow diagram.

Figure 3-5: The flow path of the sample gas through the Automatic Pressure control configuration



1. **Using the Heated Sample Line (HSL), connect the sample source to the source to SAMPLE IN.**

   The sample may pass through the optional probe and heated filter (not shown in Figure 3-5).

2. **Using the Heated Transfer Line (HTL), Connect the SAMPLE TO IGS fitting to the gas cell inlet.**

3. **Connect the gas cell outlet to the inlet of the condensation filter.**

4. **Connect the outlet of the condensation filter to the SAMPLE RETURN FROM FTIR fitting.**

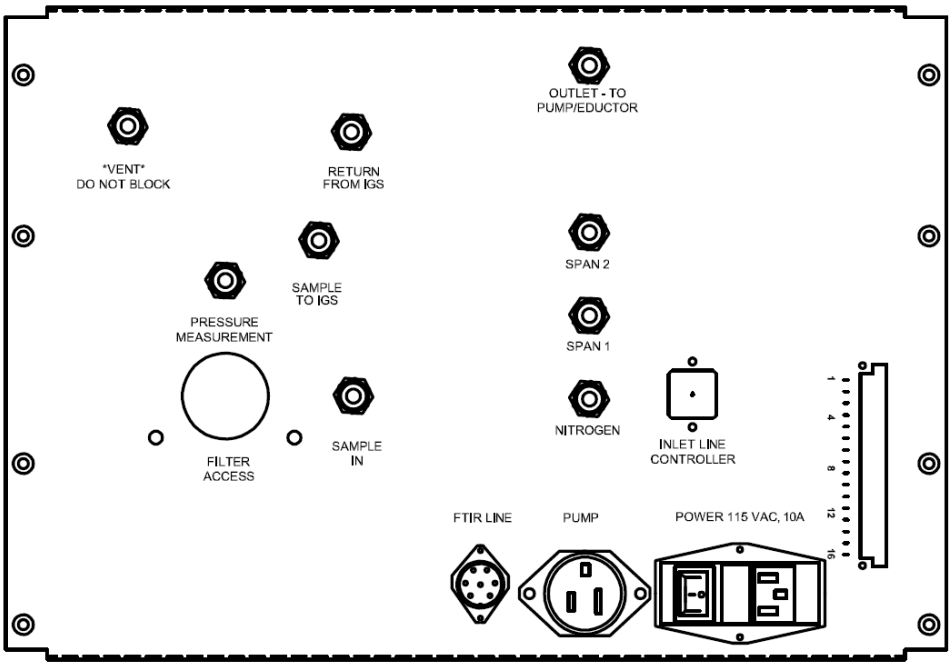
5. **Use the short gas line to connect the two fittings labeled number 8 on the Heated Valve Drawer.**

6. **Connect the OUTLET TO PUMP/EDUCTOR fitting to the inlet of the vacuum or eductor pump.**

7. **Connect the outlet of the vacuum pump to the vent or hood.**

❖ To connect the gas lines

Connect each of the gas lines to the rear panel of the drawer before connecting the electrical components.



The available gas inputs to the system include the following:

- Heated Sample Line from the sample point to the FTIR Heated Valve Drawer.
- Nitrogen (N2) used to clean the gas cell and collect a "zero" background sample. You may also use filtered, compressed air in place of nitrogen. If you are using filted, compressed air, use a filter that was designed for FTIR use.
- Optional Span 1 and Span 2 valve positions for span or calibration gas samples.

Gas lines are connected to the FTIR Heated Valve Drawer with Swagelok™ tube fittings.

1. Connect the Heated Sample Line (HSL)

   A heated sampling line (HSL) (typically 2 -3 meters in length) connects the sample site to the FTIR gas cell.Connect the HSL using the standard Swagelok fitting on the rear panel of the drawer.

Figure 3-6: The Heated Sample Line (HSL) and control box.

a. Fully insert the tubing into theSAMPLE IN fitting.

b. Rotate the nut clockwise until finger tight.

c. Using a wrench, tighten the nut 1¼ turns. Do not over tighten.

d. Connect the round black cable from the HSL to the power control box.

e. Connect the power cable (not shown) from the power control box and power strip A.

f. Use the long gray cable to connect the power control box to the Heated Valve Drawer.

2. Connect the Heated Transfer Line (HTL).

   a. Connect the HTL between the IGS gas cell and the HVD. Place the end with the electrical connectors towards the HVD.

   > **Note** The line to the IGS is distinct from the Heated Sample Line from the sample source. The Heated Sample Line from the source to the Heated Valve Drawer is much longer, while the shorter Heated Transfer Line connects the HVD to the IGS gas cell.

   b. Connect the electrical round black cable from the HTL to the back of the Heated Valve Drawer.

3. Connect the remaining un-heated gas lines, according the the plumbing diagram for your ystem. See "Automatic Pressure Control System"

4. Connect the gas cell outlet to the condensate filter inlet.
5. Install the thermal insulation wrap on the bare tube connections of the HTL and HSL.

Ventilation

WARNING

Avoid toxic inhalation. If you are sampling noxious, toxic, reactive, asphyxiant, or otherwise hazardous gases, you must provide an active venting system to vent the gases to a safe and suitable location.

This system is designed for vacuum use only. If you are sampling toxic or hazardous gases, the vent outlet must be connected to a vacuum exhaust vent system designed to safely remove these toxic or hazardous gases.

If the vent port is blocked or connected to a source of pressure, toxic or hazardous gas could enter the work area and break the gas cell windows. Never block or plug the vent port or connect it to a source of pressure.

The pressure relief valve is set to 25 PSI to protect the 2M or 10M gas cell with ZnSe windows. The relief valve is connected to the vent port.

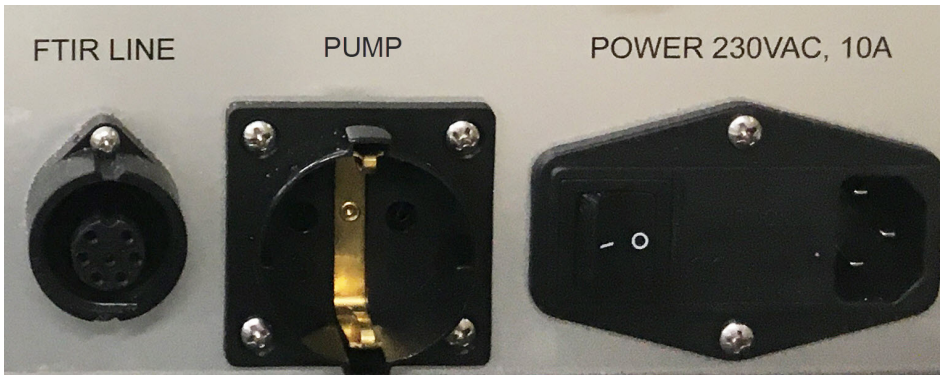
Connect the electrical wiring

The main components of the system must be installed on separate circuits. Plug the components into the two power strips and connect each of the power strips to a separate grounded AC power source on different circuits:

- Power strip A:
  - Heated Valve Drawer
  - Inlet Heated Sample Line power
  - Peristaltic pump
- Power strip B:
  - Spectrometer or analyzer
  - Heated gas cell
  - Computer

Each of the power strips in this setup will draw about 10 A. If they are plugged into the same circuit, they will overload most standard circuits.

1. Connect the vacuum pump to the back panel of the Heated Valve Drawer.



2. Plug the main power from the Heated Valve Drawer into one of the two power strips (either the front or back power strip).
3. Plug the peristaltic pump into the same power strip that you plugged the heated valve drawer into.
4. Plug the spectrometer, heated gas cell, and computer into the second power strip.
5. Plug the power strips into two separate grounded AC power sources. The outlets must be on two different circuits.

See the "Electrical service specification" for electrical requirements for the Heated Valve Drawer. See the site and safety information or user guide for your other components for additional electrical specifications.

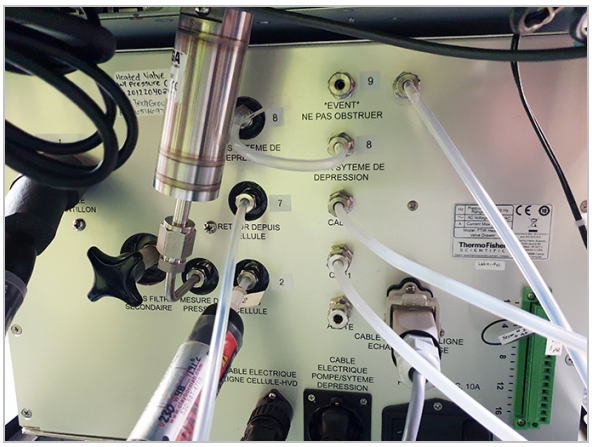
Install the pressure transducer

To install the pressure transducer, you will connect it to the Pressure Measurement fitting and connect the wiring to the Thermo Scientific Antaris IGS Temperature Controller.

On the Manual Pressure Control system, the pressure transducer should be installed horizontally, as shown in the figure below.

On the Automatic Pressure Control system, the pressure transducer should be installed vertically. It is okay if the pressure transducer is at a slight again, as shown in Figure 3-7

Figure 3-7: Correctly installed pressure transducer



❖ To connect the pressure transducer

1. Connect the pressure transducer to the **Pressure Measurement** outlet on the rear panel of the drawer. The pressure transducer must be installed upright or horizontally (not at an angle and not upside down), as shown in the previous image.

   A Swagelok VCR sealing washer for the connection is provided in a plastic bag attached the pressure measurement outlet.

   a. Pull the threaded fastener out to the end of the pressure measurement tube.

