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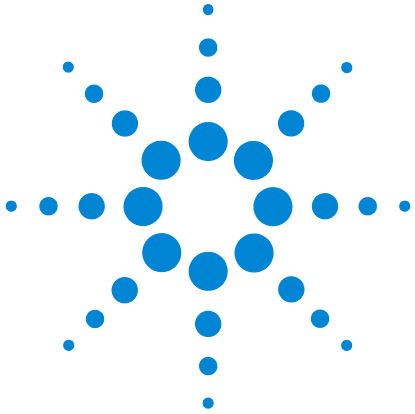

Agilent Intuvo 9000 Gas Chromatograph

Flow Path Primer

Agilent Technologies

Notices

Manual Part Number

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Contents

1 Introduction

The Intuvo 9000 GC is a gas chromatograph (GC) capable of analyzing a wide range of liquid and gaseous samples. From an applications perspective, this instrument addresses popular analyses in the hydrocarbon processing (HPI), chemical, environmental, food safety, toxicology, and pharmaceutical market segments.

With the Intuvo 9000 GC design, the outlet of the inlet interfaces directly to a microfluidic Guard Chip. This flow chip device replaces the gold seal in the 7890 S/SL and serves as a sacrificial volume to trap involatile material. Previously, customers had to use fused silica precolumns as disposable traps and had issues in making leak-free, chromatographically useful connections. The microfluidic Guard Chip reduces the skill required to install and replace this component. The Guard Chip also converts the interface to the inlet into a planar connection scheme. A planar connection, unlike the traditional ferrule connections, requires substantially less skill to make a successful connection. With ferrules and fused silica tubing, the user gets no feedback as to when the fitting is sufficiently tight. By using a planar connection, a steep force curve is encountered, allowing for a specific torque to be applied. With one torque specified, a pre-set torque wrench can be used which provides feedback in the form of an audible “click” indicating that the connection is tight and leak free.

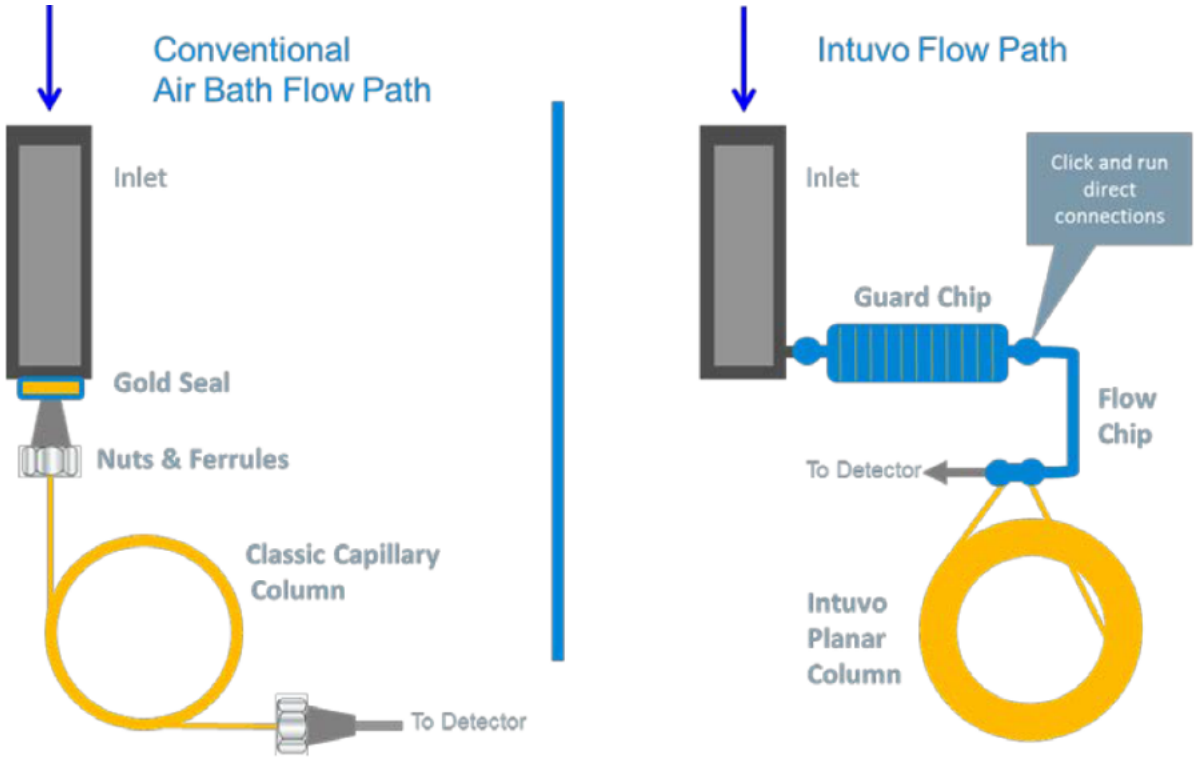


Figure 1 Conventional Air Bath vs. Intuvo Flow Path

Flow chips are also used to create the connections and junctions required for techniques like backflushing and detector splitting. These devices are installed into the bus heater and provide a complete configuration for the fluidic path in the instrument.

Rather than using an air bath oven to heat the column the Intuvo 9000 GC uses direct heating. This results in much lower power usage for existing methods and the ability to do high speed GC with faster programming rates. In addition, the column is interfaced to a metal microfluidic connector to allow simple, error-free column installation.

For user interaction with Intuvo, the 9000 GC has three user interfaces. The local user interface (LUI) or touch screen on the GC, provides similar functionality to the keyboard and display on the 7890 GC.

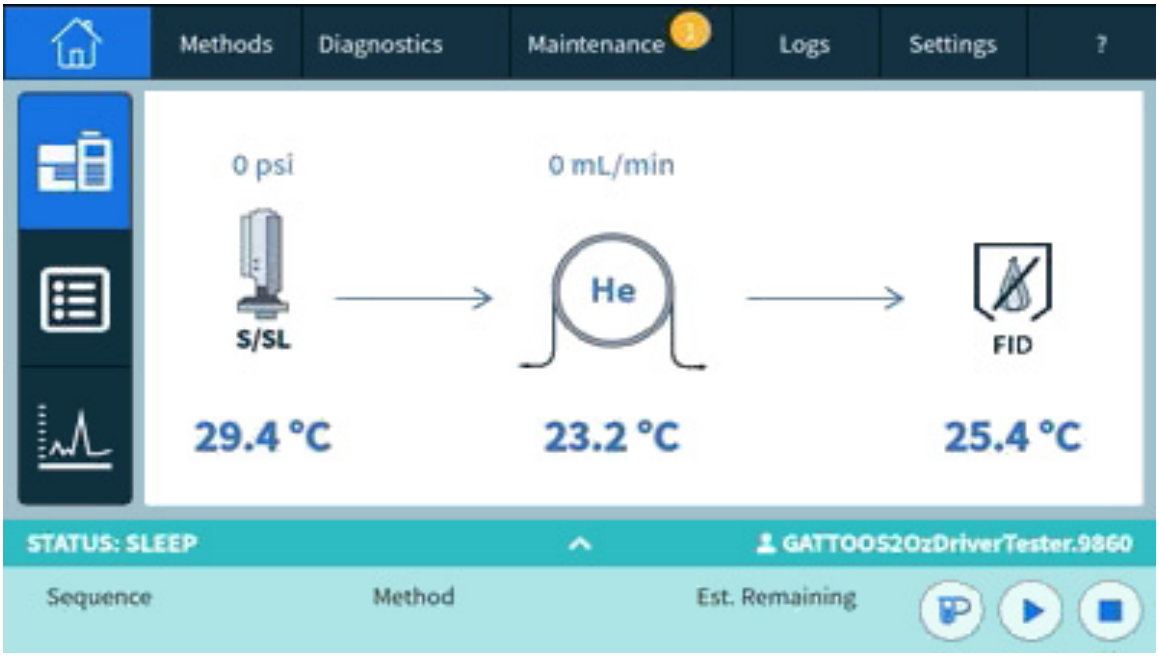


Figure 2 Intuvo local user interface (LUI) - Instrument Status

Additionally, interaction can be made using a mobile device (such as a tablet); in this case the user interface is provided (served up) by Intuvo to be viewed in a web browser from a tablet or desktop computer. Simply type the Instrument 'IP Address Number' or 'Host Name' into a browser on a PC or tablet that is on the same network as the GC. No Internet connection is required.

Example: http://xxx.xx.xxx/

(where 'xxx.xx.xxx' is the IP Address or Host Name of the Intuvo 9000 GC)

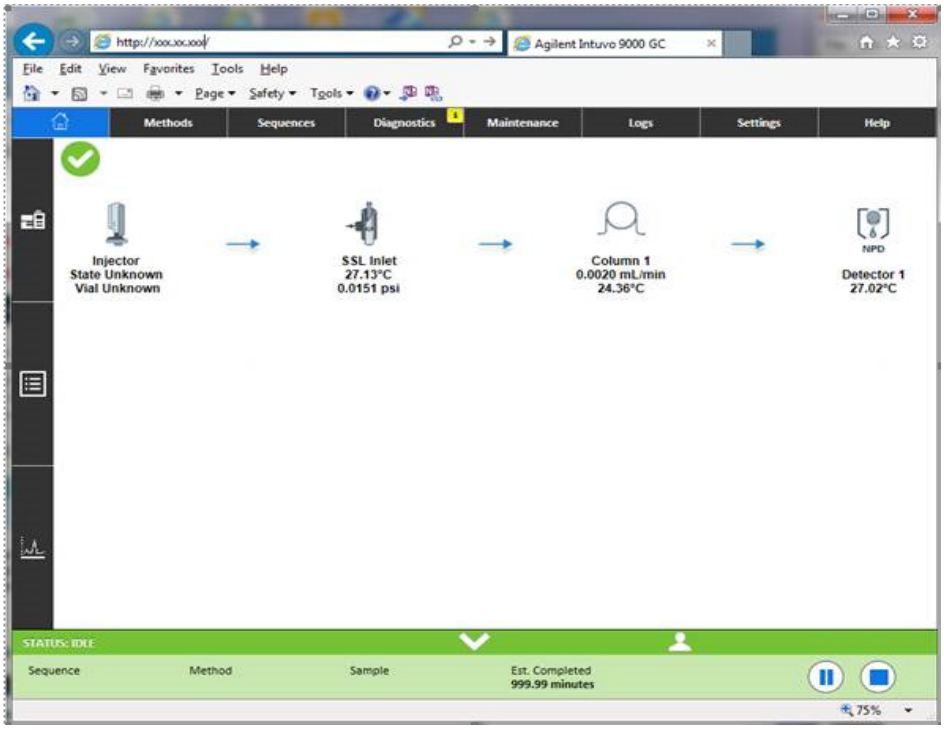
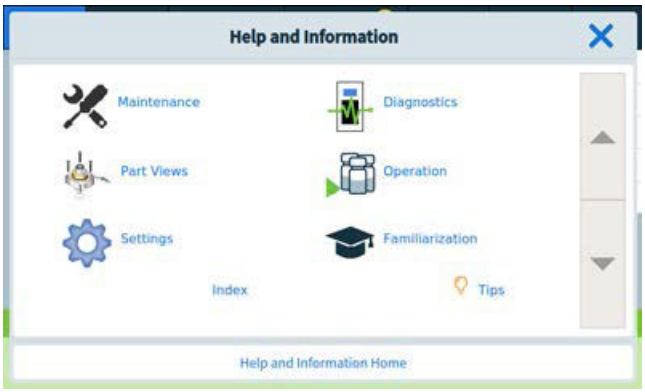


Figure 3 Intuvo web browser user interface

The third user interface is from the chromatography data system.

