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Bulletin 918

Selecting Purifiers for Gas Chromatography

Selecting the proper purifiers for a GC system begins with determining the contaminants to be removed from the gas, the levels to which the contaminants must be reduced, the flow and pressure needs of the system versus the flow maximums for effective operation of various purifiers, and the desired frequency of changing purifiers. The best purifier system includes multiple purifiers that help protect each other while protecting columns and detectors. This bulletin includes information needed to select suitable purifiers for carrier gas, and for air and hydrogen used as fuel gases.

Key Words:
€ carrier gas • gas purifiers • gas chromatography

Overview

Most analysts realize the importance of using gas purifiers in packed and capillary gas chromatography systems. It is known that capillary columns can degrade when exposed to oxygen or water vapor in the carrier gas. In addition, hydrocarbons and other contaminants in the carrier gas can appear as peaks from commonly-used thermal conductivity detectors (TCD) and flame ionization detectors (FID). With compound-specific detectors (sulfur, nitrogen/phosphorus, electron capture), hydrocarbons, oxygen, and water may be unseen, but they still can hinder quantification of analytes.

Establishing a gas purification scheme for a GC system can be a complicated process. In selecting the proper purifiers for your system, you must consider:

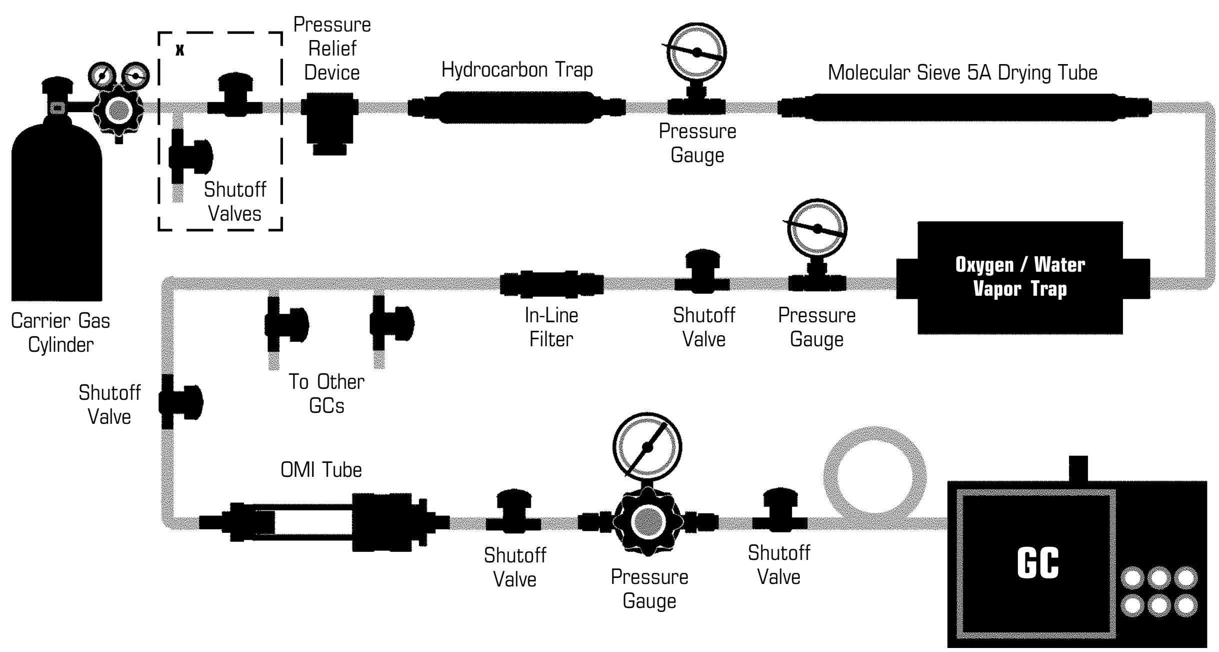
1. What contaminants must be removed from the gas **and** the levels to which these contaminants must be reduced.
2. The flow and pressure needs of your system versus the flow maximums for effective operation of various purifiers.
3. The frequency with which you are comfortable with changing purifiers.

Dozens of purifiers are listed in various catalogs, but information ensuring that a particular purifier will work for a particular application, or allowing cross-comparison, is lacking. This bulletin is an attempt to summarize all the information you need to select appropriate purifiers for carrier gas, fuel air, and hydrogen used as a fuel gas. Performance characteristics of purifiers for removing hydrocarbons, water, and oxygen from carrier gas are summarized in three separate tables.

Carrier Gas Purification

In carrier gas purification there truly is safety in numbers. The best purifier system includes multiple purifiers that help protect each other while protecting your columns and detectors. Surges of oxygen and/or water greater than 100ppm often are the result of accidental contamination of cylinders, regulators, and lines when room air enters the system during the process of changing cylinders. A single purifier that is intended for removing oxygen

Figure A. Recommended Configuration for Carrier Gas Purifiers



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and water can be overwhelmed by these high levels of contaminants; some oxygen/water traps even could be damaged. For example, an indicating purifier or heated purifier could overheat, possibly releasing previously trapped oxygen and water. Worse, overheating could break down the catalyst particles or coated beads in the purifier, generating contaminating breakdown products and/or possibly plugging the purifier or greatly increasing the back pressure.