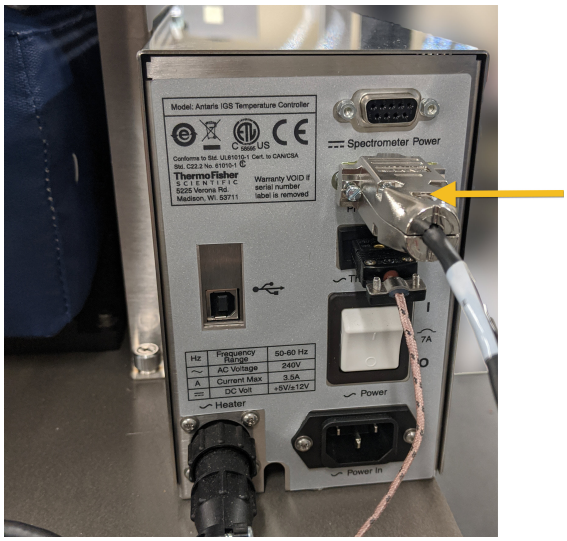
   b. Place the provided washer into the threaded fastener of the pressure transducer.

   c. Attach the pressure transducer to the pressure measurement tube and tighten by hand.

   d. Using an adjustable wrench, tighten the nut. Be careful not to bend or damage the pressure measurement tube.

2. Connect the data cable from the pressure transducer to the **Pressure Data In** port on the temperature controller. See the user manual for the temperature controller for more information on

using the pressure transducer.



Turn on the Heated Valve Drawer

Once all gas lines and electrical components are connected, you can turn on the system. Use the switches on the front of the Heated Valve Drawer to power on the system.

- | = the On position
- 0 = the Off position

To turn on the heaters, move the Power to Heaters switch to the On position.

To turn on the vacuum pump, switch the Sample Pump switch to the On position.

Chapter 4

Operation

Your FTIR Heated Valve Drawer may or may not have each of these features. The specific configuration of your drawer determines which controls you have and how they are arranged.

The system is available in 2 basic configurations:

- **Manual Pressure Control:** Set the gas cell pressure and sample flow rate by manually adjusting the valves and flow meter positions. If you switch between Sample and Span gas inputs, you must reset pressure and flow values because of the different back pressures. You may also need to correct the pressure and flow occasionally when they naturally drift.
- **Automatic Pressure Control:** The gas cell pressure and sample flow rate are controlled automatically using a variable pressure control valve. Configure the set point with a pressure controller. The variable valve maintains the gas sample pressure at a constant value, even with changes in back pressure or between different input selections. With the Automatic Pressure Control option, you can use custom sampling manifolds with multiple streams and control the input sample selection through a programmable logic controller (PLC).

The Manual Pressure Control and Automatic Pressure Control configurations have different sample tubing connections on the rear panel of the Gas Control Panel. Verify the configuration of your system before installing the tubing connections.

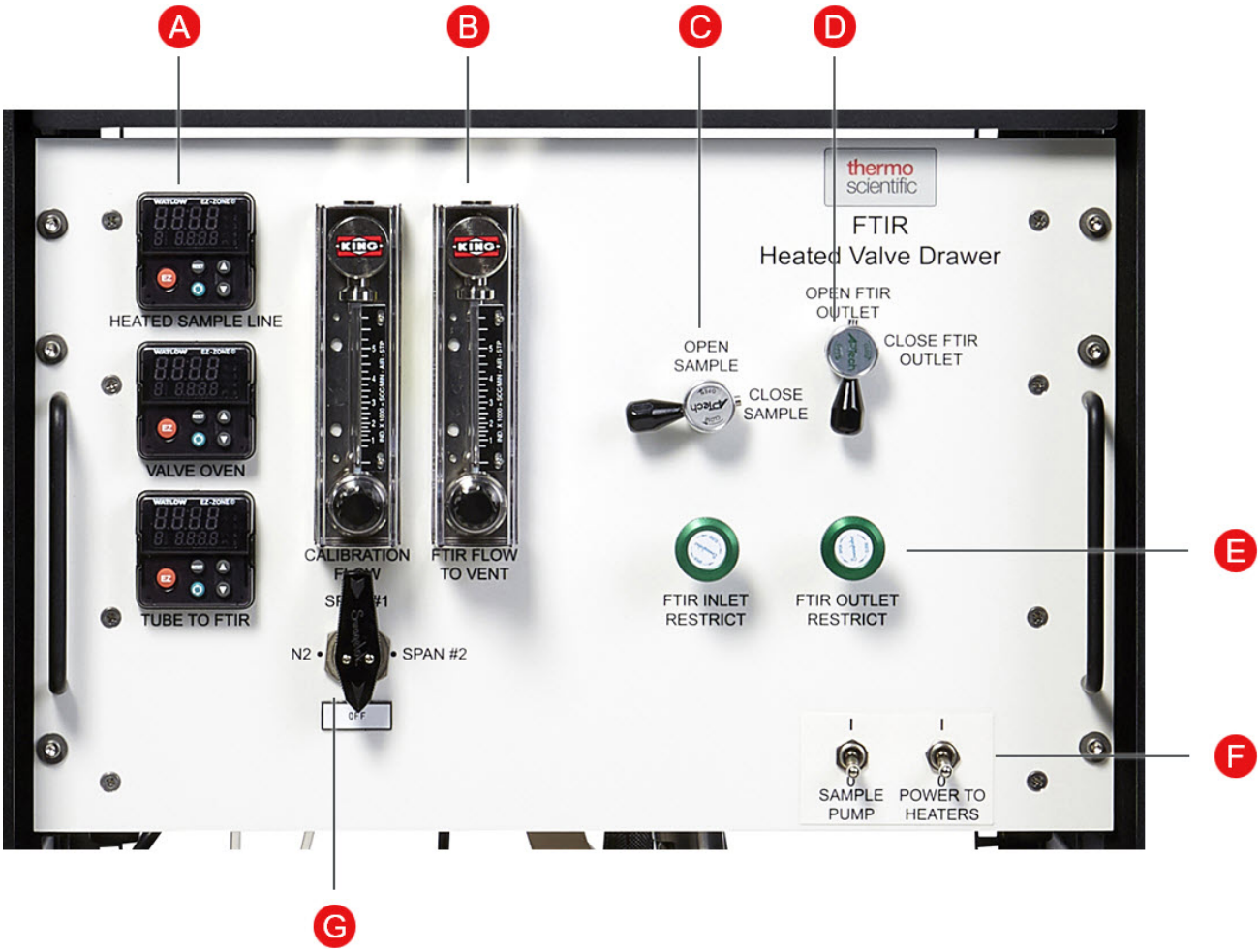
Manual Pressure Control Configuration

This section describes using the Manual Pressure Control configuration of the system.

Features and controls on the Manual Pressure Control system

The front panel of your FTIR Heated Valve Drawer features a variety of valves, temperature controllers and switches for monitoring and controlling the temperature, pressure, and flow of gas in the system.

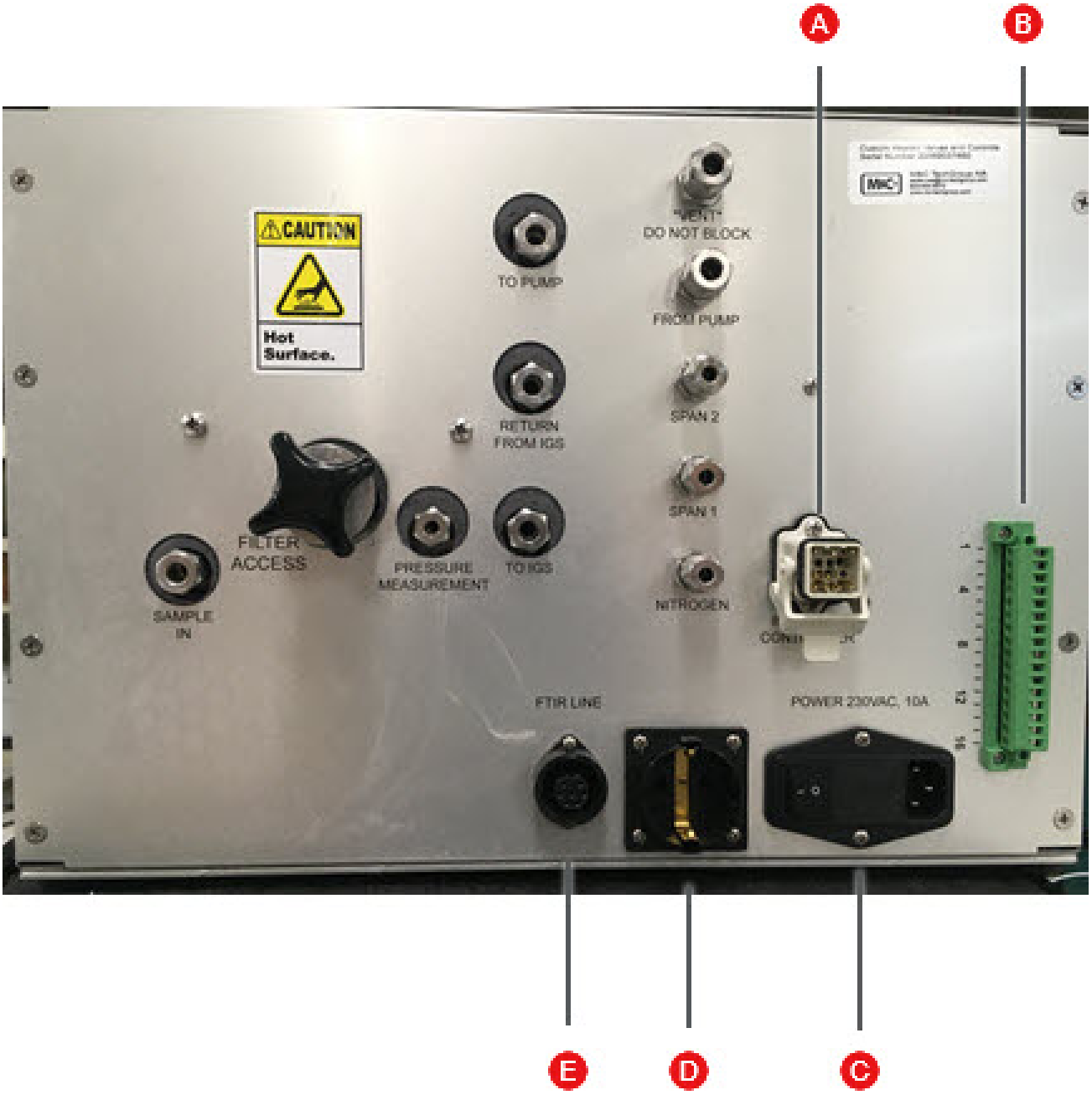
Figure 4-1: The front panel of the Manual Pressure Control system