A Help and Information package is also integrated into the Intuvo 9000 GC instrument. Right at your fingertips from the Intuvo GC is an extensive amount of onboard documentation designed to assist with topics such as getting started, familiarization, installation, operation, maintenance, troubleshooting and other useful information.

There are several ways to access this information, including through the touch screen help '?' menu. Here you will find not only context-sensitive information, but also a listing of tips to quickly guide you to information needed and a full Help and Information suite with topics about maintenance, diagnostics, part views, operations, settings and familiarization.



A more enhanced version of **Help & Information** can also be easily accessed from the Intuvo GC by typing the Instrument 'IP Address Number' or 'Host Name' into a browser on a PC or tablet that is on the same network as the GC. No Internet connection is required to use this enhanced help package.

Example: http://xxx.xx.xxx/info

(where 'xxx.xx.xxx' is the IP Address or Host Name of the Intuvo 9000 GC)

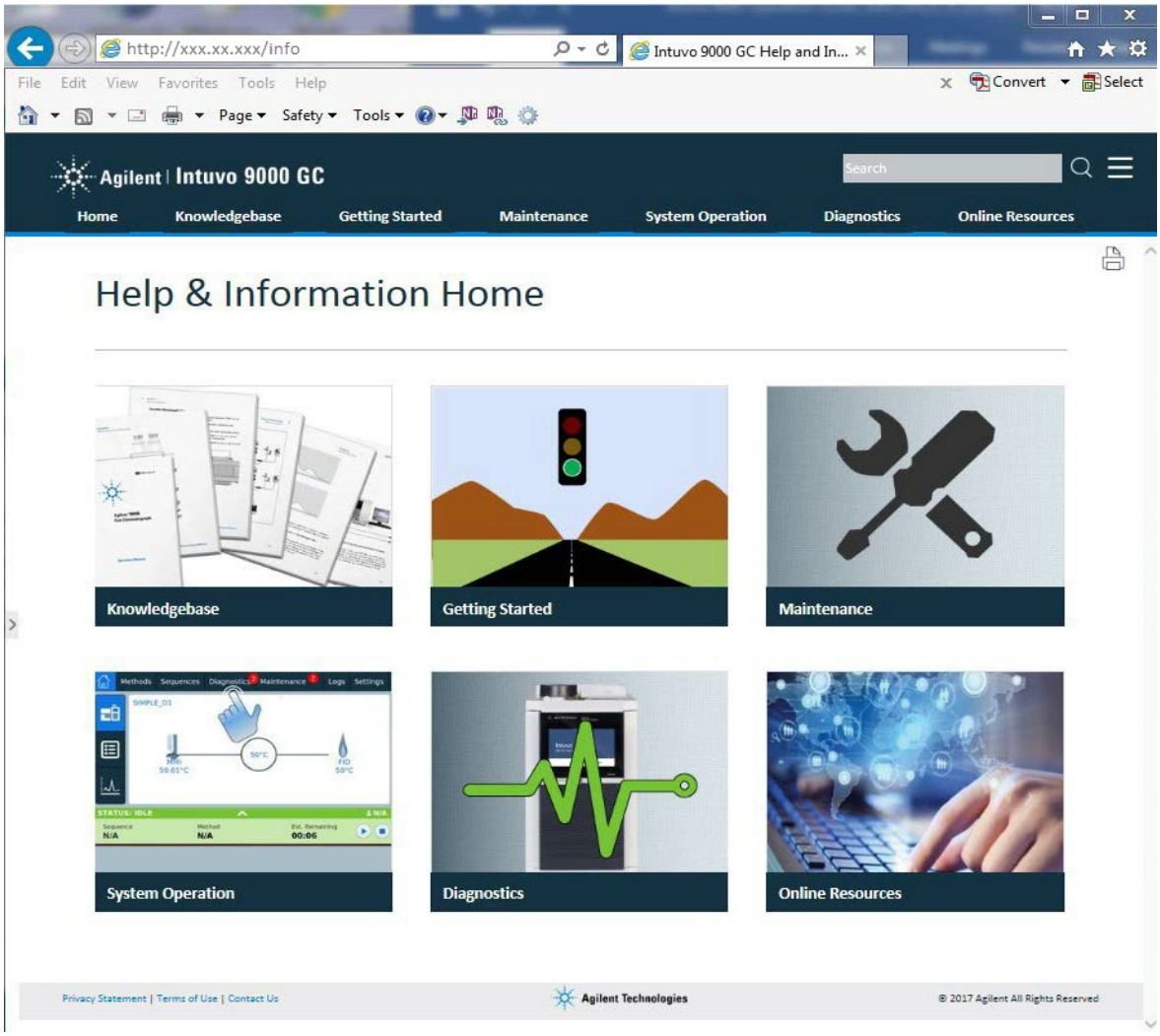


Figure 4 Intuvo Help & Information

2 Hardware Overview

Below is an overview of the Intuvo 9000 GC Hardware.