For maximum system protection and longest purifier lifetimes in most GC systems, we recommend a carrier gas purification scheme consisting of a hydrocarbon trap, a water vapor trap, and an oxygen/water trap in series, as shown in Figure A. There is always a possibility that a gas line or valving can contain residual hydrocarbons. For this reason, we recommend including a *hydrocarbon trap* in typical purification situations. The primary function of the hydrocarbon trap is to trap most hydrocarbons, but some hydrocarbon traps, like our Supelcarb™ HC trap, contain a carbon molecular sieve that also retards the elution of oxygen and water. Surges of oxygen and water that enter the gas line during the installation of a new cylinder of gas enter the hydrocarbon trap and are released slowly, diluted by the clean carrier gas from the new cylinder to levels that are more effectively dealt with by the water vapor and oxygen/water traps downstream. (Note that hydrocarbon traps do not trap methane under normal conditions.) The *water vapor trap*, which typically contains a zeolite molecular sieve, receives a reduced oxygen/water surge. It removes most of the water and continues to slow the movement of oxygen, further reducing its concentration. Gas reaching the high efficiency *oxygen/water trap* contains significantly reduced concentrations of contaminants. This conserves the purifying material in the trap, minimizing the frequency of replacement, and ensures the trap will reduce oxygen and water levels to less than 1ppm, the desired level of carrier gas purity to ensure best column performance and long column lifetimes.+

It is a decided advantage to have a visual indication of when to replace these purifiers. We recommend installing an indicating purifier immediately before the gas line connection to the chromatograph, as shown in Figure A. The indicating purifier should be of glass construction; oxygen and water vapor can penetrate the wall of a plastic-bodied indicating purifier. In most systems an OMI™-2 indicating purifier will serve ideally.

An ideal GC configuration also includes valving that can purge the system upstream from the purifiers (*x* in Figure A). For detailed information on designing gas supply schemes for your GC system, request Bulletin 898 *Gas Management Systems for GC.*

One purification device, the UOP purifier, combines the functions of hydrocarbon, water, and oxygen removal into a single system (Figure B). If you use one of these devices, you will need to replace it more often than if you use larger capacity individual devices for trapping hydrocarbons, water, and oxygen. If your gas usage is constant, and you replace the device on schedule, you can use the calculations discussed in **How to Establish a Purifier Replacement Schedule** (page 6 of this bulletin) to predict when to replace a UOP purifier. On the other hand, an OMI-2 indicating tube, installed downstream from the UOP purifier, is a simpler and more reliable indicator of when to replace the device.

The purification scheme in Figure A will not always be the most economical or practical approach. The following are examples of situations requiring other schemes.

+ Although detectors have requirements for gas purity, the purity needs of the column generally are more demanding.

Figure B. UOP Purifier Combines Hydrocarbon, Water, and Oxygen Removal in One System

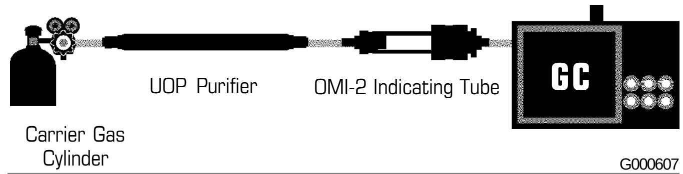


Figure C. Simple Purifier Configuration for a Single-GC System with Undemanding Requirements

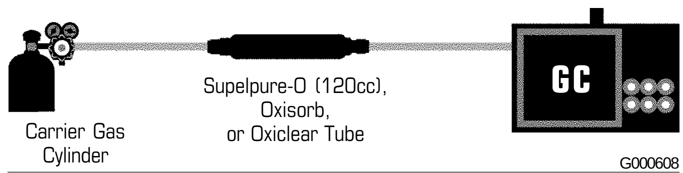
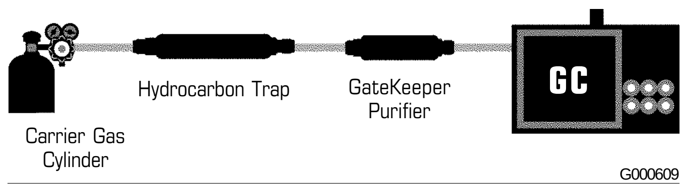


Figure D. Purifier Scheme for a System with High Purification Demands



Some analysts use a single gas chromatograph infrequently and/or with very low carrier gas flow rates. Their total carrier gas use may be only one to a few cylinders per year. Further, the analyses they perform may be at low column temperatures (e.g., 100°C or less) and the column may be relatively insensitive to water vapor. Under these types of low-demand conditions an oxygen purifier, such as one of those that call for changing with each cylinder of gas, may be sufficient protection (Figure C). Our recommendation is a 120cc Supelpure™-O tube, an Oxisorb® tube, or an Oxiclear® cartridge; each device economically removes both oxygen and water vapor when the incoming gas contains less than 10-15 ppm of each impurity.