A	**Temperature controllers**	The FTIR Heated Valve Drawer features a temperature controller for each heater. The temperature controller can be used to set the target temperature and ramp rate, monitor current temperature, set an alarm for overheating, and more.
B	**Flowmeters**	The system features two flowmeters to monitor and control the flow of gas in the system. See the Appendix for the plumbing diagram for your system to see exactly how to use the flowmeters. • Use the Calibration Flow flowmeter (left) to measure the flow of Span 1, Span 2, or Nitrogen gas inlets to the gas cell. When the calibration gas selection valve is closed, this meter will display zero. This flowmeter should display zero when the sample control valve is open and you are sampling from the Heated Sample Line. • Use the FTIR Flow To Vent flowmeter (right) to monitor the total gas flow through the cell. The two flowmeter readings may not be exactly equal due to differences in pressures seen during sampling.
C	**Sample control valve**	The sample control valve controls the flow of gas from the Heated Sample Line inlet. Close this valve when you are running gasses from the Span 1, Span 2, or Nitrogen inlets.
D	**FTIR outlet control valve**	Use the FTIR Outlet Control valve to control the flow of gas exiting the gas cell to the vacuum pump. This valve should be left in the OPEN FTIR OUTLET position for all normal operation. Close the valve for storage and shipment. Typically, you should flow clean, dry Nitrogen through the system before closing the valve for safe storage.
E	**Needle valves**	The FTIR INLET RESTRICT and FTIR OUTLET RESTRICT needle valves are used for precise control of the flow of gas into and out of the gas cell. Use these needle valves to adjust the balance between input and output gases to maintain the sample pressure and flow in the gas cell at a constant rate.

F	**Power switches**	The POWER TO HEATERS switch functions as a master switch for both switches on the front panel. The SAMPLE PUMP switch will not turn on power to the pump unless the POWER TO HEATERS switch is in the on position. • The POWER TO HEATERS switch turns on the system and powers the heaters. • The SAMPLE PUMP switch turns on power to the vacuum pump to pull gas through the system. **Note** Use the switch on Power Strip A to turn the power on and off for the HVD, peristaltic condensate pump, and the inlet Heated Sample Line.
G	**Calibration gas selction valve**	Use the calibration gas selection valve to select Nitrogen or another span gas or to turn the calibration gas off. With the calibration or a span gas selected, use the Calibration Flow flowmeter to monitor and set the flow of the calibration gas. When the calibration gas selection valve is open, turn the Sample Control valve to the CLOSE SAMPLE position.

Figure 4-2: The rear panel of a Manual Pressure Controlled system



A	**Connection for the control box of the Heated Sample Line.**

B	**16 position PCB connector**	The 16 position PCB connector can be used to connect optional electrical devices, such as a programmable logic controller (PLC). If you select the PLC option, you will be provided a schematic explaining the available electrical connections.
C	**Main power switch and power cable connection**	Connect the Heated Valve Drawer to a grounded AC power source. The maximum ratings for the connections to the vacuum pump and Heated Sample Line are 230 Vac, 50 Hz. The master power switch turns the entire system on or off.
D	**Vaccuum pumppower connection**	
E	**Power connection for the Heated Sample Line**	

Setting temperature, pressure, and flow

Use the valves and temperature controllers to monitor and control the temperature, flow, and pressure of gas as it moves through the gas cell.

Setting the temperature set point and alarms

The temperature of each component is controlled using a separate temperature controller. A high temperature limit will turn the heater off if the primary controller fails.

Over temperature

The temperature controller features an over temperature alarm that alerts you to potential overheating and shuts off the heater until you intervene. The over temperature limit is 196 °C (384.8 °F). If the limit is reached, the system will need to be manually reset.

To manually reset the system, turn the system off, allow it to cool to room temperature, and then turn the system back on.

Set Points

Set points are used for the target temperature. Change the set point by using the Up and Down keys when a profile is not running.

Controlling pressure and flow with the Manual Pressure Control system

The Automatic Pressure Control and Manual Pressure Control systems use different techniques to monitor and control pressure and flow.

MANUAL PRESSURE CONTROL SYSTEM

❖ To set the pressure and flow

1. Open the inlet and outlet needle valves completely.
2. With the sample line open, turn on the vacuum pump to start the flow of gas through the system.

   If everything is open, pressure will be at atmospheric pressure (typically between 740 and 760 mmHg).
3. Slowly close the inlet valve to restrict the flow of gas into the system. The gas cell pressure will drop.
4. Adjust the flow until it is close to the target pressure (typically 650 mmHg).

   Note There is some delay before the pressure stabilizes. The length of the delay varies depending on gas cell volume and length of sample line.
5. Use the flow meters to fine tune the flow.

   The left flow meter (calibration flow) adjusts the flow from the nitrogen, span 1, and span 2 inlets. The right flow meter (flow to vent) restricts the flow from the vacuum pump.

   Once the flow meters are set, you should see stable pressure throughout the course of the experiment. Readings from the gas cell temperature controller and pressure valve may be read into RESULT or OMNIC software to compensate for small deviations from your pressure and temperature set points during the experiment.

Automatic Pressure Control Configuration

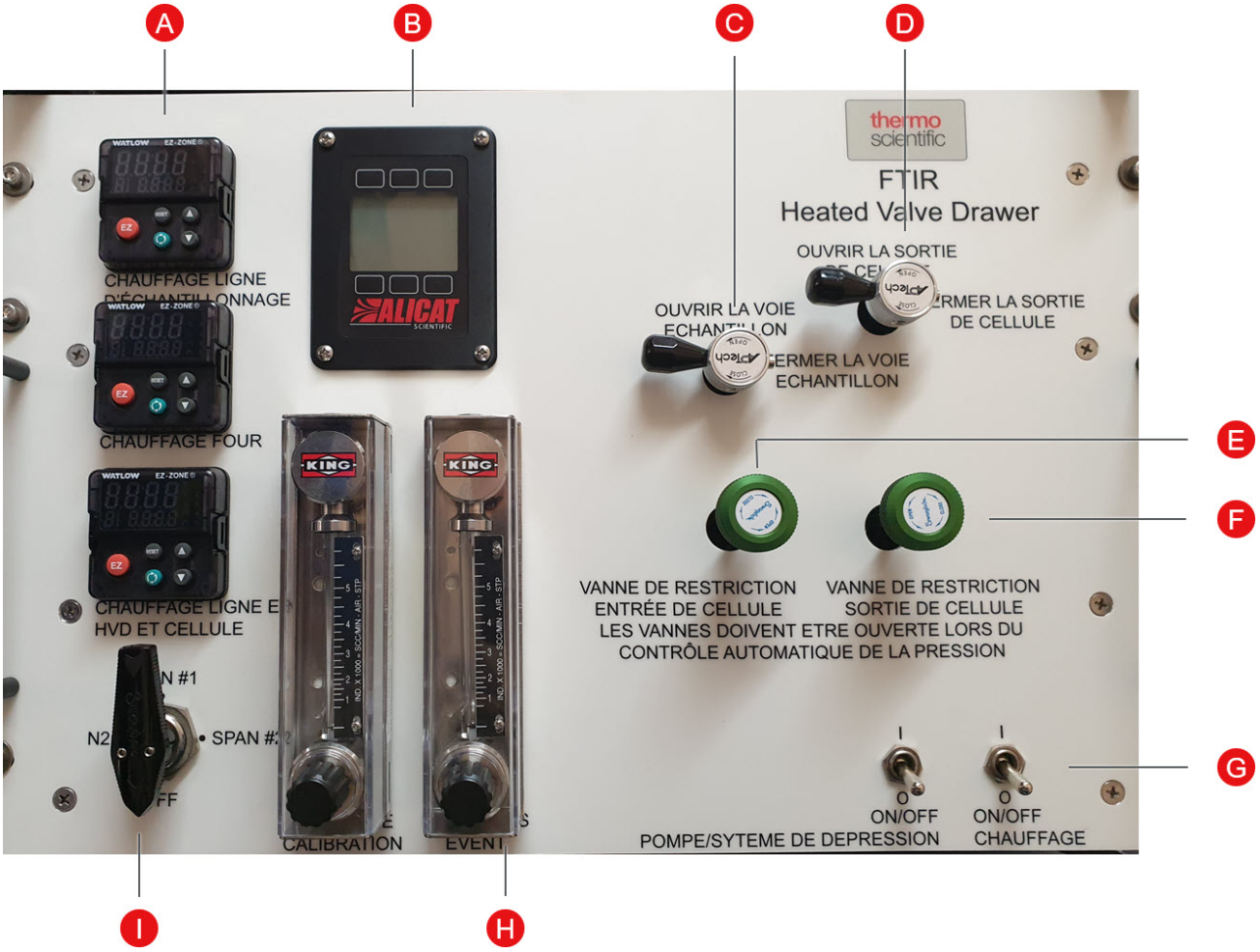
This section describes using the Automatic Pressure Control configuration of the system.

Features and controls on the Automatic Pressure Control system

The front panel of your FTIR Heated Valve Drawer features a variety of valves, temperature controllers and switches for monitoring and controlling the temperature, pressure, and flow of gas in the system.