Outside View

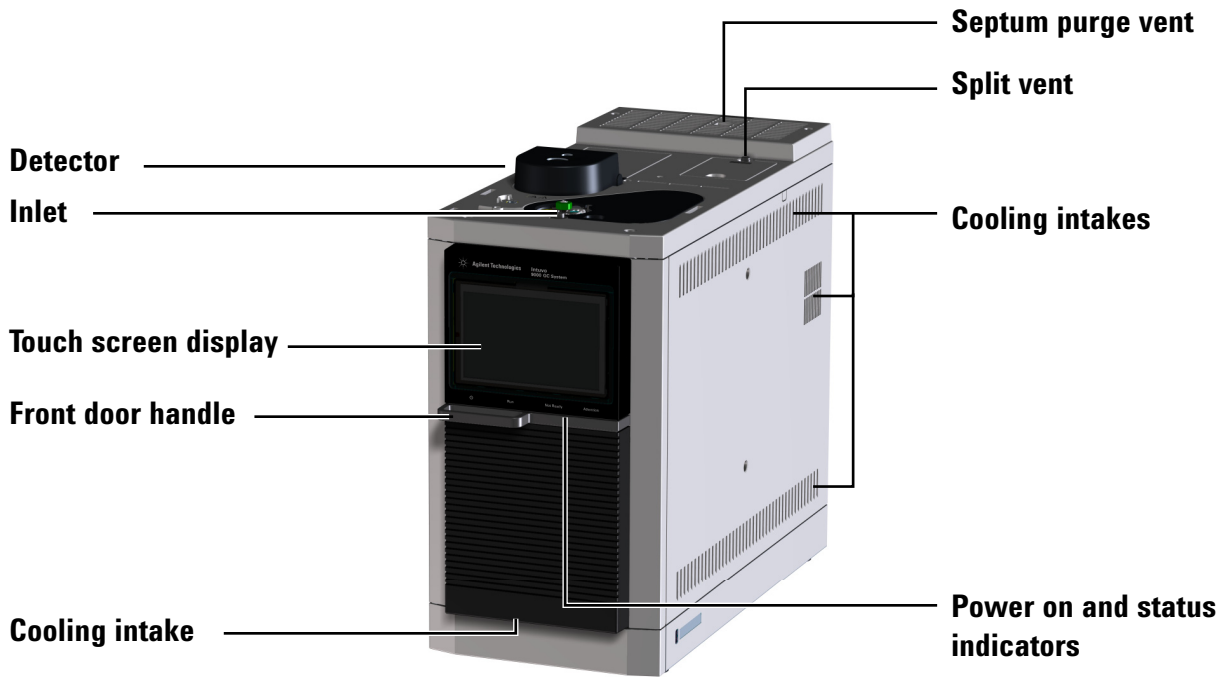


Figure 5 Front of the Intuvo GC

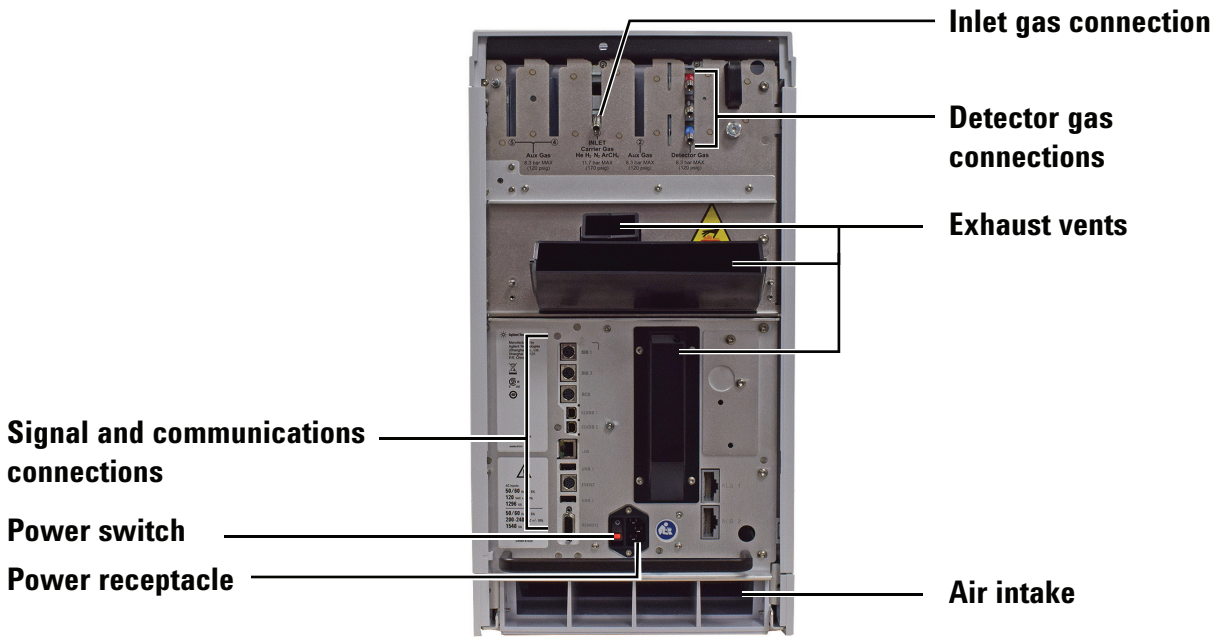


Figure 6 Back of the Intuvo GC

Inside View

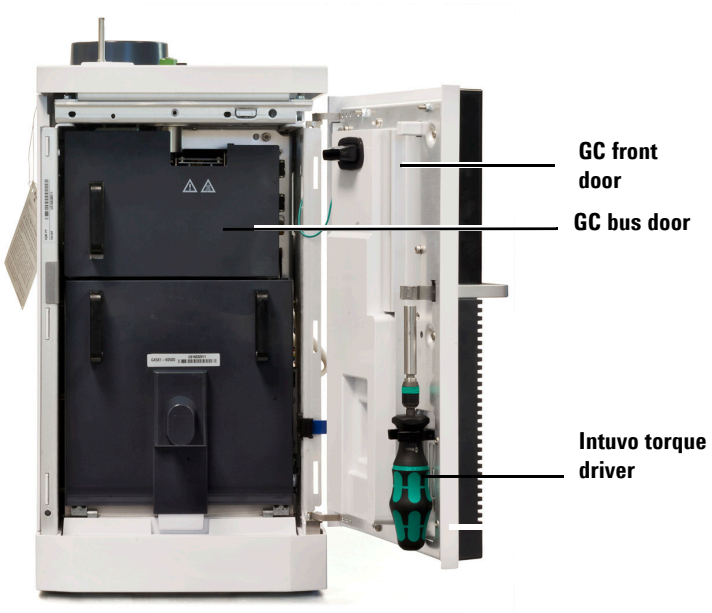


Figure 7 GC front door, bus door, and Intuvo torque driver

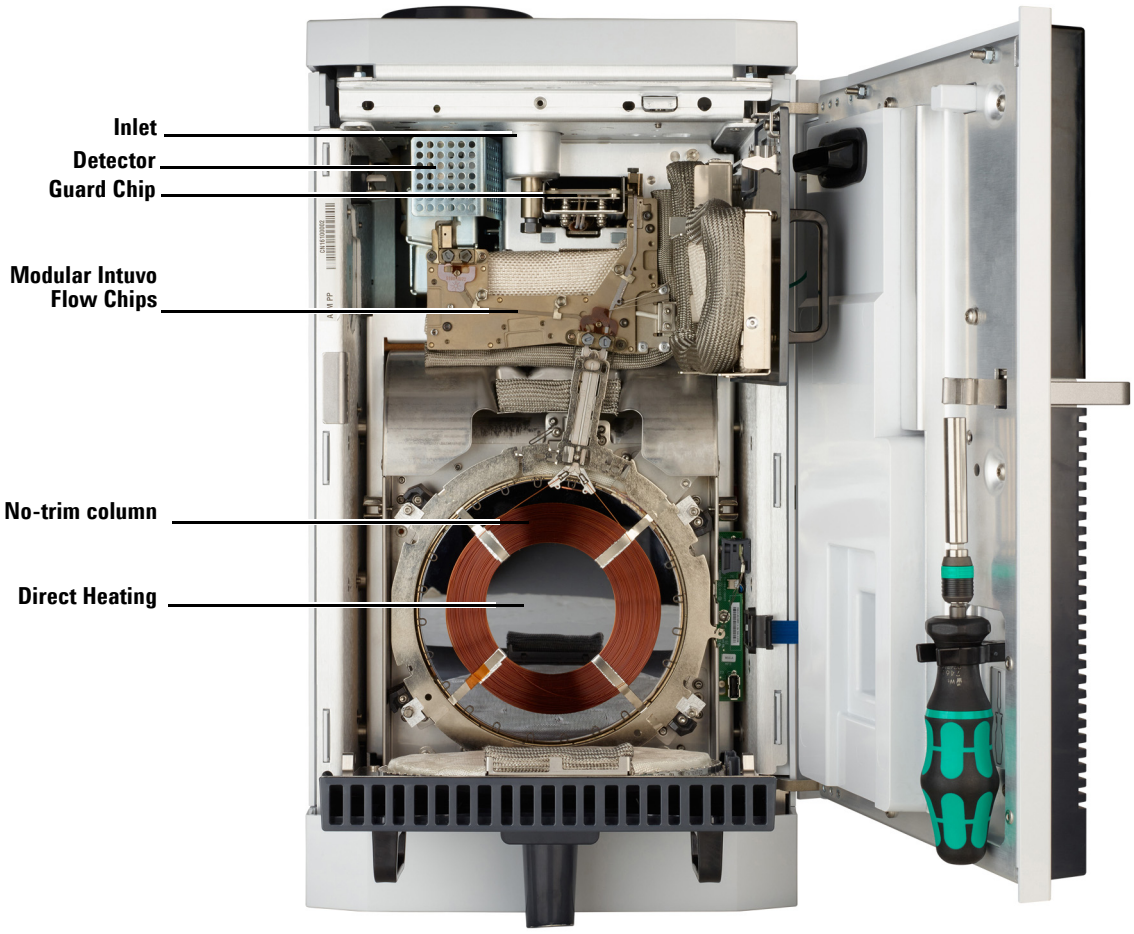


Figure 8 Inside view of Intuvo GC

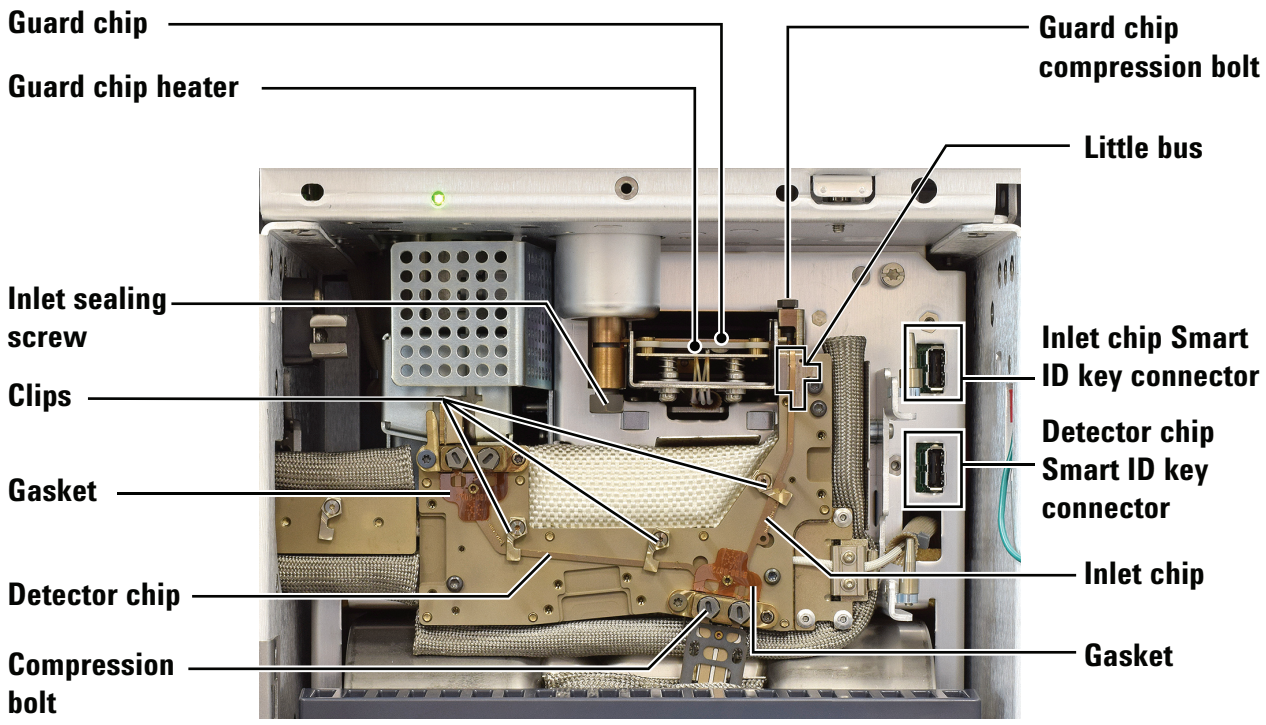


Figure 9 Intuvo GC Bus component, S/SL inlet and simple D1 configuration shown

3
GC Consumables

Column Modules

Intuvo columns are identical in dimensions, construction materials, and separation phase to the existing Agilent GC capillary columns, allowing for easy transfer of existing GC methods directly over to Intuvo.

Intuvo GC columns differ in their compact, planar design to work efficiently with the fast-direct heating and cooling technology of Intuvo. Protected by the Intuvo Guard Chip, these columns never need to be trimmed and are easily replaced using the Intuvo click-and-run connections and the Intuvo torque driver. All Intuvo columns include a smart key, which enables the system to immediately identify the column configuration and temperature limits (including column part number and serial number), as well as to track the use of the column.

Gaskets

The Agilent Intuvo GC system uses ferrule-free face seals for all fittings within the sample gas flow path. Within Intuvo, face seal connections made by gaskets produce a leak-free connection between capillary flow path components, eliminating the need for ferrules.

Three types of gaskets are available: polyimide, nickel, and no-hole. The polyimide gasket is for standard use up to 350 °C, while the nickel gasket provides a solution for high-temperature applications up to 450 °C. The no-hole gasket can be used as a plug to check for leaks or troubleshoot the flow path.

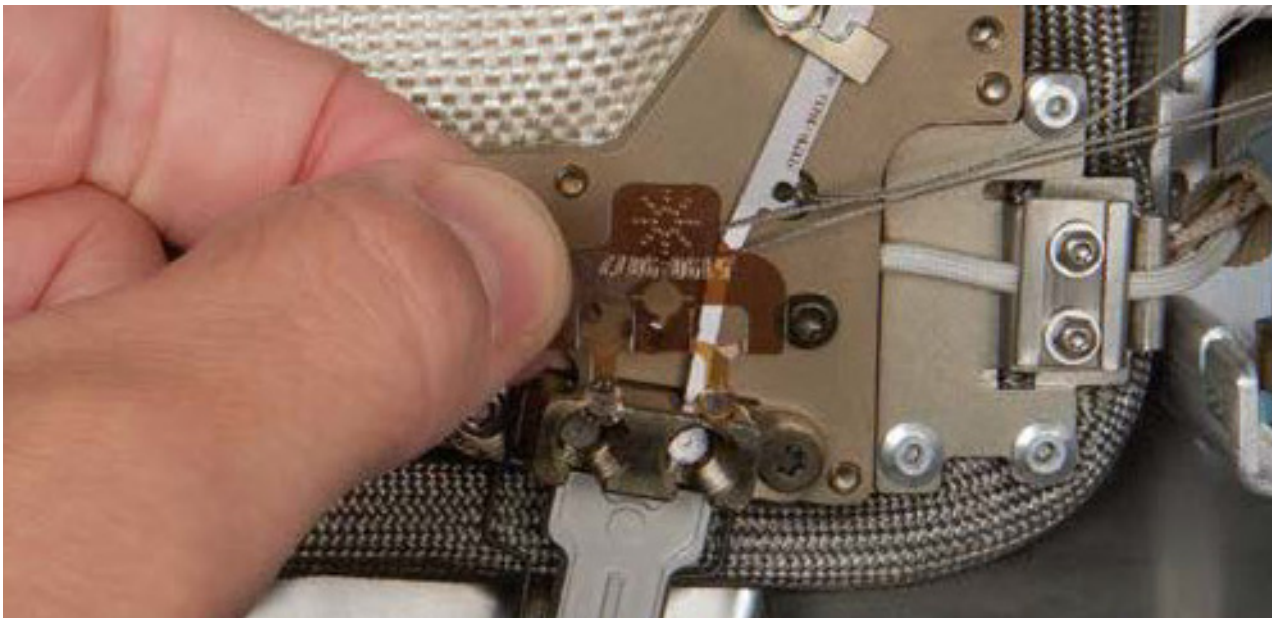


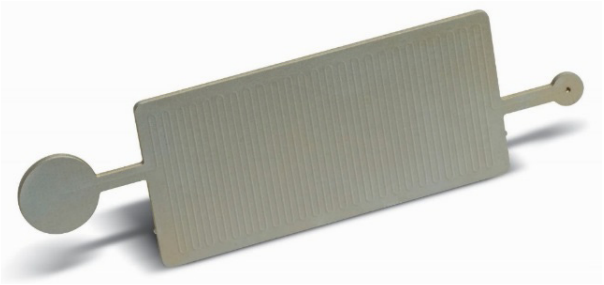
Figure 10 Intuvo Gasket and Installation

Guard Chip

The Agilent Intuvo Guard Chip harnesses the protective power of a traditional retention gap within an easy-to-install, disposable, microfluidic chip. It traps sample residue by providing almost one meter of inert flow path between the liner and the column. With rapid, regular replacement, sample contamination never reaches the head of the Intuvo GC column, eliminating the need for column trimming.