Conversely, some analysts make extreme purity demands on their systems, in order to ensure maximum detection/quantification capability. In these situations, carrier gas purification needs can be met with a hydrocarbon trap and a GateKeeper® purifier (Figure D). The electropolished stainless steel cartridge design, face-seal fittings or compression fittings, and highly efficient catalytic medium enable the GateKeeper purifier to deliver gas with low ppb levels of hydrocarbons, water, and oxygen for very demanding applications, for a long time, at high flow rates. Because of its cost, a GateKeeper purifier should be used only in these special cases, and when the incoming gas is of high purity or better.

Gas purification schemes for multiple GC systems are shown in Figures E and F. Scheme 1 in Figure F places more emphasis on water vapor removal than on oxygen removal. A 750cc Supelpure-O trap has less capacity for oxygen than a High Capacity Heated Purifier, but can be operated at higher maximum flow rates (10 liters/minute, versus 1.1 liter/minute) that typically are needed to operate multiple instruments. Scheme 2 emphasizes oxygen

Figure E. Purifier Scheme for a Multiple GC System: 2-5 Units, Total Flow of 1 Liter/Minute or Less

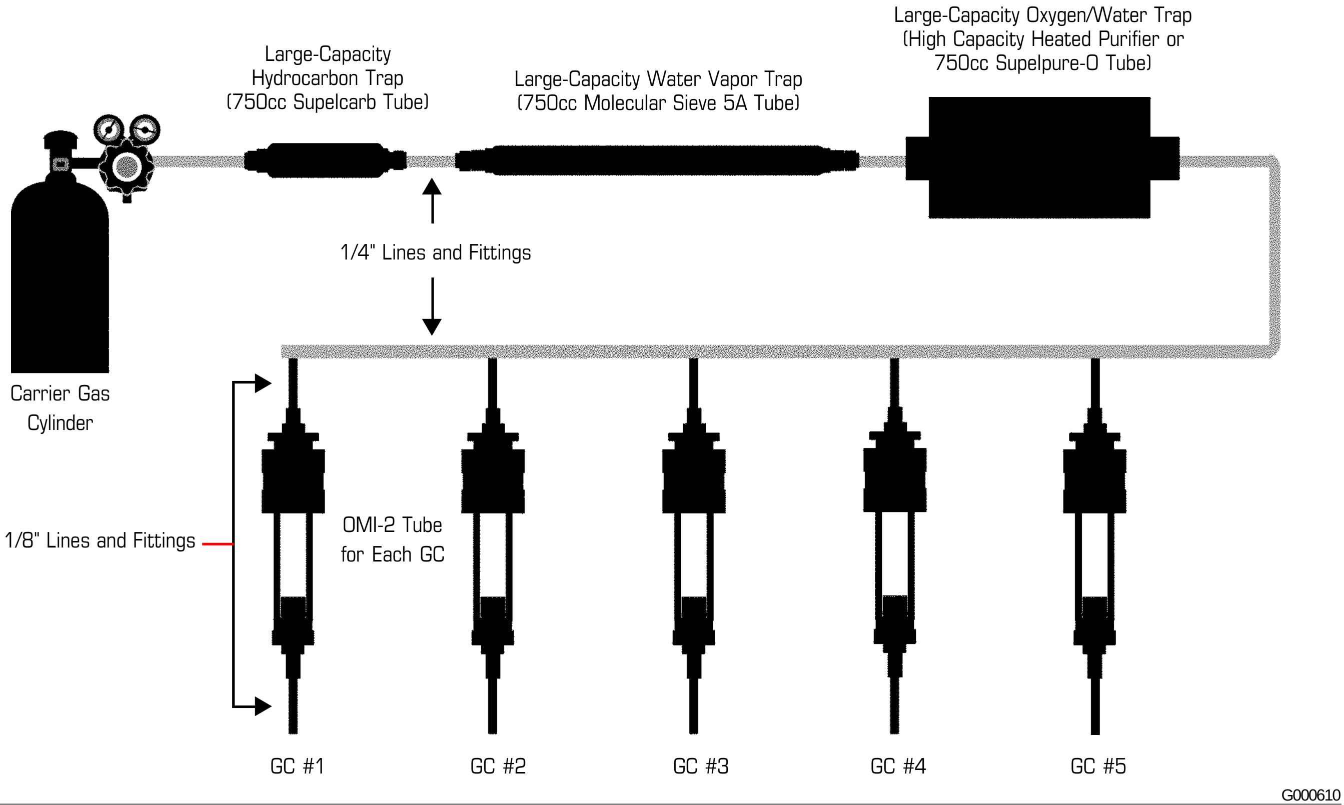


Figure F. Purifier Scheme for a Multiple GC System: Multiple Benches, 2-5 Units/Bench, Total Flow of More Than 1 Liter/Minute