Front panel

Figure 4-3: The front panel of the Manual Pressure Control system

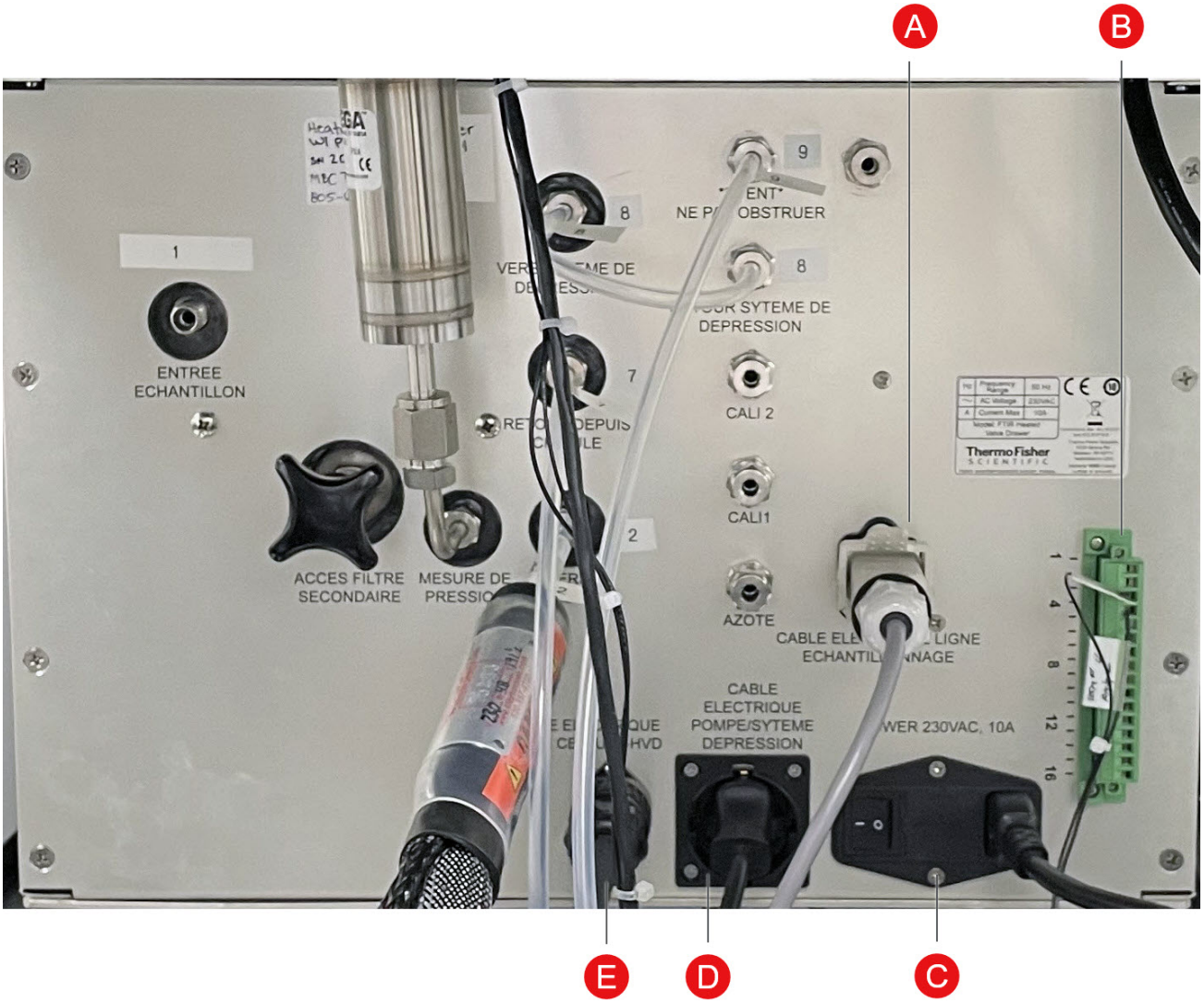


A	**Temperature controllers**	The FTIR Heated Valve Drawer features a temperature controller for each heater. The temperature controller can be used to set the target temperature and ramp rate, monitor current temperature, set an alarm for overheating, and more.
B	**Pressure controller**	The automated pressure control system uses an Alicat pressure controller. For instructions on using the controller to set and monitor the pressure in your system, see "Controlling pressure and flow with the Manual Pressure Control system". For full instructions on using the pressure controller, see materials Alicat Scientific at https://www.alicat.com/.
C	**Sample gas valve**	Open and close inlet from the sample source
D	**Cell ouput**	Open and close cell outlet to the vacuum
E	**Gas cell inlet (cell entrance)**	Control flow of gas to the inlet of the gas cell
F	**Gas cell outlet valve (Cell exit)**	Control flow of gas from the outlet of the gas cell
G	**Power switches**	The POWER TO HEATERS switch functions as a master switch for both switches on the front panel. The SAMPLE PUMP switch will not turn on power to the pump unless the POWER TO HEATERS switch is in the on position. • The POWER TO HEATERS switch turns on the system and powers the heaters in the Heated Valve Drawer. It does not control the Heated Sample Line. • The SAMPLE PUMP switch turns on power to the vacuum pump to pull gas through the system.

H	**Flowmeters**	The system features two flowmeters to monitor and control the flow of gas in the system. See the Appendix for the plumbing diagram for your system to see exactly how to use the flowmeters. • Use the Calibration Flow flowmeter (left) to measure the flow of Span 1, Span 2, or Nitrogen gas inlets to the gas cell. When the calibration gas selection valve is closed, this meter will display zero. This flowmeter should display zero when the sample control valve is open and you are sampling from the Heated Sample Line. • Use the FTIR Flow To Vent flowmeter (right) to monitor the total gas flow through the cell. The two flowmeter readings may not be exactly equal due to differences in pressures seen during sampling.
I	**Calibration gas selction valve**	Use the calibration gas selection valve to select Nitrogen or another span gas or to turn the calibration gas off. With the calibration or a span gas selected, use the Calibration Flow flowmeter to monitor and set the flow of the calibration gas. When the calibration gas selection valve is open, turn the Sample Control valve to the CLOSE SAMPLE position to purge the system.

Back panel

Figure 4-4: The rear panel of the Automatic Pressure Controlled system



A	**Connection for the control box of the Heated Sample Line.**

B	**16 position PCB connector**	The 16 position PCB connector can be used to connect optional electrical devices, such as a programmable logic controller (PLC). If you select the PLC option, you will be provided a schematic explaining the available electrical connections.
C	**Main power switch and power cable connection**	Connect the Heated Valve Drawer to a grounded AC power source. The maximum ratings for the connections to the vacuum pump and Heated Sample Line are 230 Vac, 50 Hz. The master power switch turns the entire system on or off.
D	**Vaccuum pumppower connection**	
E	**Power connection for the Heated Sample Line**	

Controlling pressure and flow with the Automatic Pressure Control system

The Automatic Pressure Control and Manual Pressure Control systems use different techniques to monitor and control pressure and flow.

AUTOMATIC PRESSURE CONTROL SYSTEM

The Automatic Pressure Control system maintains the sample pressure at a set value, even with changes in flow rate or pressure waves from the sample source. This section describes how to adjust the settings on the Gas Control Panel to meet the targets for pressure and flow rate for the experiment.

The default setting of the Alicat pressure controller is 650 mmHg (Torr), which is slightly below ambient pressure (760 mmHg = 1 bar). The Alicat controls a variable pressure valve to maintain the pressure at the set value.

See the user guide for the temperature controller with pressure sensor mounted on the Antaris IGS system for more details.

Figure 4-5: To set the pressure and flow

1. Open the **FTIR INLET RESTRICT** and **FTIR OUTLET RESTRICT** needle valves completely. Adjust the knob on the flowmeter labelled "**FTIR FLOW TO VENT**" to be wide open.
   - If your system includes the optional eductor panel.
     a. On the eductor panel on the rear of the MGS rack, turn on the source of compressed air used by the eductor system to create a vacuum.
     b. Turn the regulator dial on the Pressure Gauge to adjust the compressed air pressure to a minimum of 500 kPa, or 70 psia.
     c. On the HVD front panel, use the SAMPLE PUMP ON/OFF switch to turn on the power to the Eductor vacuum source.
   - If using a standard vacuum pump, on the font panel of the HVD, use the Sample Pump On/Off switch to turn on the power to the vacuum.
2. Check the pressure value on the Alicat LCD. If the pressure reading is higher than 650 mmHg, it means the total gas flow is higher than the Alicat can control with the given vacuum and flow rates. Adjust the **FTIR INLET RESTRICT** valve to restrict the flow slightly. With the input flow reduced to a similar volume as the vacuum pump can handle, the Alicat gauge will compensate and maintain the pressure at the set point (650 mmHg default).

   Note There is some delay before the gas cell pressure stabilizes. The length of the delay varies depending on gas cell volume, the length of sample line, and the vacuum/flow rate values.

3. Check the flow rate in liters per minute through the FTIR FLOW TO VENT flowmeter. If the flow is too high for the desired rate, adjust the flowmeter knob to reduce the flow.

   Note You may need to adjust the FTIR INLET RESTRICT Swagelok valve again to compensate for the change in flow rate and keep the Alicat value constant.

   Note The Alicat pressure control circuit uses some of the gas flow for valve control. Consequently, even when the FTIR FLOW TO VENT flowmeter is closed completely to the sample gas, you will still see a small flow continuing through the flowmeter.

While the sample source is typically at atmospheric pressure, your nitrogen or span gas is often pressurized, to "push" the gas through the cell. If so, you may have to use the CALIBRATION FLOW flowmeter to reduce the gas flow through the system in able to maintain the set pressure value.