Intuvo Guard Chips are designed as a disposable consumable. To prolong the lifetime of your Intuvo GC column, the Guard Chip should be replaced at about the same frequency as you would typically trim your conventional analytical column, or whenever chromatographic performance begins to decline.

For some ultra-clean applications where a Guard Chip may not be needed, the Jumper Chip provides a short, direct flow path. For example, customers whose applications do not require column trimming may be able to use Jumper Chips. See Table 1 for a list of Intuvo guard chips.



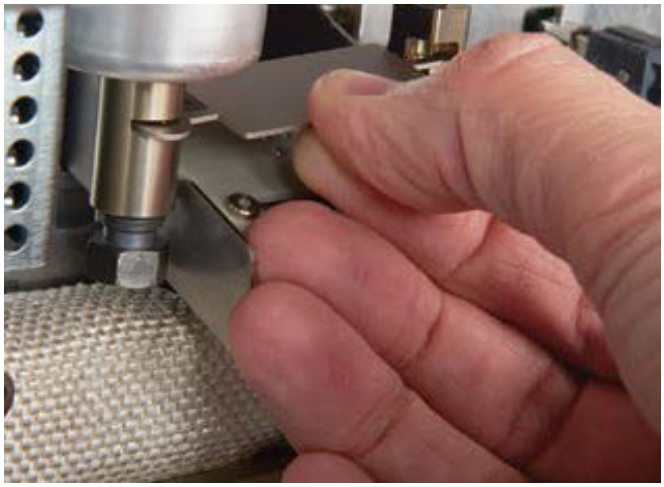
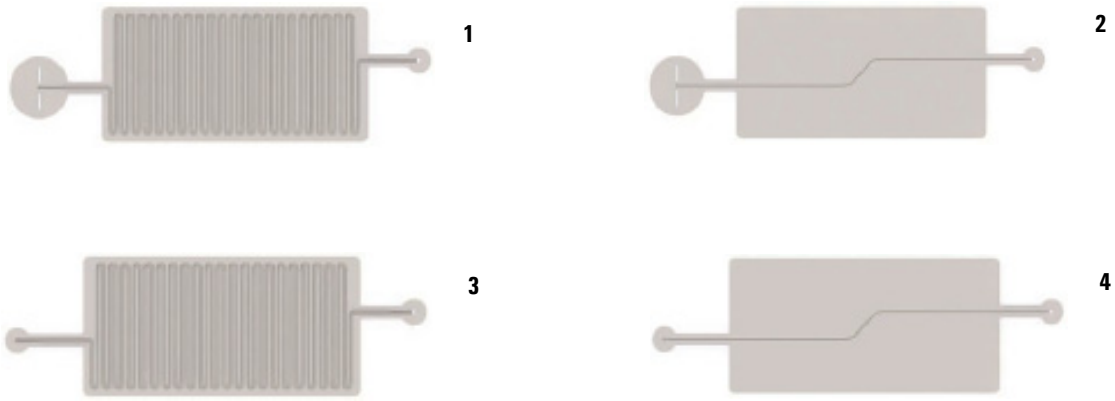


Figure 11 Intuvo Guard Chip and Installation

Table 1 Intuvo guard chips

Description	Purpose
1. Intuvo guard chip, split/splitless inlet	Prevents unwanted material from depositing on and damaging the head of the column
2. Intuvo jumper chip, split/splitless inlet	Provides a short direct flow path
3. Intuvo guard chip, multimode inlet	Prevents unwanted material from depositing on and damaging the head of the column
4. Intuvo jumper chip, multimode inlet	Provides a short direct flow path



Flow Chips

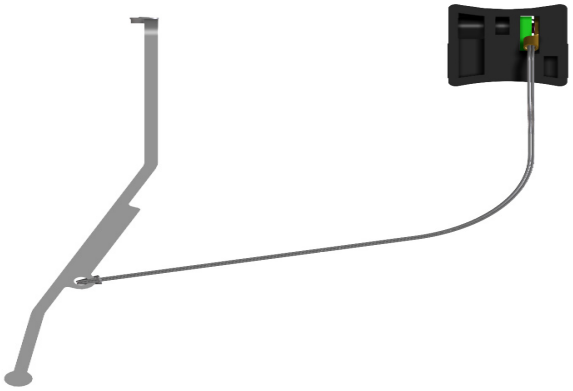
Intuvo Flow Chips are modular, microfluidic components that create connections between the inlet, column, and detector(s) without the need for ferrules, and can be easily swapped in minutes. Intuvo Flow Chips are comprised of high-purity silica flow channels treated with Intuvo Ultra Inert, a third-generation deactivation treatment, to ensure an inert flow path.

All Flow Chips are fitted with Smart Keys that communicate digitally to enable automatic system configuration, which allows Intuvo to help set method parameters specific to its immediate configuration. Complex flow calculators are no longer required, since Intuvo already knows all dimensions, flows, and temperatures throughout the flow path.

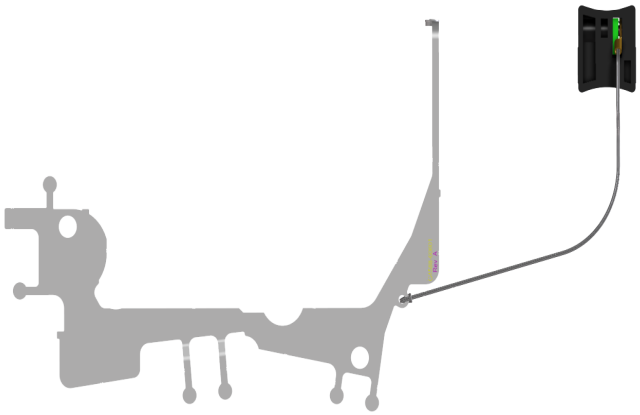
The inlet Flow Chip provides a direct connection from the Guard Chip to the column. The D1, D2, and D2-MS Flow Chips provide connections from the column to detector 1, detector 2, or the mass spectrometer, respectively. The remaining Flow Chips combine all the complex connections for capillary flow technology, such as backflush and/or splitting to dual columns/detectors, into a single device. See Table 2 for a list of Intuvo flow chips.

Table 2 Intuvo flow chips

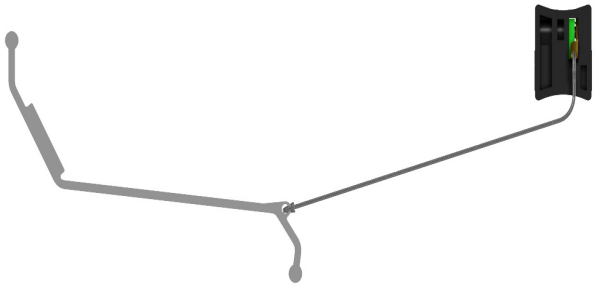
Description	Purpose
Intuvo Flow Chip, inlet	Connects Guard Chip to column
Intuvo Flow Chip, inlet splitter chip	Splits flow from Guard Chip to two columns
Intuvo Flow Chip, D1	Connects column to detector 1
Intuvo Flow Chip, D2	Connects column to detector 2
Intuvo Flow Chip, D2-MS	Connects column to MS
Intuvo Flow Chip, mid column backflush to D1	Connects column to detector 1, mid column backflush capability
Intuvo Flow Chip, mid column backflush to D2	Connects column to detector 2, mid column backflush capability
Intuvo Flow Chip, D1 post column backflush	Connects column to detector 1, post column backflush capability
Intuvo Flow Chip, D2-MS post column backflush	Connects column to MS detector, post column backflush capability
Intuvo Flow Chip, D1-D2 splitter chip, 1:1	Equally splits column effluent between 2 GC detector
Intuvo Flow Chip, D1-MS splitter chip, 1:1	Equally splits column effluent between GC detector and MS



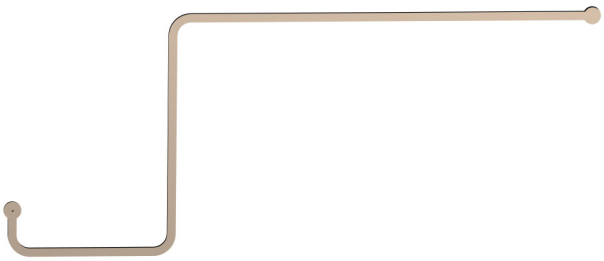
Intuvo Flow Chip, inlet
(Connects Guard Chip to column)



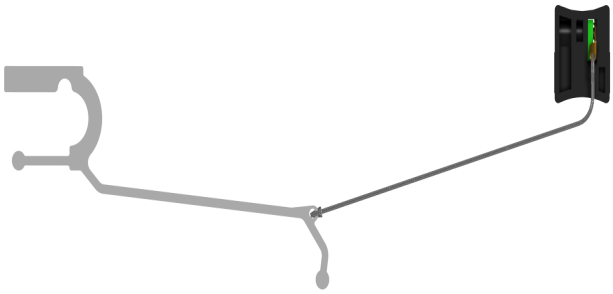
Intuvo Flow Chip, inlet splitter chip
(Splits flow from Guard Chip to two columns)



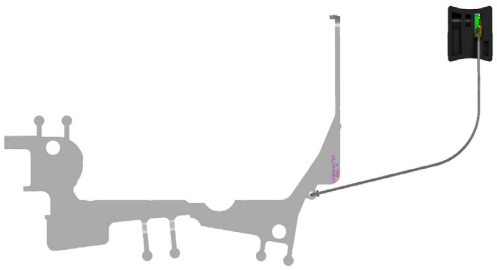
Intuvo Flow Chip, D1
(Connects column to detector 1)



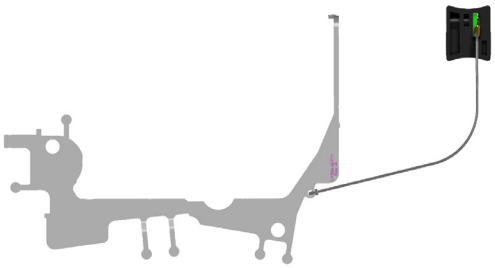
Intuvo Flow Chip, D2
(Connects column to detector 2)



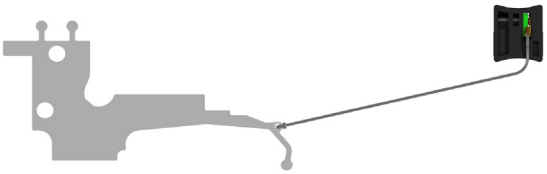
Intuvo Flow Chip, D2-MS
(Connects column to MS)



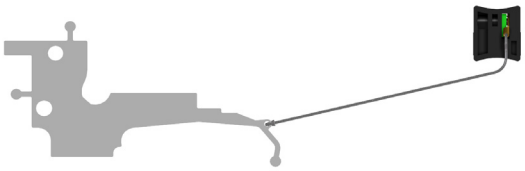
Intuvo Flow Chip, mid-column backflush to D1
(Connects column to detector 1, mid-column backflush capability)



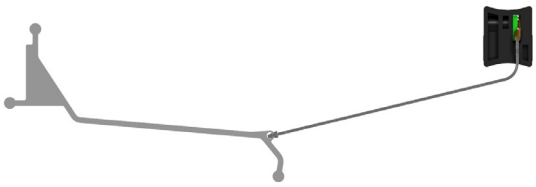
Intuvo Flow Chip, mid-column backflush to D2
(Connects column to detector 2, mid-column backflush capability)



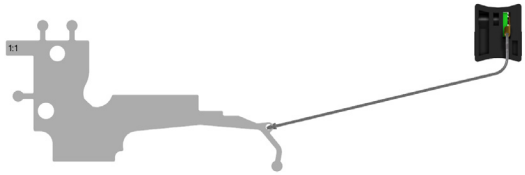
Intuvo Flow Chip, D1 post column backflush
(Connects column to detector 1, post column backflush capability)



Intuvo Flow Chip, D2-MS post column backflush
(Connects column to detector 2, post column backflush capability)



Intuvo Flow Chip, D1-D2 splitter chip, 1:1
(Equally splits column effluent between two GC detectors)



Intuvo Flow Chip, D1-MS splitter chip, 1:1
(Equally splits column effluent between GC detector and MS)

Detector Tails

The Detector tail connects the output of the flow path (D1, D2, MS, splitter, or backflush) to a detector. See Table 3 for a list of Intuvo detector tails.