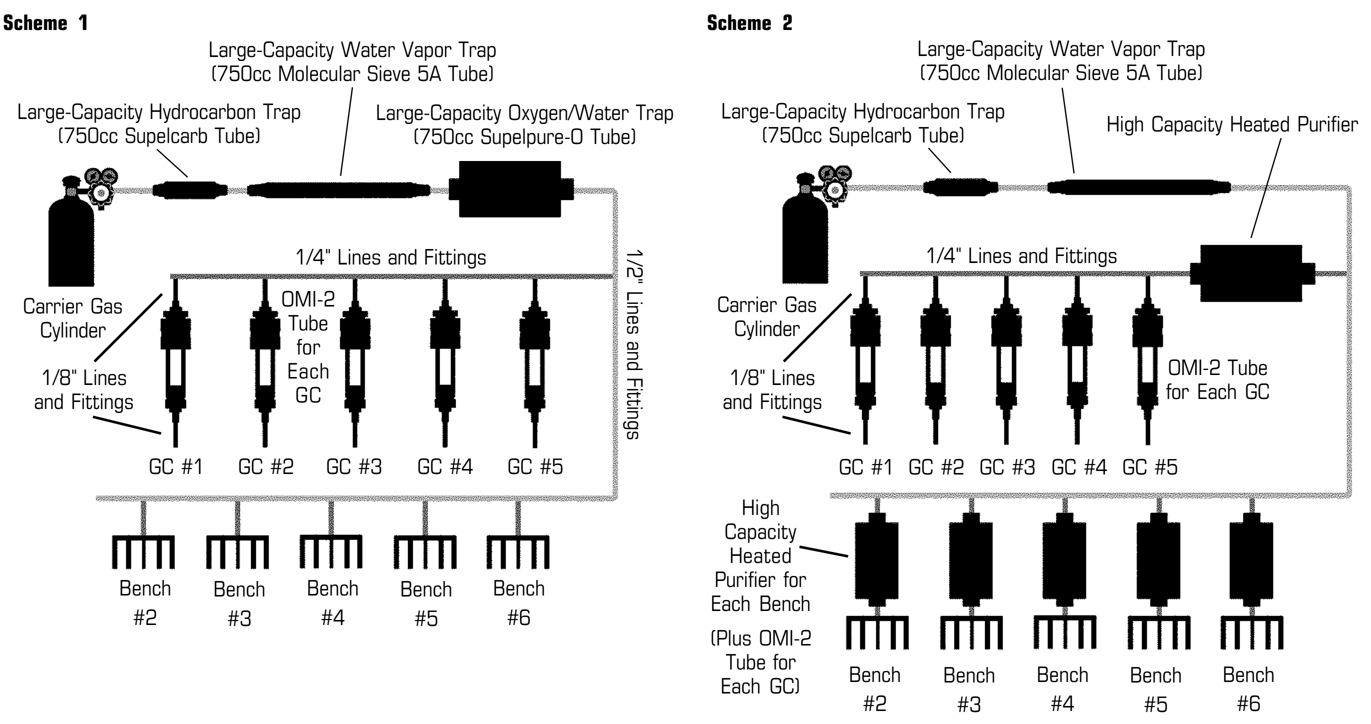
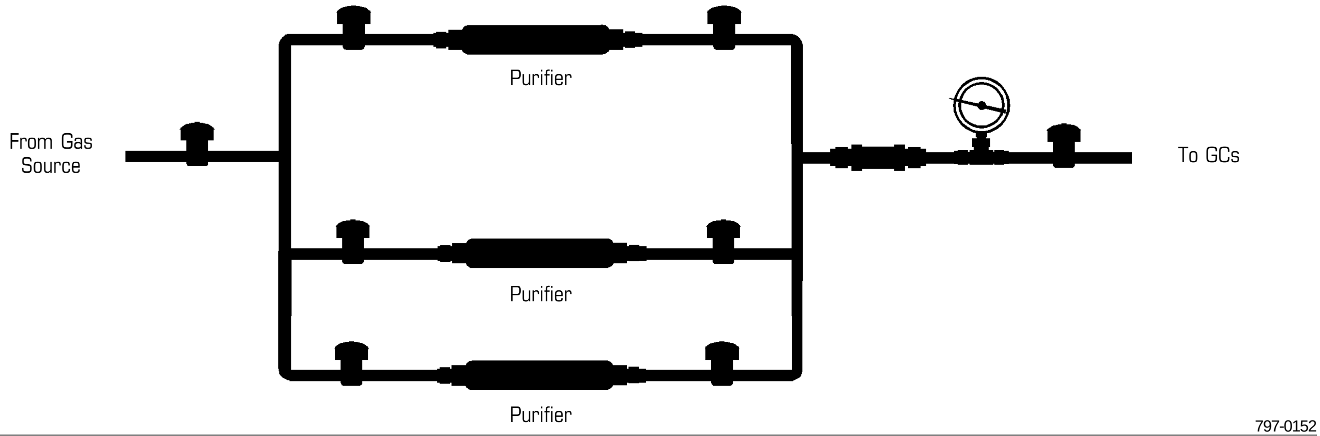


Figure G. Parallel Purifier Configuration for System Requiring High Gas Flows



removal by including a High Capacity Heated Purifier for each bench of chromatographs, yet accommodates the lower maximum flow allowed by the heated purifier.