Using an eductor to generate vacuum

In place of the standard diaphragm pump, an Eductor panel may be used to generate the vacuum to pull the sample gas through the sampling system. An Eductor uses compressed air to generate a flowing stream, with the sample gas outlet connected via a tee fitting into the side of the flow. The compressed air flow creates a vacuum force, pulling the sample gas through the eductor by means of the Venturi effect.

The eductor panel uses the following fitting sizes:

- For the 115 Volt model:
  - Instrument air inlet: 1/4 inch
  - Exhaust outlet: 3/8 inch
- For the 230 Volt model:
  - Instrument air inlet: 6 mm
  - Exhaust outlet: 8 mm

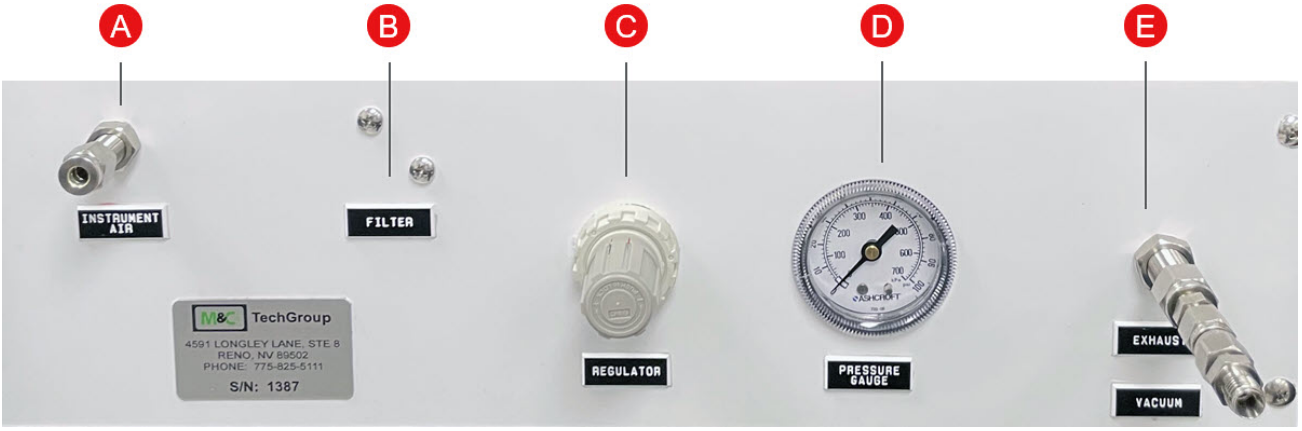
See the plumbing diagram for the connecting the panel.

WARNING

Avoid toxic inhalation.

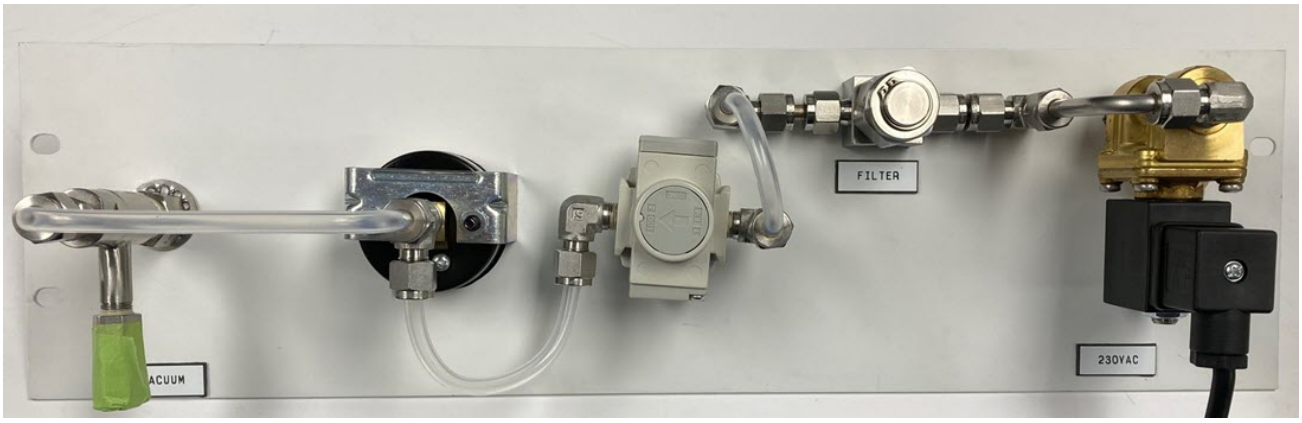
When sampling toxic gases, the exhaust must be connected to a safe vent system.

Figure 4-6: Front of the eductor panel



A	**Compressed air input**	The compressed air from the source should be within the following range: • Minimum: 60 PSI (400 kPa) • Maximum: 150 PSI (1030 Kpa) The actual pressure through the eductor is adjusted with the regulator. You may need to adjust the pressure setting to adapt to different sampling configurations. The tubing will be either ¼” or 6mm.
B	**Filter (behind the panel)**	
C	**Regulator**	Use the regulator to adjust the actual pressure through the eductor.
D	**Pressure gauge**	Displays the pressure in the eductor.
E	**Exhaust**	The Exhaust fitting uses a larger diameter tubing, ie 3/8” or 8mm, in order to eliminate any restrictions of the flow. **Note** The sound from the gas flowing out the Exhaust fitting can be very loud if the tubing to the exhaust or vent is not connected.

Figure 4-7: Rear of the eductor panel



Using the temperature controllers

The FTIR Heated Valve Drawer features a temperature controller for each heater. The temperature controller can be used to set the target temperature and ramp rate, monitor current temperature, set an alarm for overheating, and more.

Device Controls

The temperature controller can be operated using displays and controls on the device.

For additional details on using the temperature controller, see the manufacturer's user guide at https://www.watlow.com/.

Figure 4-8: Watlow Temperature Controller

Operating Limits

Do not raise the set point above 191 °C. The temperature controller is programmed to prevent raising the set point above this temperature to protect the system.

NOTICE

Do not raise the set point beyond the operating limits of the gas cell you are using. Heating the gas cell beyond the cell limits can damage the cell windows and gaskets, causing leaks and degrading the quality of the measurement.

See the user guide for your gas cell for more information.

Factory Presets

To protect the gas cell and instrument, the following parameters have been preset:

- **Set point:** The temperature controllers have been configured with a set point of 180 °C. You can change the set point as needed.
- **Ramp rate:** We configure the system with a ramp rate of 1 °C per minute (1.8 °F per minute) until the set point is reached to protect the gas cell and instrument.

- **Over temperature limit:** The temperature high limit is 196 °C (364.8 °F) to prevent damage to the Heated Valve Drawer. If the temperature exceeds this, the heat will automatically shut off.

Collect a background and purge the system

Purge the system with clean, dry air or nitrogen between combustion gas samples.

CAUTION

Avoid explosion and fire hazard. Never use a flammable gas to purge your system. The purge gas must be free of moisture, oil, carbon dioxide and other reactive or infrared-absorbing materials.

❖ To purge the system

1. Use the calibration gas selection valve, select **N2**.
2. Turn the sample control valve to **Close Sample.**
3. Purge the system for a time that you have established previously based on testing and that is known to remove contaminants.

Chapter 5

Maintenance

The FTIR Heated Valve Drawer requires only minor maintenance, including replacing fuses and filters. See the user guides that came with other components of your system for additional maintenance instructions.

Test for leaks

The pressure and flow controls of the MGS system require that all the plumbing connections are sealed tightly, with no leaks.

Test the system for leaks periodically to ensure that all connections are secure. Be sure that the procedure you use for leak testing is appropriate for your gas system configuration.

To test that the fittings are all properly tightened, you adjust the MGS settings to pull a maximum vacuum on the gas cell and system, with all inputs closed and with outputs to the vacuum fully open.

After the internal pressure is reduced to its minimum, you close all valves, turn off the vacuum, and monitor the gas pressure to verify that it remains stable. If there are leaks, the pressure value will drift back towards ambient pressure (typically around 760 mmHg).

If your system includes the Alicat pressure controller, you must also set the pressure setpoint of the Alicat pressure controller from 0 mmHg for this test.

Before you begin, plug the sample line inlet to prevent any gas from entering the system. You can test the system for leaks without checking the sample inlet connections by turning the gas selection valve to Nitrogen and turning the Nitrogen valve to close.

Checking for leaks requires somewhat different procedures for the automatic and Manual Pressure Control systems.

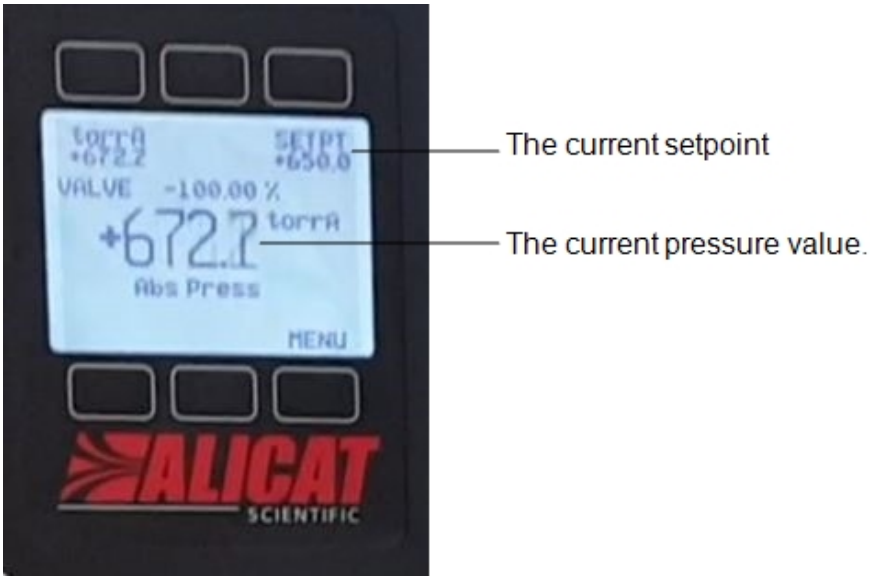
Note The following procedure does not test any connection to the vent outlet. Test the vent connection using another procedure that is appropriate for your gas system configuration.