Table 3 Intuvo detector tails

Description	Purpose
Intuvo Detector tail, MS	Connects output flow path to MS
Intuvo Detector tail, HES MS	Connects output flow path to HES MS
Intuvo Detector tail, FID or TCD	Connects output flow path to FID or TCD detector
Intuvo Detector tail, ECD	Connects output flow path to ECD detector
Intuvo Detector tail, NPD	Connects output flow path to NPD detector
Intuvo Detector tail, FPD	Connects output flow path to FPD^{+} detector
Intuvo Detector tail, XCD	Connects output flow path to XCD detector

For a complete list of Agilent Intuvo 9000 GC Columns and Supplies, refer to the Intuvo Mini-Catalog (part number: 5991-7292EN).

4
GC Configuration and Flow Path Diagrams

The Intuvo 9000 GC utilizes a single inlet with up to two columns and two detectors to support many common GC applications. See below for an overview of the available GC configurations.

Intuvo Simple D1

Intuvo Simple D2

Intuvo with MS

Simple D1 — Single Inlet, Single Detector

The Simple D1 configuration replicates the typical GC flow path of inlet-column-detector.

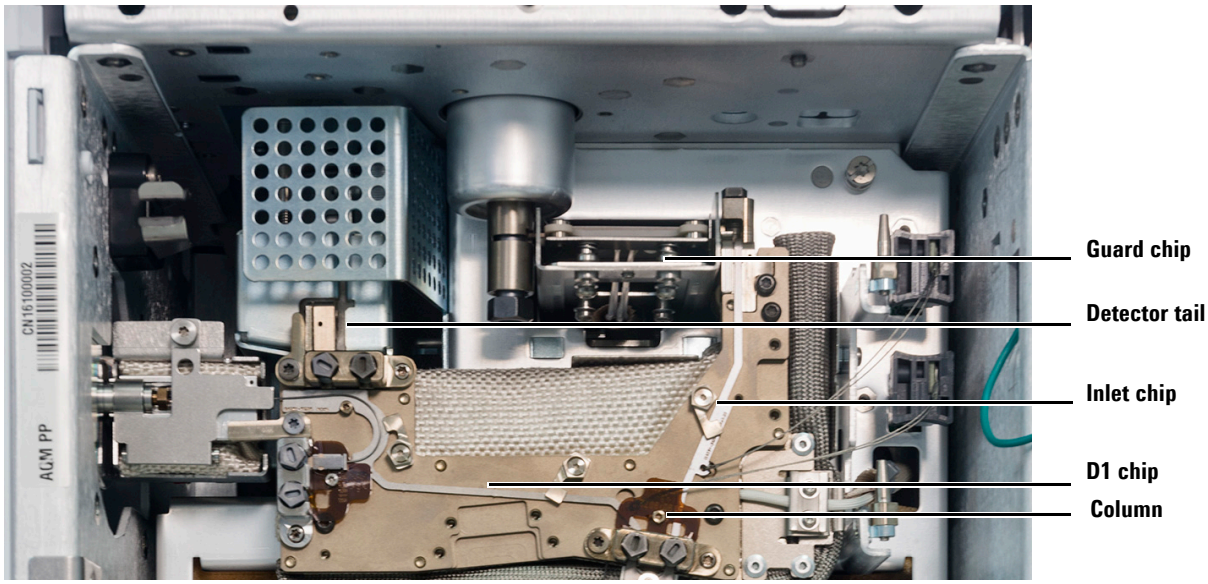


Figure 12 Single Inlet, Single Detector

Simple D2 — Single Inlet, Single Detector

The Simple D2 configuration directs the column effluent only to the second detector.

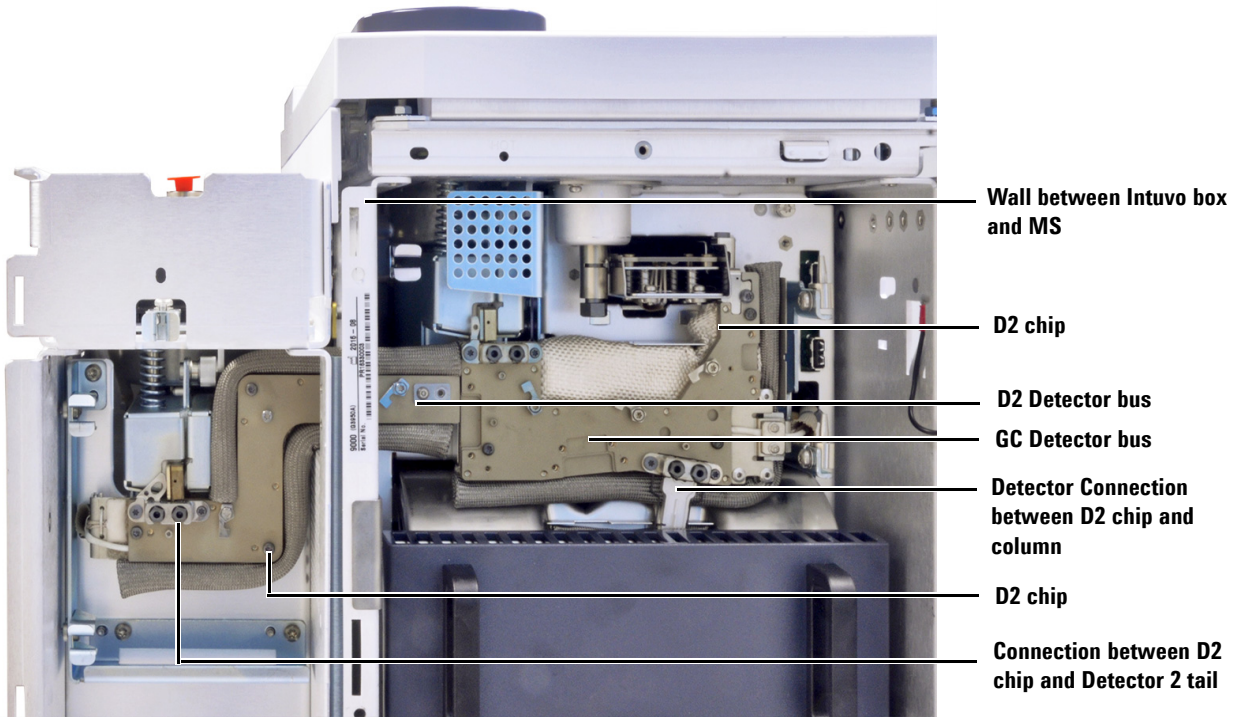


Figure 13 Single Inlet, Single Detector

GC with Mass Spectrometer

This configuration directs the column effluent to the mass spectrometer.

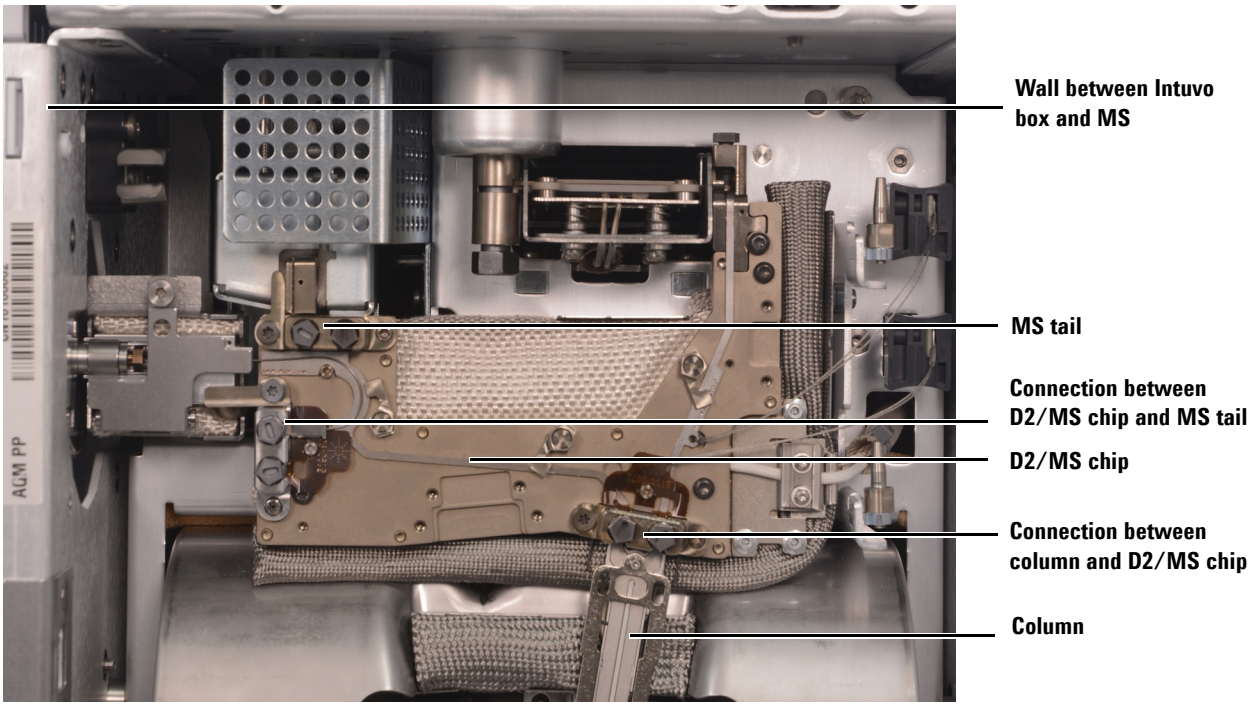


Figure 14 GC with Mass Spectrometer

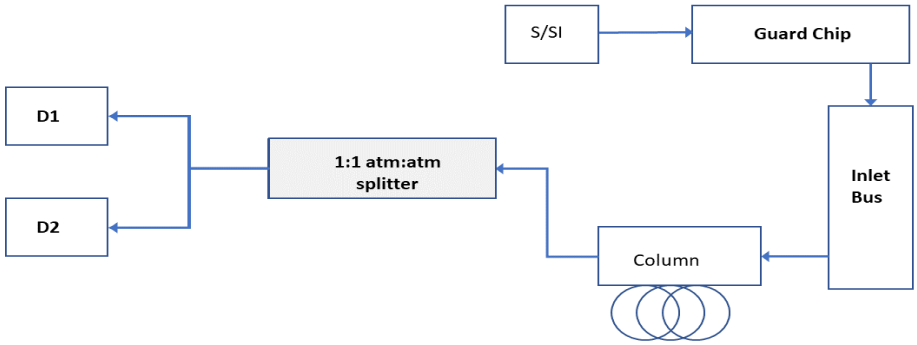
1:1 D1:D2 Detector Splitter

Overview

The Intuvo 1:1 D1:D2 Detector Splitter is passive in that it does not require the use of an Intuvo pneumatic switching device electronic pressure control (PSD EPC) module. Based on the outlet pressure of both the D1 and D2 detectors being at atmospheric pressure, the column effluent is evenly split between the two detectors.