The first step in deciding which purifiers to use is to determine, based on the number and types of chromatographs in your system, what the gas flow through the purifiers will be. Exceeding the flow rate that a purifier is designed for will reduce the contact time between the gas and the medium in the purifier, and the purifier may not reduce the contaminants in the gas to the advertised levels of purity. If the total flow in your system is 1 liter/minute or less, smaller purifiers (typically containing 100-120cc of adsorbent material) can be used. If the flow is between 1 liter/minute and 10 liters/minute, a large capacity purifier of each type (typically 750cc of adsorbent material) can be used. For flows greater than 10 liters/minute, we recommend using two or more large purifiers of each type in parallel (Figure G). In the larger flow systems, which typically serve 5 or more chromatographs, an ideal carrier gas purification scheme consists of a large purifier (or purifiers) for removing hydrocarbons, a large purifier (or purifiers) for removing most water, and a large capacity oxygen/water trap, plus a small capacity, high efficiency oxygen/water indicating trap in the line to each chromatograph. The indicating trap will remove the last traces of contaminants, including any contaminants introduced by leaks at connections, valves, or regulators. As large purifiers, we recommend a 750cc Supelcarb™ HC hydrocarbon trap, a 750cc molecular sieve 5A water vapor trap, and a 750cc Supelpure-O trap or our High Capacity Heated Purifier. OMI™-2 or OMI-4 indicating purifiers will remove the last traces of oxygen and water from the carrier gas, any oxygen or water entering the system at leaks downstream from the main purifier.

Air Purification

Air used as fuel for a flame-type detector does not require the same degree of purification as is required for carrier gas. Effective air purification consists of removing the hydrocarbons and reducing the water level to 50ppm or less. The approach to air purification differs, however, depending on whether the source of the air is cylinders, an air compressor, or an air generator.

Figure H shows the purification scheme for air from low-grade compressed air cylinders is relatively simple. An air compressor, however, may complicate the issue. Most air compressors have built-in water vapor traps, but the heat generated by the unit can cause significant amounts of water vapor to still be present in the air produced. A water vapor trap downstream from the hydrocarbon trap will reduce the water content in the air (Insert B, Figure H). Depending on whether the compressor is oil-sealed or oilless, the quantity of hydrocarbons will vary greatly. Even an oilless compressor can allow hydrocarbon levels that should cause concern. (The location of the air intake for the compressor is very important in determining hydrocarbon levels.) If you use an oil-sealed air compressor, we recommend installing three special filters between the compressor and the hydrocarbon and water vapor traps: a large particle (40µm) trap, followed by an oil-removing (coalescing) filter, followed by an oil vapor removing trap (Insert A, Figure H). We recommend placing the filters and traps some distance from the compressor, to allow the air to cool prior to filtration/purification.

As an alternative to air cylinders or compressors, a modern, low-maintenance zero air generator will provide air at a purity exceeding the quality demands of your chromatograph.

As with carrier gas, determine your total air flow requirement, and use purifiers of suitable capacity.

Hydrogen (Fuel) Purification

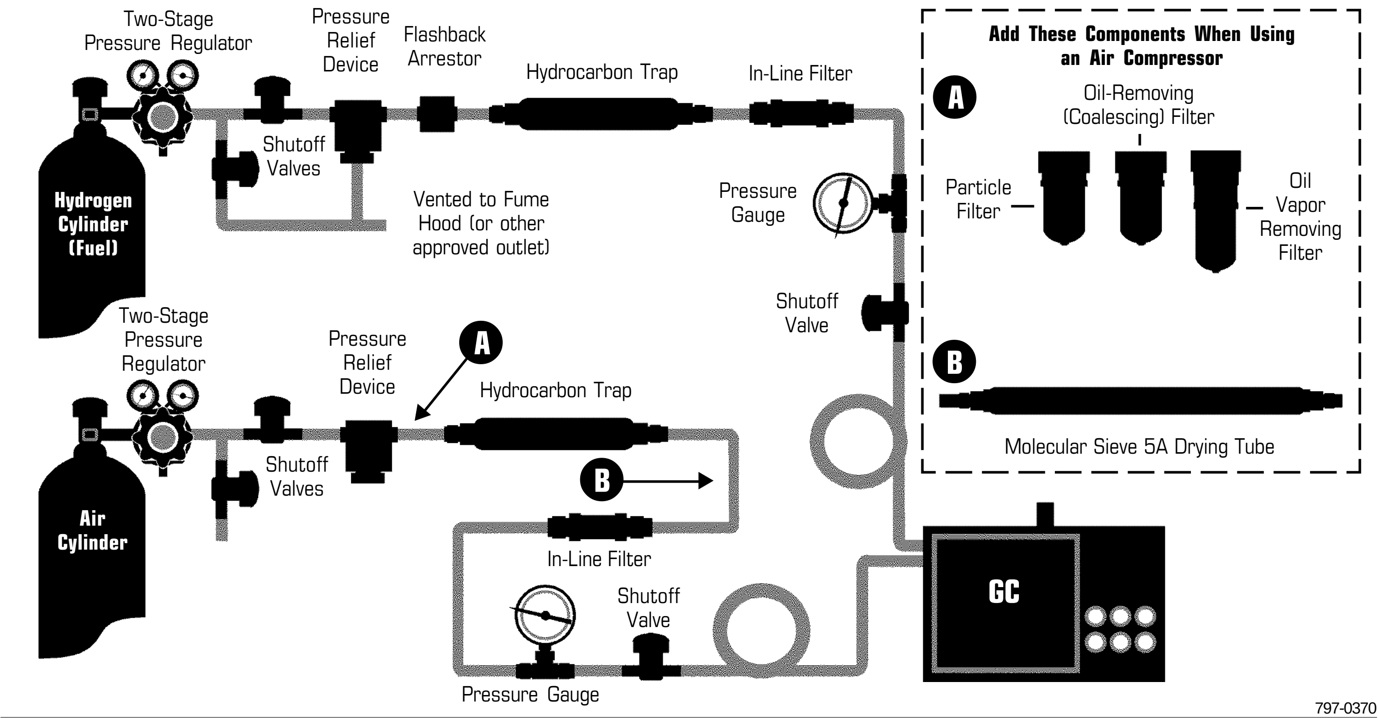
For hydrogen used as fuel for a flame-type detector, the same purification system is used as for air from cylinders. We do not recommend using plastic bodied purifiers to purify fuel hydrogen because they are permeable to oxygen and water in the atmosphere. Instead of reducing the oxygen and water content, these traps can allow the oxygen and/or water level to become too high.