❖ To test for leaks in the Automatic Pressure Control system

1. Turn the N2/Span1/Span2 valve to the Off position.
2. Close the CALIBRATION FLOW flowmeter dial to block any flow.
3. Turn the FTIR INLET RESTRICT Swagelok valve to the closed position
4. Turn on the SAMPLE PUMP switch to pull a vacuum onto the gas cell and system.
5. Adjust the Alicat Set Point from 650 mmHg to 0 mmHg:

a. Press the SETPT button to enter a sub-menu to edit the SETPT values.

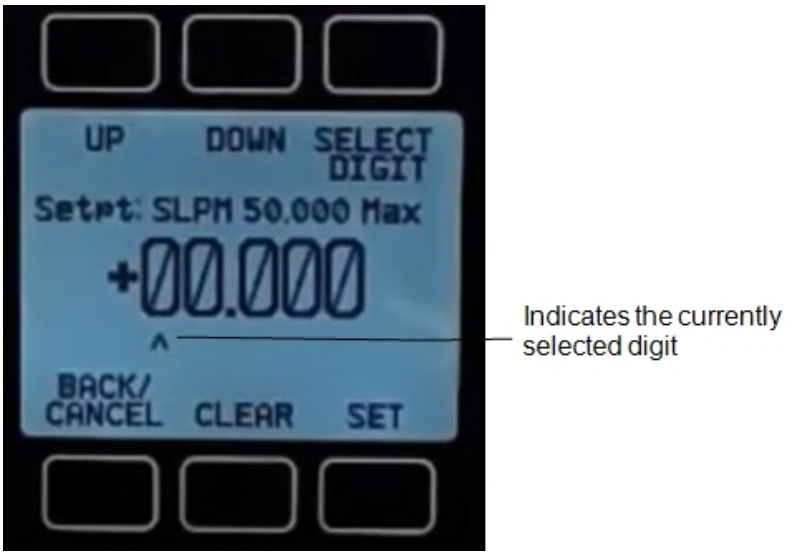
Figure 5-1: Alicat showing the default settings



The pressure value shown here should be close to that of the pressure gauge reading from the Antaris IGS Temperature Controller and Pressure Guage, but the values may not be identical due to differences in where the pressure is measured between the 2 gauges.

b. Set the value to 00.0 mmHg. The UP and DOWN buttons adjust the value of the currently-selected numeral from 0 – 9. Press the SELECT DIGIT button to change the selected numeral (100's place to 10's, 10's to 1's, and so on). Press the SET button when finished to return to the Main Menu.

Figure 5-2: Setting the value of the setpoint.



With the Alicat set to 00.0 mmHg, and all the inlet valves closed, the gas cell and system MGS should now experience maximum vacuum. The pressure reading should drop significantly; depending on the strength of the vacuum, the pressure will likely be between 20 – 125 ppm.

6. When the pressure has dropped, close the FTIR OUTLET RESTRICT Swagelok valve to block the vacuum from the gas cell. The Alicat reading may bounce slightly when the vacuum is blocked but should stabilize quickly.

7. If the gas cell/MGS fittings are all properly tightened, the pressure value should stay constant, with a leak rate < 1 torr/minute. Typically, you will see much faster changes in pressure if there is a leak somewhere in the system.

   a. If the pressure changes significantly, check the fittings/connections on the rear panel to verify a tight fit and test again.

   > **Note** Adjust the fittings to be finger-tight, then tighten nut 1-1/4 turns of the fitting with a wrench. Do not overtighten.

   b. If the Alicat pressure reading stays constant or indicates only a slow leak, then the MGS fittings are connected properly.

8. Reset the Alicat SETPT values from 00.0mmHg back to 650.0 mmHg and turn the OPEN SAMPLE valve to bring the gas cell pressure back to the 650 mmHg target value.

❖ To test for leaks in the Manual Pressure Control system

1. Turn the sample selection valve to the CLOSE SAMPLE position.
2. Make sure the FTIR OUTLET valve is in the OPEN FTIR OUTLET position.
3. Close the FTIR INLET needle valve completely and open the FTIR OUTLET needle valve completely.
4. Turn on the vacuum pump.

   The pressure will drop down to a minimum value (likely between 0 and 10 mmHg, but the value can vary with different configurations).
5. Close the FTIR OUTLET needle valve so that no more vacuum is applied to the gas cell.

   Pressure in the gas cell should remain constant with a leak rate less than 2 to 3 mmHg per minute.

Replace the particulate filter

The PSP4000 heated gas sample probe has a replaceable filter. Change the filter only when the probe is cool.

For more on the PSP4000 heated gas sample probe, see www.mc-techgroup.com.

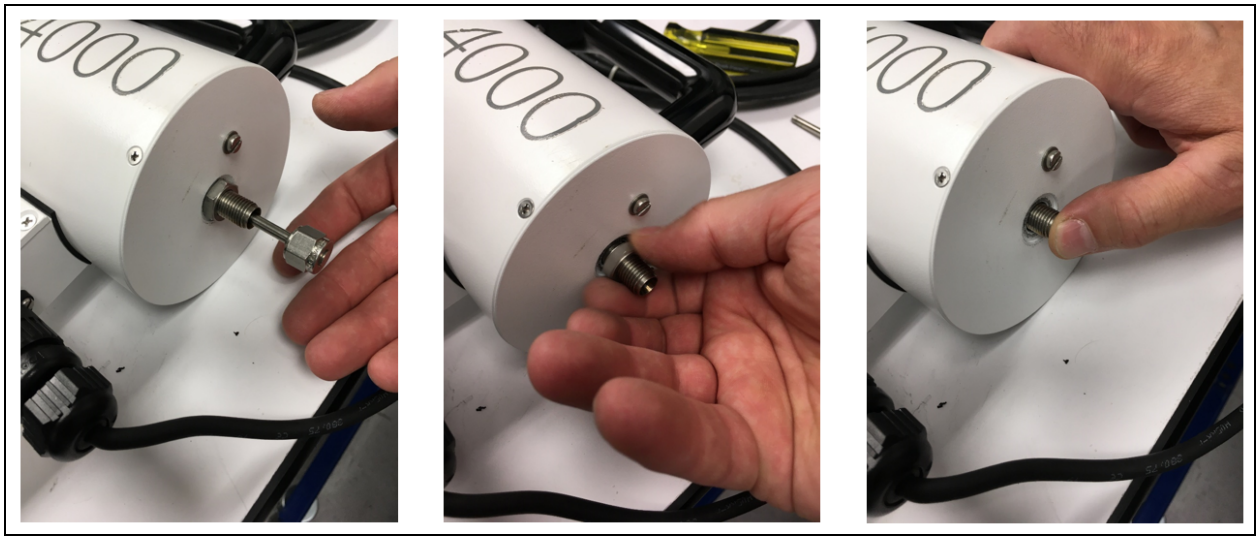
CAUTION

Avoid burn hazard.

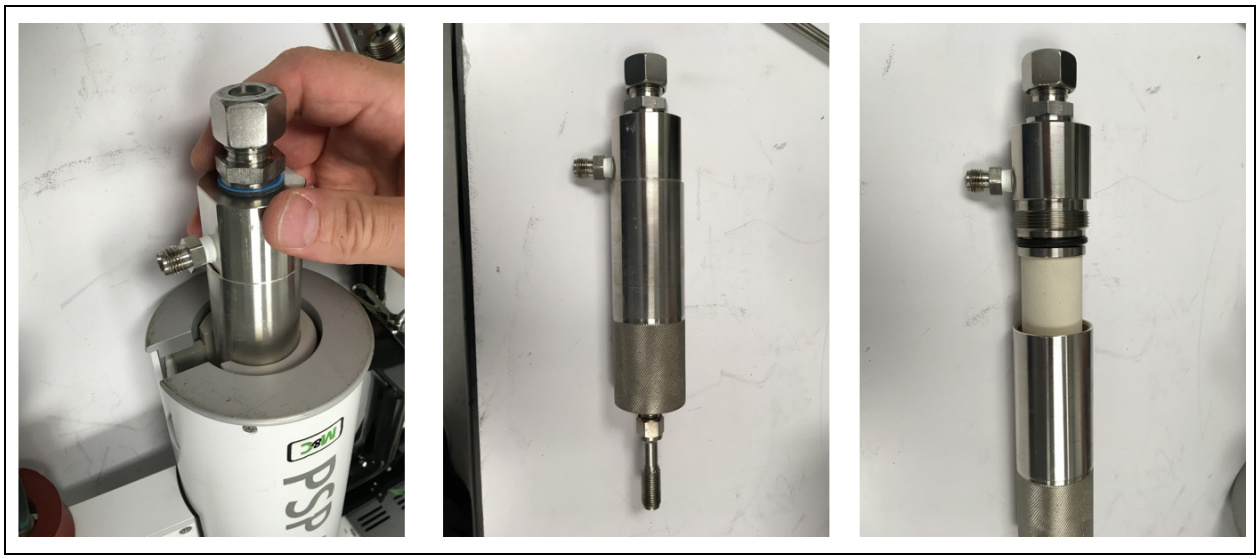
The gas sampling probe is hot during use and can cause burns. Before replacing the filter, turn off the system and allow the probe to cool to room temperature.

❖ To replace the particulate filter

1. Disconnect the sample line from the filter.
2. Remove the fitting on the far side of the heater and push on the internal tube to slide the filter assembly out.



3. Pull the internal filter assembly completely out of the main assembly.
4. Unscrew the two sections of the filter assembly to expose the filter.



5. Grasp the knurled end of the filter, and unscrew the filter holder. Take care not to lose the o-rings.
6. Slide the old filter off of the screw and replace with the new filter.