How it works

The Intuvo 1:1 D1:D2 Detector Splitter is used to split the effluent from the analytical column to two different detectors, each operating at atmospheric pressure.



The splitter supports the use of any combination of one detector from each of the following two groups:

Atmospheric pressure detectors for D1

- FID (flame ionization detector)
- TCD (thermal conductivity detector)
- NPD (nitrogen-phosphorus detector)
- ECD (micro-electron capture detector)
- FPD+ (flame photometric detector)

Atmospheric pressure detectors for D2

- FID (flame ionization detector)
- TCD (thermal conductivity detector)
- NPD (nitrogen-phosphorus detector)
- ECD (micro-electron capture detector)

The 1:1 D1:D2 Detector Splitter Chip is a passive device where the split ratio is achieved based on balanced restrictions between the D1 and D2 detector paths.

Details

The Intuvo 1:1 D1:D2 Detector Splitter replaces the separate D1 and D2 flow chips in the flow path. The inlet flow chip is still a separate piece as it is not incorporated into the 1:1 D1:D2 Detector splitter.

The standard Intuvo detector tails are used in both the D1 and D2 detectors. The standard Intuvo D2 flow chip connects the 1:1 D1:D2 Detector Splitter to the D2 detector.

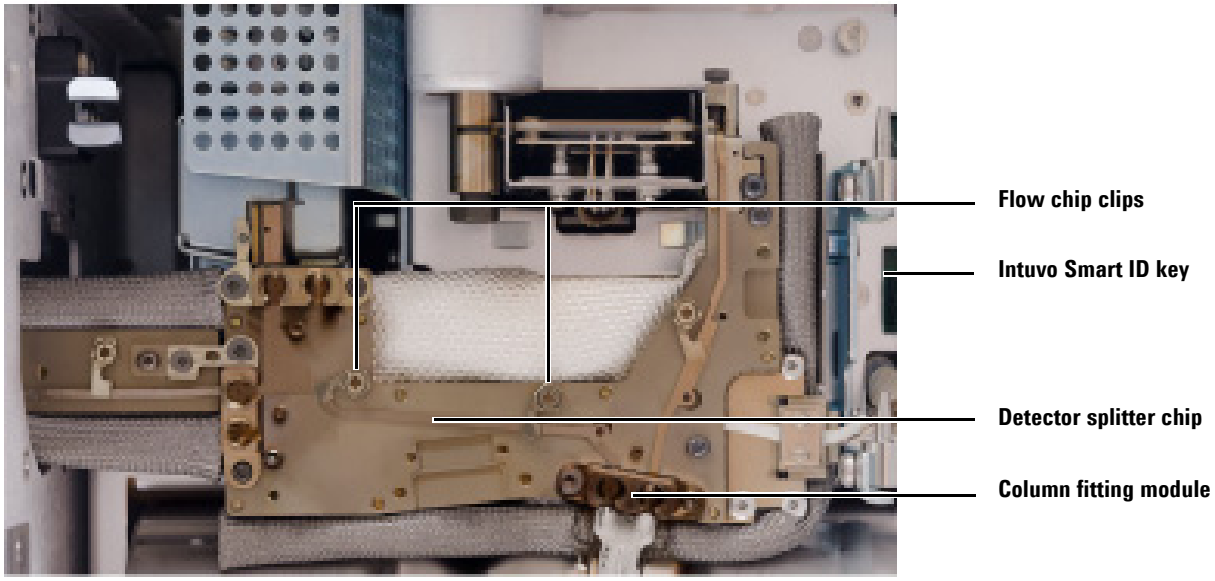
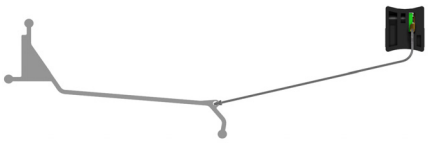


Figure 15 D1:D2 Detector Splitter

Part Identification

Intuvo D1-D2 Splitter Chip, 1:1



Inlet Splitter (D1:D2)

Overview

The Intuvo Inlet Splitter requires the use of two Intuvo columns and two Intuvo atmospheric detectors.

While the same Intuvo Inlet Splitter can be used regardless of the user's choice of columns and detectors, the appropriate hardware necessary to support the choice of the second detector will need to be installed accordingly; for example, a D2 Detector Accessory is required when D2 is an atmospheric detector.

How it works

The Intuvo Inlet splitter is used to split the effluent from the gas chromatograph (GC) inlet to two separate columns and their corresponding detectors for analyte detection.

The splitter supports the use of any two Intuvo analytical columns and any combination of atmospheric detectors:

Atmospheric pressure detectors

- FID (flame ionization detector)
- TCD (thermal conductivity detector)
- NPD (nitrogen-phosphorus detector)
- ECD (electron capture detector)
- FPD+ (flame photometric detector)

The Intuvo Inlet Splitter is a passive device that does not require an additional pressure source (for example, a PSD EPC). The split ratio delivered by the inlet splitter is determined by the dimensions of the two analytical columns. For example, a pair of identical columns would provide a 1:1 split of the inlet effluent to both detectors. In the case where columns of dissimilar dimensions are chosen, the effective split ratio can be calculated based on the ratio of carrier flow going through each column. The carrier flow going through a given column can be determined using the Agilent Pressure/Flow Calculator included in the instrument's software driver.

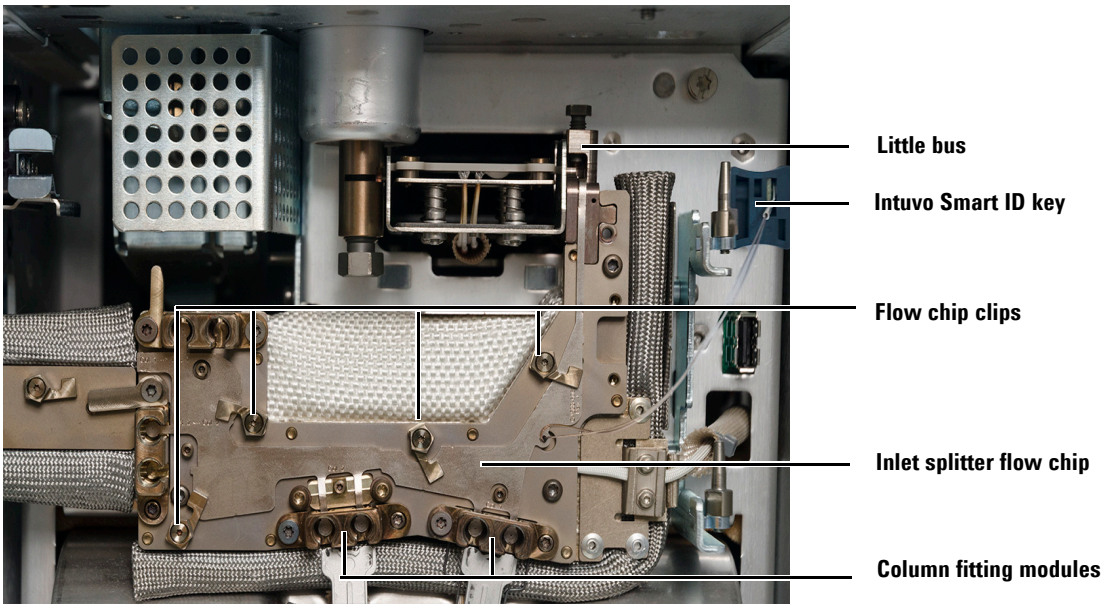


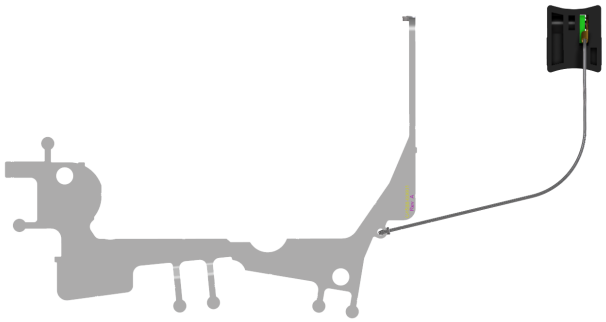
Figure 16 Inlet splitter D1 to D2

Requirements

The Intuvo Inlet Splitter requires the use of two Intuvo columns which necessitates the installation and use of a second column header heater.

Parts Identification

Intuvo Inlet Splitter Flow Chip



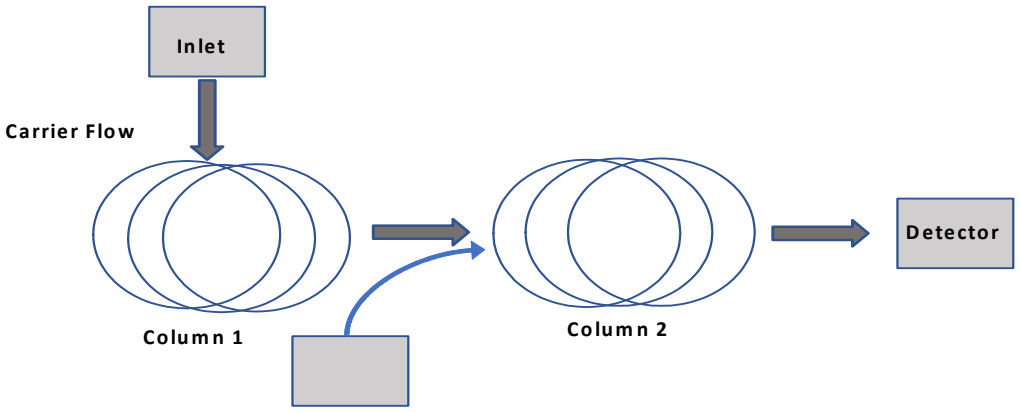
D1 and D2/MS Mid-Column Backflush

Overview

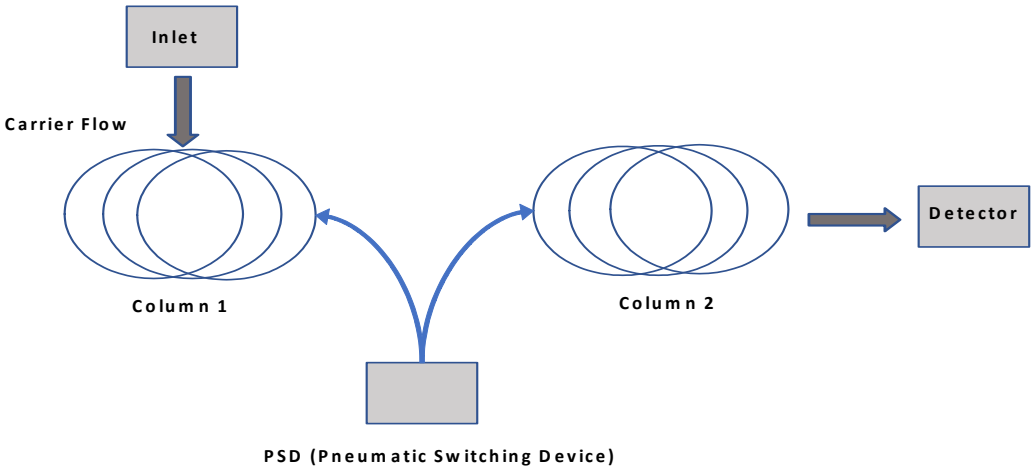
The D1 or D2/MS Mid-Column Backflush chips, coupled with an electronic pressure control (EPC) mechanism called a pneumatic switching device (PSD), provides the Intuvo 9000 GC system with backflush capability. Backflushing uses an additional pressure source at the end of a column to flow carrier gas backwards through the column and out the inlet split vent. This removes high boiling point compounds from the head of the column which reduces carryover and matrix contaminant effects, avoids fouling of the mass spectrometer source, and increases sample throughput.