Evaluating Carrier Gas Needs

A gas chromatograph normally is a two-column unit with two packed columns, one packed column and one capillary column, or two capillary columns. Knowing the flow needs of each of these units will enable you to calculate the number of cylinders of gas you will need each month.

Typical carrier gas requirements are shown in Table 1. To determine your gas consumption per month, determine how many chromatographs you have with each combination of columns, and estimate the gas flow to each chromatograph. You can use Table 1 to estimate the number of cylinders of carrier gas required by each chromatograph each month. Add these values to determine your cylinder per month needs. The lines in Table 1 separate 1 liter/minute flows from higher flows. If your gas requirement is on the high side of the line you should use large purifiers to ensure efficient removal of impurities and to minimize the frequency of changing purifying devices.

Figure H. Recommended Configuration for Purifying Fuel Gases from Cylinders



Purifier Selection Tables

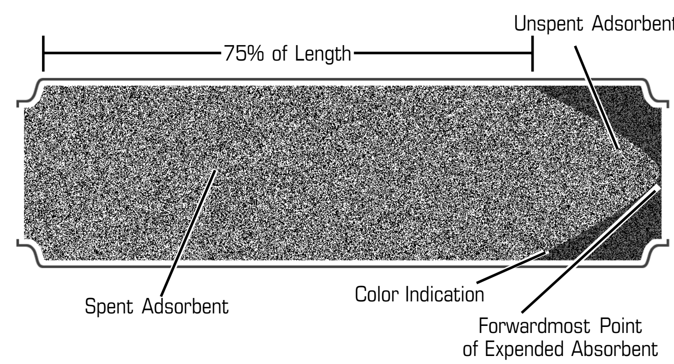
The values in Tables 2, 3, and 4 are reasonable expectations of purifier performances, based on several assumptions.

In developing the information in these tables, we began with stoichiometric reactions between the purifier media and the contaminant indicated, to determine the number of grams of contaminant theoretically absorbed by one gram of each medium. But, typically, contaminants start to break through a purifier after about 75% of the theoretical capacity is expended. This is because the contaminants react with the medium along the center of the purifier tube before they react with the medium along the periphery of the tube, creating a cone-shaped profile (Figure I). When the tip of the cone reaches the end of the tube breakthrough begins, although there is still a large amount of unreacted medium in the tube. In Tables 2, 3, and 4, we have adjusted the purifier lifetime values to 75% of the theoretical values, to allow for this phenomenon.

Purifier lifetimes, in numbers of cylinders, are based on 9" x 51", 218 cubic foot cylinders of helium carrier gas containing 50ppm of hydrocarbons (Table 2), water (Table 3), or oxygen (Table 4). Even inexpensive grades of carrier gas offer better initial purity than this, but we use this high value to account for other sources of contaminants, such as oxygen and water entering the gas system during the cylinder changing process. The fewer and smaller the sources of contaminants in your system, the greater is the likelihood that your purifiers will have longer lifetimes. Use of cylinders of other sizes or pressures also will affect these estimates.

Pick purifiers from Tables 2, 3, and 4 based on the flow and pressure needs of your system and the frequency with which you would prefer to change purifiers (e.g., once a month, once every 6 months, once a year). It is possible to choose purifiers that work for years under the flow and gas purity demands of your system. Typically these are forgotten about and never changed. For this reason, we recommend routinely changing purifiers semi-annually or annually, unless they need more frequent replacement.

Figure I. Breakthrough Begins at About 75% of Apparent Purifier Capacity



Notice that the indicating purifiers listed in Tables 2, 3, and 4 have very small capacity. These purifiers are intended for installation downstream from larger purifiers – their primary function is to give notice of when the larger purifiers must be changed. Indicating purifiers will require frequent changing if they are used as the only purifiers in the system.