7. Reassemble the filter assembly.

Replacing the rear filter

How often you need to replace your heated filter depends on your specific use and sample gases. One indication that you need to replace the filter is a noticeable decline in the flow of the sample gas entering the system. Replace the filter if more than 70% of the filter has changed color.

Before you begin, disconnect or turn off the sample gas connected entering the system.

For replacement filters or other parts, contact technical support.

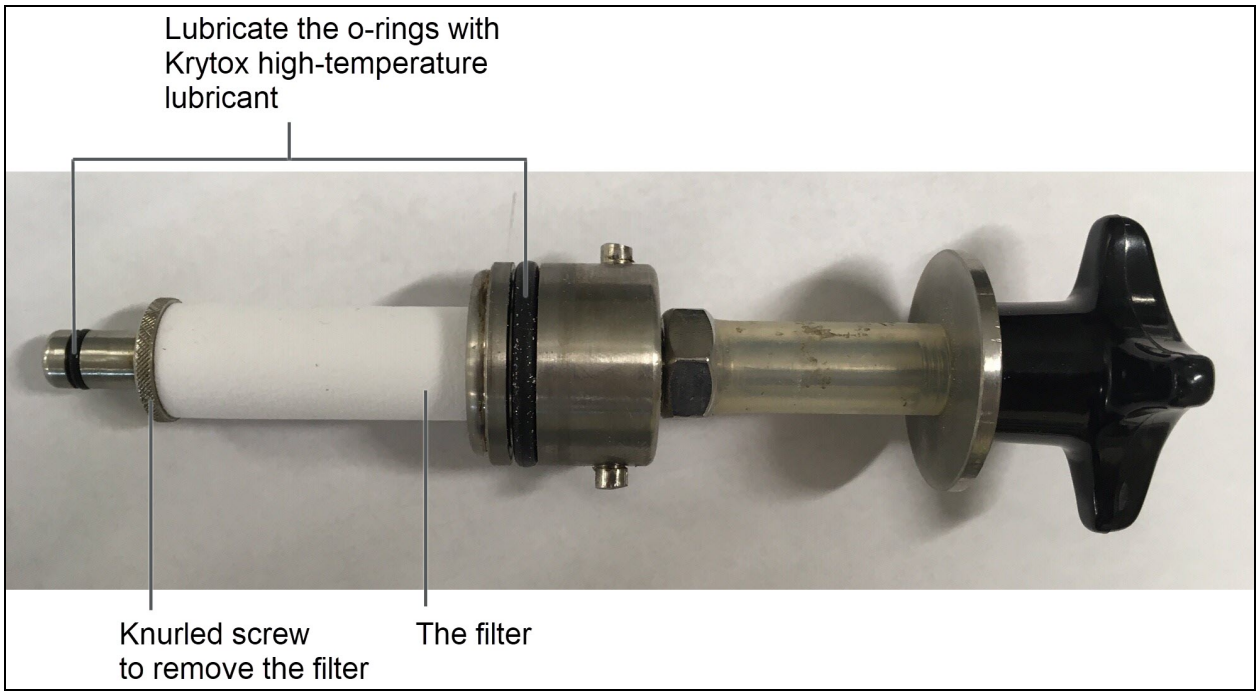
CAUTION

Avoid burn hazard. The filter assembly becomes very hot during regular operation. Before replacing the filter, turn off the heater and allow the filter assembly to cool to room temperature.

❖ To replace the optional heated filter

1. Ensure that the heaters and vacuum pump switches are in the off position. Use the main power switch on the back of the Heated Valve Drawer to turn off the entire system.
2. To remove the filter assembly, press the black handle in and turn counterclockwise about 5 degrees. It takes about 3 to 5 pounds to overcome the spring.

3. Pull the assembly straight out.



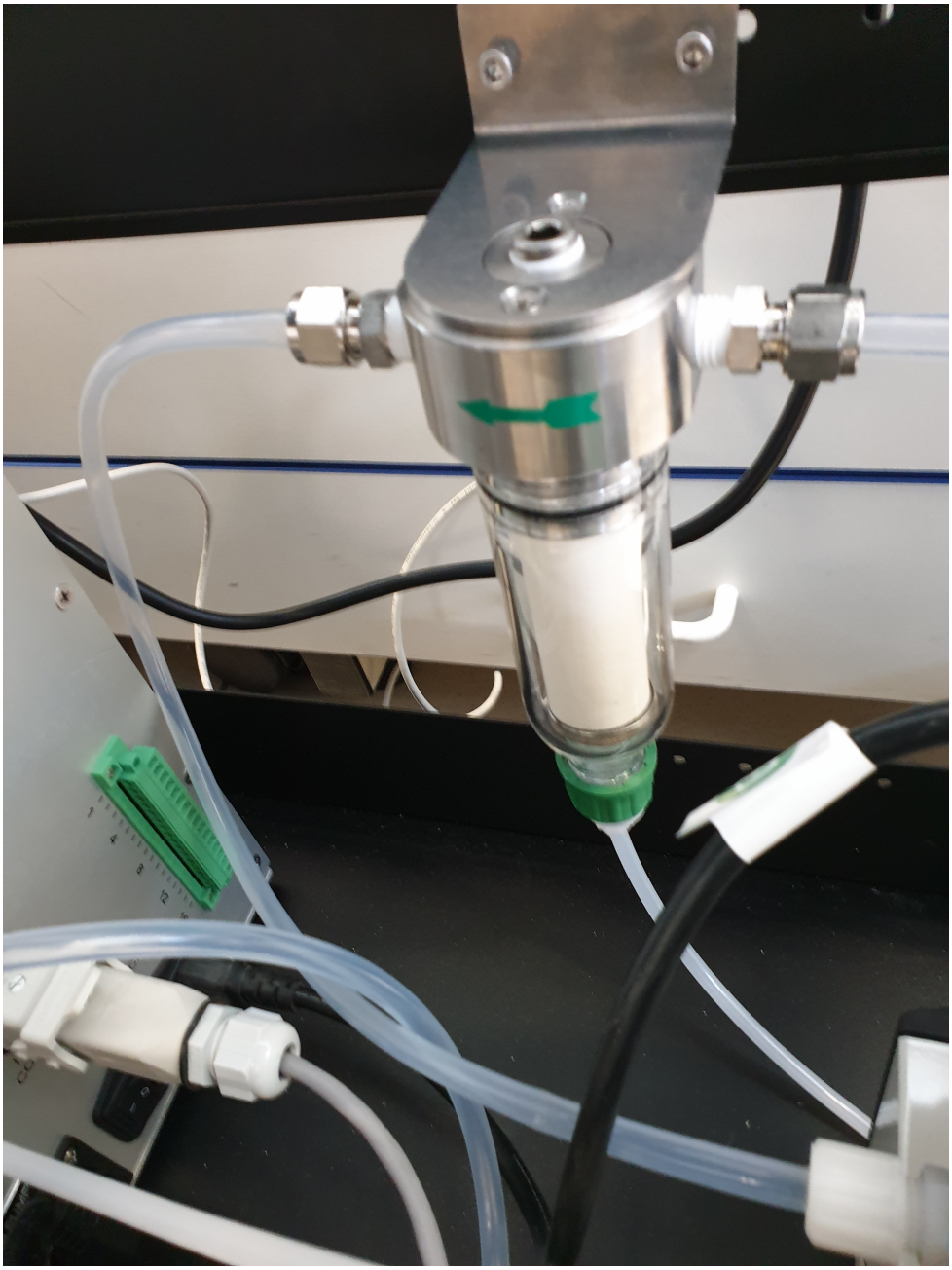
4. Using your hand, unscrew the knurled filter screw that holds the filter in the filter holder assembly.
5. Remove the filter and inspect the filter element seals and replace them if necessary.
6. Place the new filter on the knurled screw and insert the screw into the housing. Be careful to properly align the screw so as not to cross the threads. Tighten by hand.
7. Using Krytox high-temperature lubricant, lubricate the two o-rings.
8. Inset the filter assembly into the heated valve drawer. Note the orientation of the assembly. The washer has 'UP' and an arrow etched into it.

9. Rotate the assembly clockwise back into position. The washer sticks out about an inch away from the back of the drawer.

Replace water catch filters

The system includes a water catch filter between the heated valve drawer and the vacuum pump. The filter bowl collects water condensate and prevents contaminants from clogging the vacuum pump.

Replace the filter when it is yellow or otherwise discolored or if it is contaminated with debris or foreign particles.



CAUTION

Avoid burn hazard. Parts of the filter assembly may become hot during normal operation. Turn off power to the heaters and allow the filter to come to room temperature before handing the filter assembly.

❖ To remove the water or change the filter

1. Turn off the heaters and vacuum pump.
2. Turn the Sample Control valve to Close Sample.
3. Turn the calibration gas selection valve to the off position to prevent any gas from entering the system.
4. Remove the bowl protecting the filter, and then remove the filter (both can be removed by hand).
5. Inspect filter seals for signs of damage and replace if necessary.
6. Install the new filter and reinstall the bow.

Replace fuses

The Heated Valve Drawer includes two replaceable fuses. The fuses are 5x20 mm, time-lag, 10A 250V fuses.

DANGER

Avoid shock hazard. Always disconnect equipment from electrical power before removing a fuse; not doing so could result in serious injury.

❖ To replace the fuses

1. Remove the main power plug from the **POWER 230VAC, 10A** connection.
2. Using a small slotted screwdriver, use the tab on the left side of the fuse cover to pry the cover away from the panel, as shown:

3. When you can grasp the fuse cover with your fingers, pull it straight out and away from the fuse compartment.

   Two fuses are clipped into the fuse holder.

4. Remove the two fuses from each side of the fuse holder.
5. Replace the fuses with identical type replacements.
6. Make sure that the words on the fuse cover are oriented so that you will be able to read them when the cover is installed, and return the fuses to the fuse compartment.
7. Press on the cover until it snaps back into place.