How it works

Regular Flow Operation



Backflush Operation



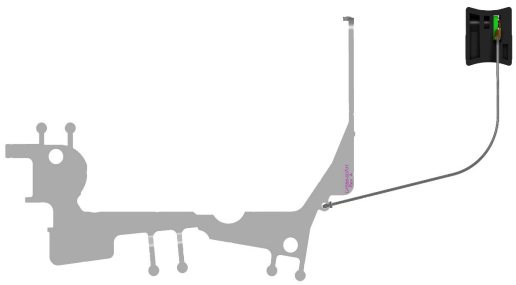
In a mid-column backflush setup two columns are used. Column one is the backflush column and column two is the analytical column. An additional pressure source, the pneumatic switching device (PSD), is placed between two columns to adjust carrier gas flow in one of two modes. In regular flow operation, the PSD adds a small amount of flow in addition to the column 1 flow to provide flow to column 2. In this mode, analytes will pass from column 1 to column 2 as if it were one continuous column. The analytes are carried through column 2 to the detector.

During backflush operation, at a specified time after sample introduction (that is, the backflush time), the inlet pressure is reduced. The PSD maintains the same flow rate through column 2. However, since the inlet pressure is now lower than the PSD pressure, the flow through column 1 reverses and flows out through the inlet split vent trap.

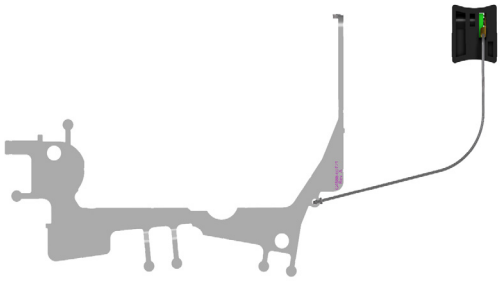
GC Requirements and Details

The Intuvo Inlet Splitter requires the use of two Intuvo columns which necessitates the installation and use of a second column header heater.

- **Mid-Column Backflush Chip for D1**



- **Mid-Column Backflush Chip for D2/MS**



- Two columns
- Additional column header heater
- A detector in the requisite position

- Split/Splitless or MMI inlet (one required by all Intuvo GCs)
- Pneumatic Switching Device (PSD)

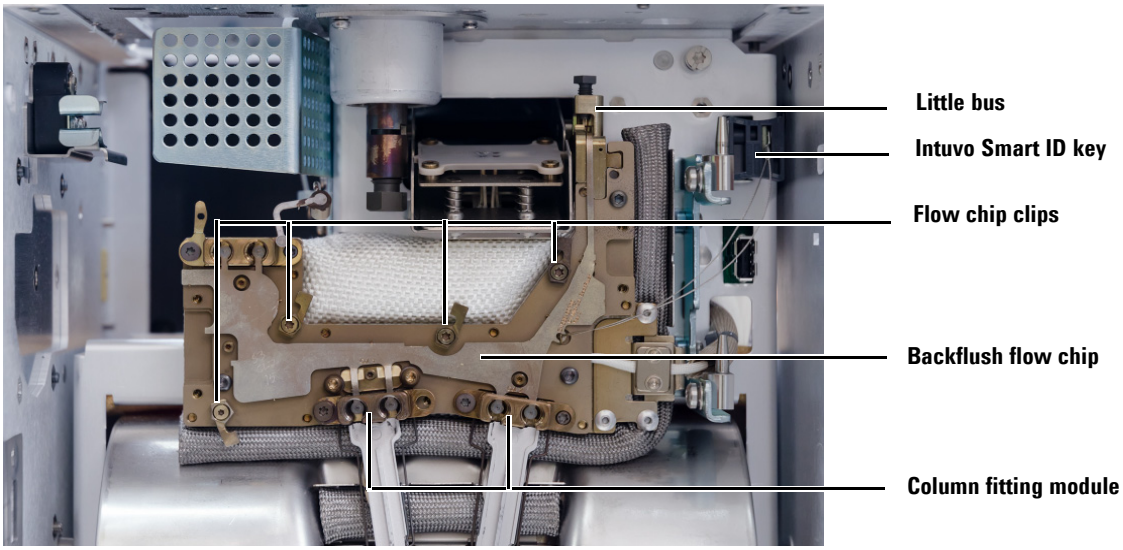


Figure 17 Mid-Column Backflush to D1

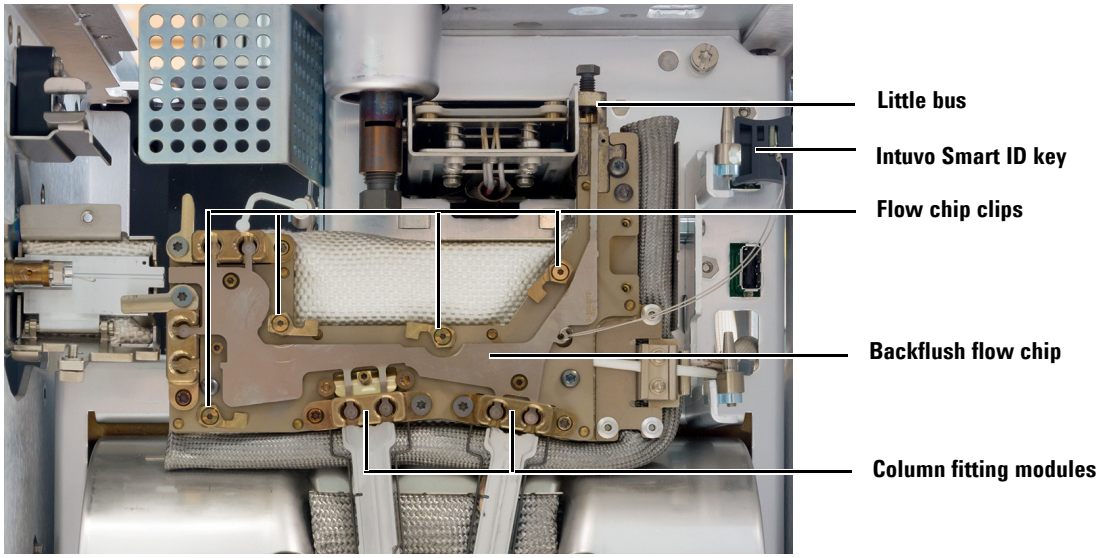


Figure 18 Mid-Column Backflush to D2/MS

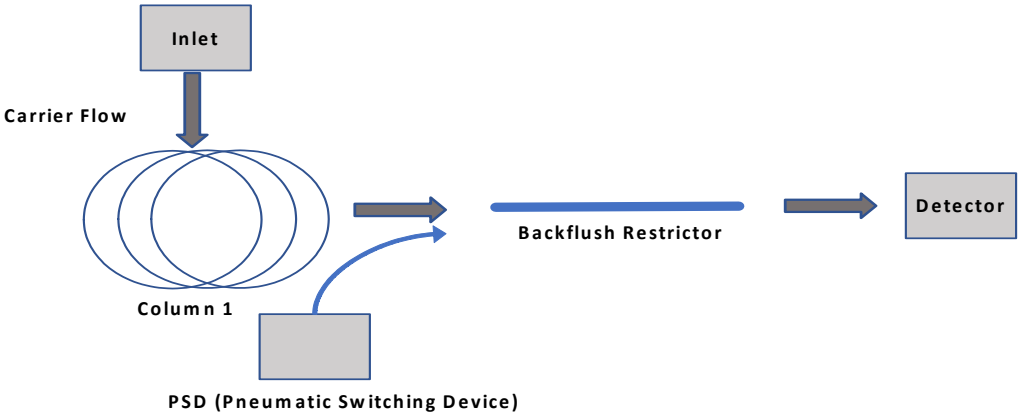
D1 or D2/MS Post Column Backflush

Overview

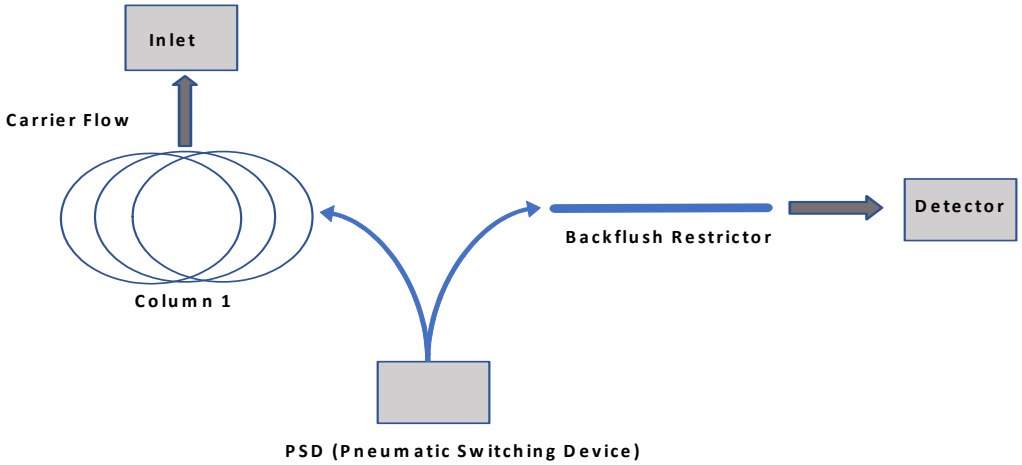
The D1 or D2/MS Post-Column Backflush flow chip, coupled with an electronic pressure control (EPC) mechanism called a pneumatic switching device (PSD), provides the Intuvo 9000 GC system with backflush capability. Backflushing uses an additional pressure source at the end of a column to flow carrier gas backwards through the column and out the inlet split vent. This removes high boiling point compounds from the head of the column which reduces carryover and matrix contaminant effects, avoids fouling of the mass spectrometer source, and increases sample throughput.

How it works

Regular Flow Operation



Backflush Operation



In a post-column backflush setup, a single analytical column is used in conjunction with a backflush restrictor situated between the end of the analytical column and the detector. The backflush restrictor is built into the Agilent G7325A Post-Column Backflush flow chip. An additional pressure source, the pneumatic switching device (PSD) is connected via a node (also build into the Post-Column Backflush flow chip) between the column and the restrictor to adjust carrier gas flow in one of two modes.

In regular flow operation, the PSD adds a small amount of carrier gas in addition to the column 1 carrier gas to provide flow through the restrictor to the detector. In this mode, analytes will pass from column 1 through the restrictor to the detector as if it were one continuous column. In backflush operation, however, the inlet pressure is dropped (generally to 1-2 psi) and the PSD pressure is raised to reverse the flow of carrier gas and flush any remaining analytes out the inlet split vent.