Tables 2, 3, and 4 focus on the number of cylinders that a purifier will clean before the purifier is expended ("Stated Life in Cylinders"). These values are based on operation of one chromatograph fitted with two capillary columns, each column requiring a flow of 133cc/minute. Table 1 shows other typical cases: a GC with two packed columns, used at a range of flow rates, and a GC with one packed column and one capillary column. If you want to know how long a purifier will last with one of these systems, multiply the Stated Life in Cylinders value by 266 and divide by the estimated flow in the system you choose. You can use the flow values in Table 1 as estimates, or measure the flows in your system. In most cases the flow requirements of the two capillary columns will be the higher flow; therefore your estimated life in cylinders should be greater. Likewise, you can extrapolate from the table to situations in which a purifier is used to serve multiple GCs. Remember, however, not to exceed the maximum flow capacity of the purifiers you wish to use.

How to Establish a Purifier Replacement Schedule

Tables 2-4 show values for a specific situation – one gas chromatograph equipped with two capillary columns, each requiring 133mL/minute of helium from 218ft³ cylinders. We will explain how we arrived at the numbers in these tables, and will enable you to calculate corresponding values for other situations: other numbers of chromatographs, other carrier gases (hydrogen, nitrogen), other sizes of cylinders, or other levels of gas purity.

First, you must determine your carrier gas consumption per month (**G**).

Sum up all gas flows to all the columns in your system to get the total gas flow rate per minute (**Tg**):

Tg = (column flow + make-up gas* + split vent flow + septum purge flow) x number of columns

If you need help in determining gas flows, consult your instrument manuals or refer to Bulletin 898 (available free on request).

Using the number of minutes in a year:

60min/hr x 24hr/day x 365 days = 525.6 x 10^3 minutes/year

Determine one year's gas demand:

Tg x 525.6 x 10^3

If your system is not operated continuously, revise the number of minutes per year accordingly.

G = one year's gas demand / 12

From **G**, calculate the number of cylinders you need per month: cylinders/month = **G** (mL) / [amount of gas in a cylinder (ft^3) x 28,320mL/ft^3]

where 28,320mL/ft^3 is the factor for converting from ft^3 to mL

Impurities in a cylinder of gas usually are stated in parts per million, volumetric (ppm). Determine the amount of impurities from the concentration:

X ppm / 1,000,000 x 100% = **X**1% impurities

* If the make-up gas is the same as the carrier gas.

Next, convert the amount of impurities from volume to weight. You must know the density of the impurity. Knowing the volume of the cylinder, and using 28,320mL/ft^3 to convert from ft^3 to mL, calculate the volume of impurities in the cylinder:

X1% x ft^3 x 28,320mL/ft^3 / 100% = **Y** mL
(at standard pressure)

Then, knowing the impurity density (**D**), determine the amount of impurity in the cylinder by weight:

Y mL x D grams/mL = **Y1** grams

Tables 2, 3, and 4 in this bulletin indicate the amount of an impurity each purifier can remove. Therefore, you can determine how many cylinders of gas a particular purifier can purify at a given concentration of a given impurity. Gases usually have less impurity than stated, but you must be conservative in your calculations. Consider that oxygen, water vapor, and hydrocarbons also can enter the system from leaks, during the cylinder changing process (unless you have a purging system that displaces air from the tubing after the cylinder change), from defective valving, etc. To ensure a safe margin for error in your estimates, you should assume that concentrations of impurities in your system are higher than the levels stated by the gas manufacturer.

Once you determine how many cylinders a purifier can purify, from the cylinders per month of gas usage calculations, you can establish a schedule of changing cylinders and purifiers.

Example:

For a system consisting of 2 GCs, each fitted with 2 capillary columns, requiring a flow of 133mL/minute for each column:

2 GCs x 266mL/min x 525.6 x 10^3 min /
[12 months/year x 218ft³ x 28,320mL/ft³]
= 4 cylinders/month

Grade 4.5 (high purity) gas usually is 99.995% pure, or has 0.005% (**X** = 50ppm) of impurities

X1 = 50ppm x 100% / 1,000,000 = 0.005%

This means that if the 50ppm of impurities in the cylinder were oxygen alone, there is:

Y = 0.005% x 218ft³ x 28,320mL/ft³ / 100%
= 308.7mL oxygen in the cylinder (at standard pressure)

or

Y1 = 1.33g/L x 10^{-3}L/mL x 308.7mL = 0.411g oxygen

where 1.33g/L is the density of oxygen (gas) at 760mm Hg and 20°C.