Do not continue to replace the fuse if it blows immediately after you replace it. If this occurs, contact Thermo Scientific technical support.

Clean the flowmeters

If the flowmeters become dirty or discolored, you can remove and clean the central glass tube.

For more information on cleaning the flowmeters, see www.kinginstruments.com.

❖ To clean the flowmeters

1. To remove the front shield, pinch the sides and carefully pull the front shield away from the flowmeter.
2. Remove the black plug on the top of the frame.
3. Insert a 3/16 inch hex key in the outlet hole and into the compression screw.
4. Turn the hex key counterclockwise until the compression screw is raised enough to remove the glass tube.
5. Carefully remove the glass tube, taking care not to lose the float.
6. To remove the float and float stops, insert a rod into one end of the glass tube and push the components out the other end.
7. Clean the components with a mild soap solution.
8. To reassemble, reinsert the float and float stop, place the glass tube back into position, and turn the compression screw clockwise. Make sure the rube is facing frontward. Tighten the compression screw to 4 in. lbs. of torque. Snap the front shield back into place and replace the black plug.

Clean the FTIR Heated Valve Drawer

If the outside of the FTIR Heated Valve Drawer needs to be cleaned, turn off the power and disconnect the power cord from the AC power source.

Use a damp (not wet), soft cloth and a mild soap to clean the outside of the unit. Contact technical support if you are unsure about the suitability of cleaning agents.

WARNING

Avoid shock hazard. Do not allow cleaning solutions or liquids to run into the controller unit.

Note Do not use harsh detergents, solvents, chemicals or abrasives to clean the controller unit; these can damage the finish.

Cleaning the flowmeter's glass meter tubes

You may need to clean the glass meter tubes on the flowmeters periodically if they become dirty with residue from the sample gas. You can remove the tube from the flowmeter and clean it.

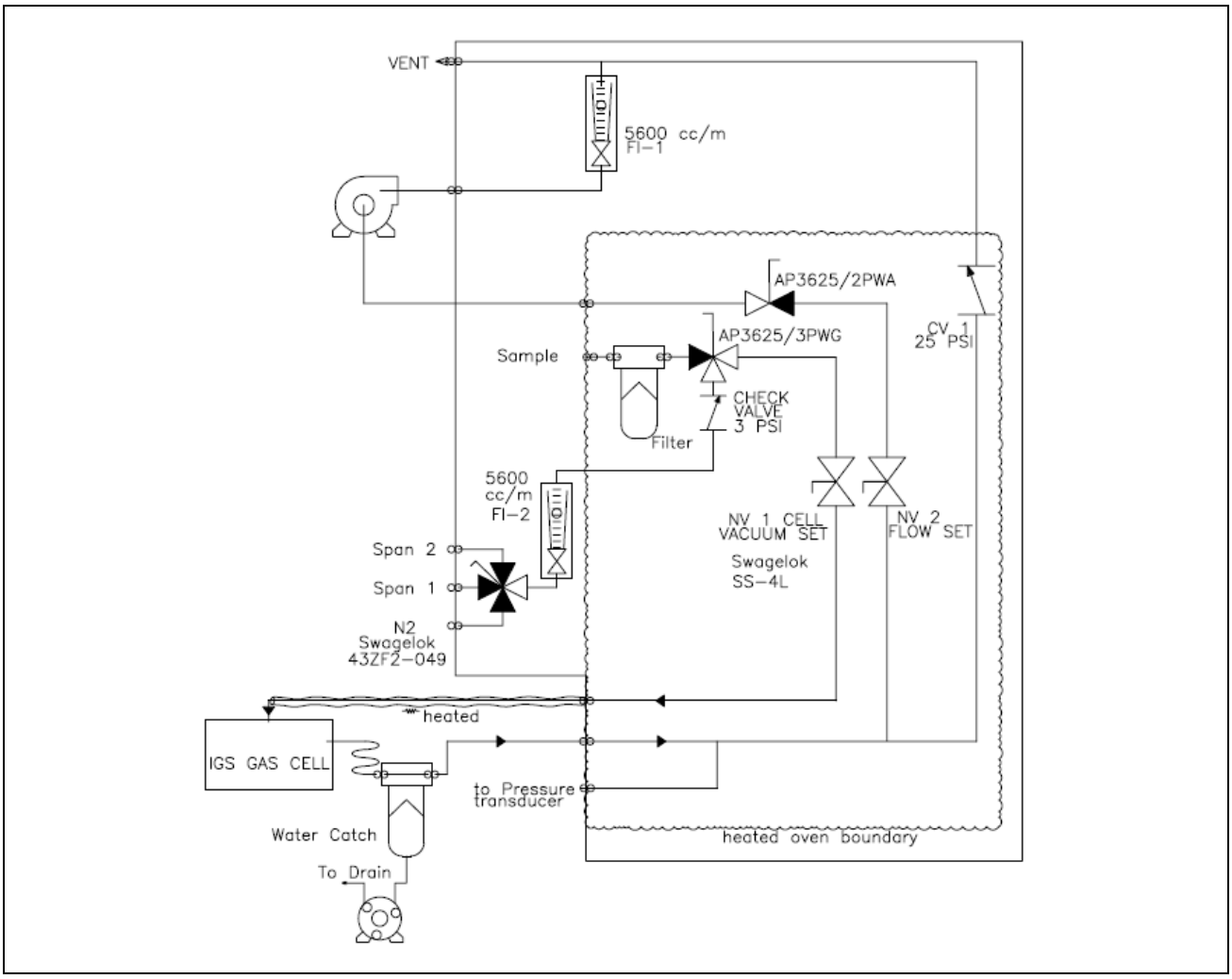
For instructions on cleaning the flowmeter, see instructions from King Instrument Company at https://kinginstrumentco.com/.

Chapter 6

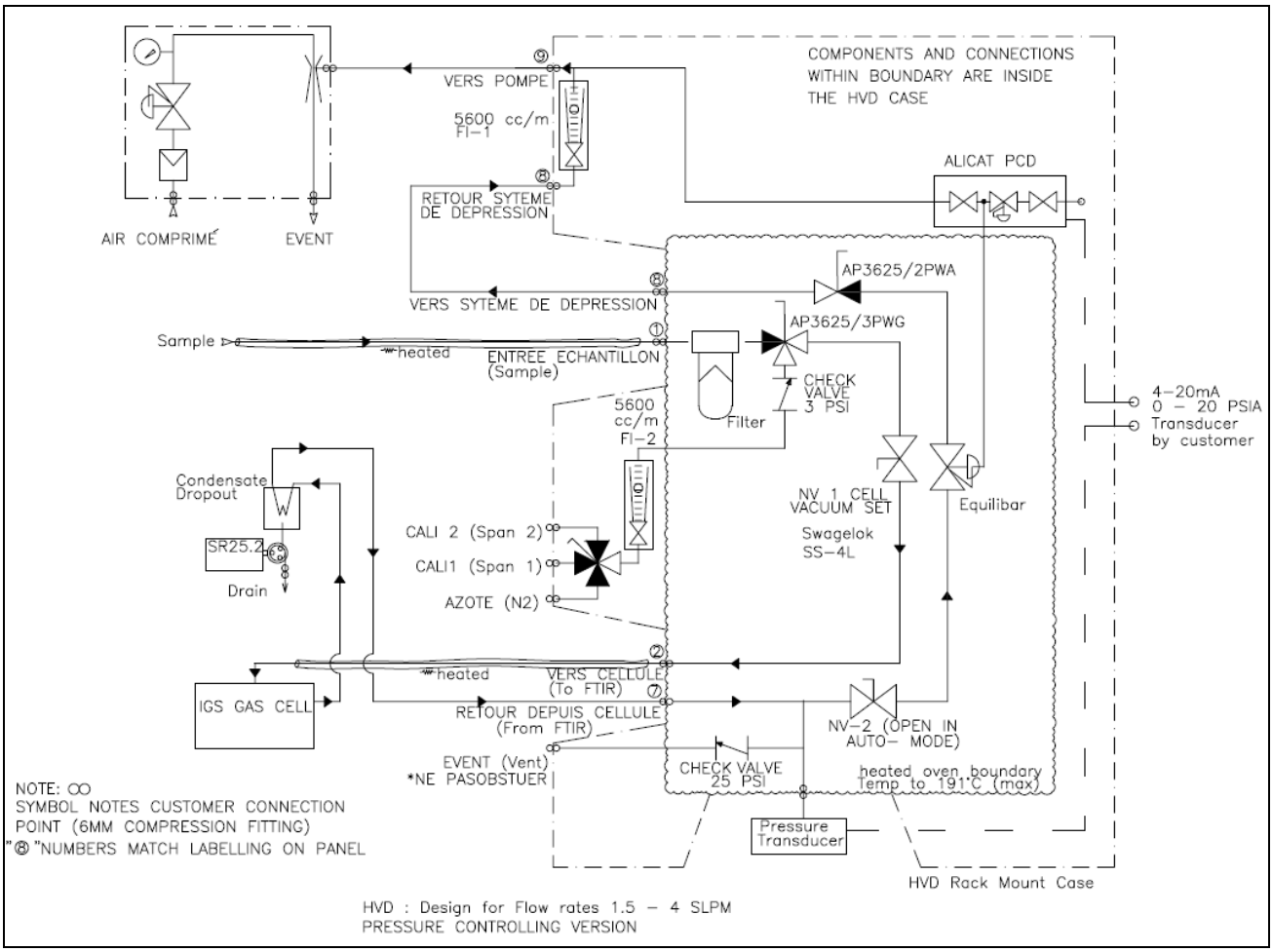
Plumbing diagrams

Following is the plumbing diagram for your system:

Manual Pressure Control System



Automatic Pressure Control System



Eductor Panel