To enable backflush operation, the user specifies a time for the system to perform backflush. This time (that is, the backflush time) is generally at the end of the run when the last peak of interest has eluted from the column and been detected. At the backflush time, the inlet pressure is reduced while simultaneously the PSD pressure is increased. The higher the PSD pressure is raised during backflush, the faster the backflushing will occur. However, when increasing the PSD pressure during backflush, part of the flow is also sent through the restrictor to the detector. If using an MS, the flow during backflush cannot be greater than the operational limits of the MS.

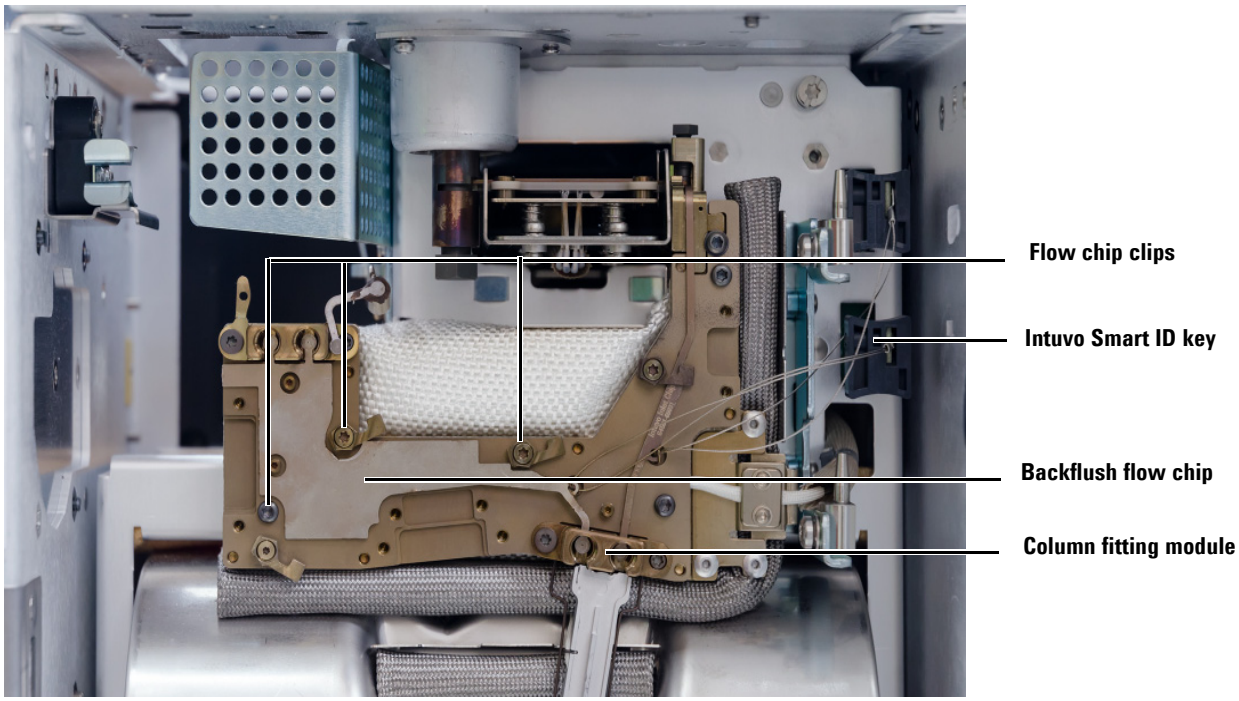
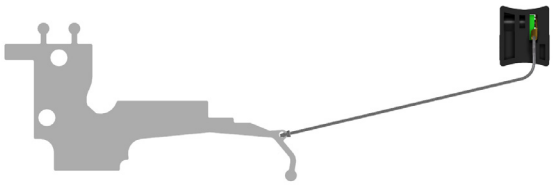


Figure 19 Post Column Backflush Flow

Part Identification

Post Column Backflush Flow



1:1 D1-MS (ATM-VAC) Detector Splitter

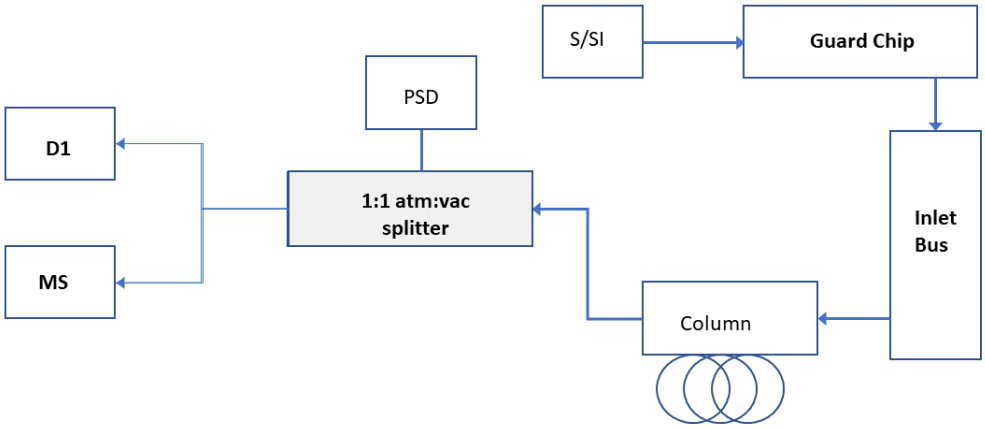
Overview

The Intuvo 1:1 D1:MS Detector Splitter Chip divides the column effluent from one column to two detectors. The D1 detector can be any of the supported atmospheric detectors and D2 is a mass spectrometer (MS).

The Intuvo 1:1 D1:MS Detector Splitter requires the use of an Intuvo pneumatic switching device electronic pressure control (PSD EPC) module. The PSD EPC provides a constant pressure drop across the restrictions built into the splitter which are necessary to compensate for the differences in operating pressure between the D1 and MS detectors.

How it works

The Intuvo 1:1 D1:MS Detector Splitter is used to split the effluent from the analytical column to two different detectors where one detector is operated at atmospheric pressure and the other is operated at sub-ambient pressure:



The splitter supports the use of any combination of one detector from each of the following two groups:

Atmospheric pressure detectors

- FID (flame ionization detector)
- TCD (thermal conductivity detector)
- NPD (nitrogen-phosphorus detector)
- ECD (micro-electron capture detector)
- FPD+ (flame photometric detector)

Mass Spectrometers

- 5975A, 5977A, 5977B single quadrupole MS
- 7000 series, and 7010 triple quadrupole MS

The 1:1 D1:MS Detector Splitter Chip is an active splitting device because it uses a PSD EPC to maintain a constant pressure at the split point throughout the oven temperature program. By maintaining a constant pressure at the split point, the carrier flow rate going to each detector remains constant throughout the run. Keeping the carrier flow rate constant is important to maintain a constant response on certain GC detectors; most notably, the MS.

The split ratio delivered by the splitter is fixed by the differences in restriction between the D1 and MS channels that are built into the 1:1 D1:MS Detector Splitter. Slight differences in the split ratio of column effluent being directed to the different detectors can be achieved by changing was designed to provide a 1:1 split for a specific set of conditions:

- Carrier gas = He
- Column flow = 2.5 mL/min (constant)
- Oven program maximum temperature = 325 °C
- PSD EPC pressure = 26.2 kPa (3.8 psig)

Details

The Intuvo 1:1 D1:MS Detector Splitter replaces the separate D1 and D2 flow chips in the flow path and combines them on the same flow chip. The inlet flow chip is still a separate piece as it is not incorporated into the 1:1 D1:MS splitter.

The standard Intuvo detector tails are used in the D1 detector. The standard Intuvo MS tails are used with the MS. Note: which MS tail to use is dictated by which MS ion source is being used; HES or Extractor.

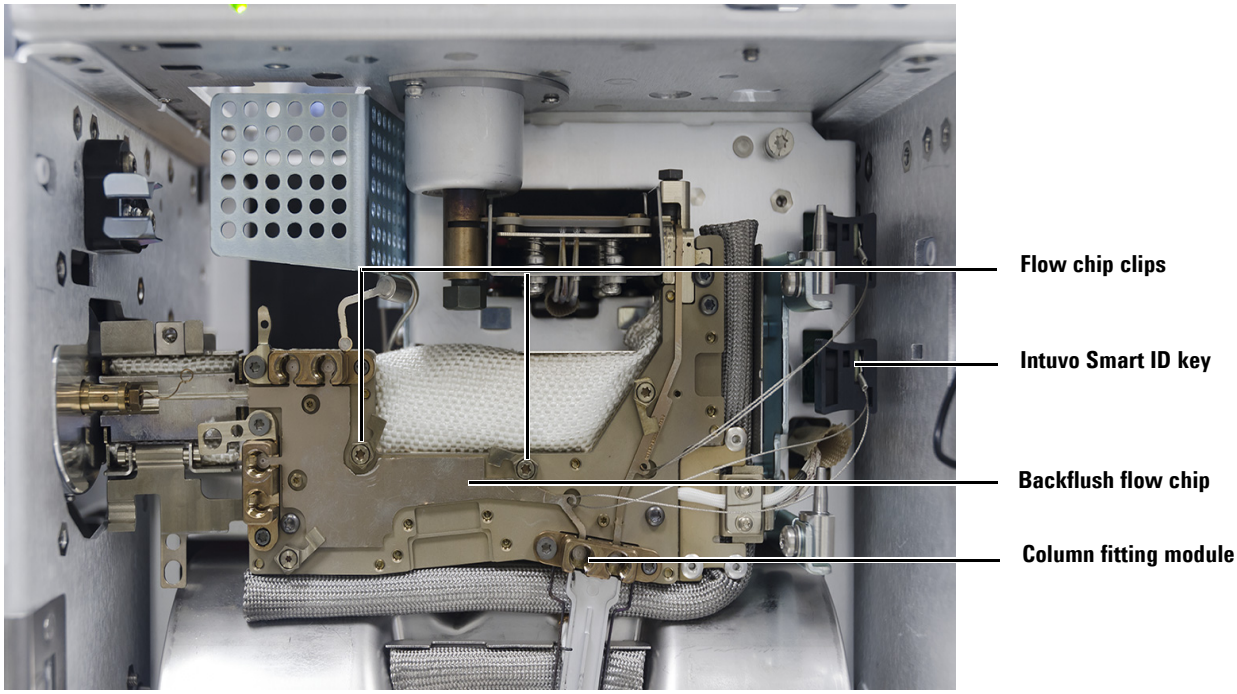
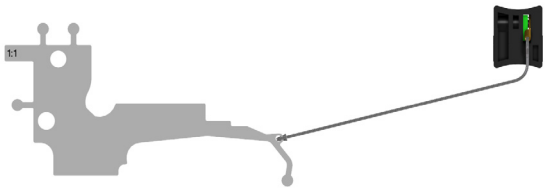


Figure 20 Post Column Backflush Flow

Part Identification

Intuvo D1-MS Splitter Chip, 1:1



A
Glossary

Bus heater – the bus, an isothermal device that serves as the connection mechanism for all Separation Path devices.

Intuvo Flow Chips – provide connection between the inlet, column and detector.

Guard Chips – a disposable consumable which eliminates the need to clip columns by protecting downstream components from contamination. It traps sample residue by providing almost one meter of inert flow path between the liner and the column.

Smart ID Keys – attached to critical flow path components provide information such as configuration and column age with default parameters for configuration.

Direct heating – oven delivers linear and repeatable temperature ramps from 30 to 450 at 250 °C/min.

Click-and-run connections – By coupling two planar face seals together with a torque driver, we can ensure exactly the right tightness for a leak-free seal. The click of the torque driver is an audible and tactile indicator of proper connection.

Agilent Technologies

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