Table 1. Carrier Gas Flow versus Gas Consumption

No. GCs	2 Packed Columns Flow (cc/min) low	→ high	2 Packed Columns Cylinders/Month** low	→ high	1 Packed / 1 Capillary Column Flow (cc/min) low	→ high	1 Packed / 1 Capillary Column Cylinders/Month** low	→ high	2 Capillary Columns Flow (cc/min)	2 Capillary Columns Cylinders/Month**
1	40	120	0.3	0.9	153	193	1.1	1.4	266	1.9
2	80	240	0.6	1.7	306	386	2.2	2.7	532	3.8
3	120	360	0.8	2.6	459	579	3.2	4.1	**798**	5.6
4	160	480	1.1	3.4	612	772	4.3	5.4	1064	7.5
5	200	600	1.4	4.3	765	**965**	5.4	6.8	1330	9.4
6	240	720	1.7	5.1	**918**	1158	6.5	8.2	1596	11.3
7	280	840	2.0	6.0	1071	1351	7.6	9.5	1862	13.2
8	320	**960**	2.2	6.8	1224	1544	8.6	10.9	2128	15.0
9	360	1080	2.5	7.7	1377	1737	9.7	12.2	2394	16.9
10	400	1200	2.8	8.5	1530	1930	10.8	13.6	2660	18.8

All values are based on 24 hour/day, 7 day/week operation. If you operate at high flow rates, but use a carrier gas saving mode at night and over weekends, consumption will be nearer the low consumption values.
Flows to capillary columns assume a split vent flow of 50-100mL/minute for each column.
** Values are based on 218 cubic foot cylinders, used at standard temperature and pressure. Values will differ for other cylinder sizes or pressures. For the number of cylinders/month for your system, determine the number of standard cubic feet in a cylinder of your carrier gas, divide by 218, then multiply the cylinders/month listed in Table 1 by this value.

Table 2. Carrier Gas Purifiers for Hydrocarbon Removal[1]

Name of Purifer	Carrier Gases Purifed	Contaminants Removed	Product Description[2]	Maximum Flow and Inlet Pressure (cc/min)	(psig)	Capacity (grams HC x 75%)[3]	Stated Life (cylinders)
Supelcarb HC	He, H_2, N_2, Ar/CH_4, air	C3 and higher hydrocarbons	120cc tube 1/8" **24448** 1/4" **24449**	2000	250	18	16.5
			750cc tube 1/4" **24564** 1/2" **24565**	10,000	250	120	110
Supelpure HC	He, H_2, N_2, Ar/CH_4, air	C4 and higher hydrocarbons	120cc tube 1/8" **22445-U** 1/4" **22446**	2000	250	9	8.0
			750cc tube 1/4" **24518** 1/2" **24519**	10,000	250	60	55.0
UOP Inert Gas Purifier	He	O_2, H_2O, CO_2, CO halocarbons, hydrocarbons, sulfurs	364cc tube 1/8" **22680-U** 1/4" **22681**	500	250	7.5	6.9

[1] Based on 9" x 51" cylinders (218 cubic feet) of carrier gas containing 50ppm of contaminants supplying 1 chromatograph with 2 capillary columns. Ask your supplier for specifications for the cylinders you use. To correct for other volumes of gas per cylinder, multiply values for *Stated Life (cylinders)* by the number of cubic feet in your cylinders divided by 218.
[2] Quantity of adsorbent material - dimensions of fittings - **catalog number**.
[3] Expressed as medium weight (C8-C20) hydrocarbons.

Table 3. Carrier Gas Purifiers for Water Removal[1]

Name of Purifer	Carrier Gases Purifed	Contaminants Removed	Product Description[2]	Maximum Flow and Inlet Pressure (cc/min)	(psig)	Capacity (grams H_2O x 75%)	Stated Life (cylinders)
Molecular Sieve 5A Trap	He, H_2, N_2, many others	H_2O	200cc tube 1/8" **20619** 1/4" **20618**	2000	250	15.6	68
			750cc tube 1/4" **23991** 1/2" **23992**	10,000	250	58.5*	253
High Capacity Heated Purifier	He, N_2, Ar/CH_4 *not compatible with* air, O_2, H_2	O_2, H_2O, CO_2, CO	32cc tube[3] 1/8" **22396** 1/4" **22398**	1100	150	16.9	73
OMI	He, H_2, N_2, Ar/CH_4 *not compatible with* air or O_2	O_2, H_2O, CO_2, CO, NH_3, alkynes, halocarbons, halogens, hydrogen halides	OMI-2, 15cc tube[4] 1/8" **23906**	1000	150	0.2	0.8
			OMI-4, 90cc tube[4] 1/8" **23909**	1000	150	1.3	5.8
GateKeeper	He, H_2, Ni_2, Ar *not compatible with* air or O_2	O_2, H_2O, H_2, CO_2, CO, (removes H_2 as a contaminant, also can purify H_2 carrier gas)	35cc cartridge **24970**	1000	200	0.1	0.5
			500cc cartridge **24971**	60,000	200	1.4	6.0
Supelpure-O	He, H_2, N_2, Ar/CH_4 *not compatible with* air or O_2	O_2, H_2O, CO_2, CO, NH_3, alcohols, alkanes, alkenes, amines, aromatics, diethylether, halogens, sulfurs	120cc tube 1/8" **22449** 1/4" **22450-U**	250	100	1.5	6.5
			750cc tube 1/4" **503088** 1/2" **503096**	10,000	250	10.2*	44.3
UOP Inert Gas Purifier	He	O_2, H_2O, CO_2, CO, halocarbons, hydrocarbons, sulfurs	364cc tube 1/8" **22680-U** 1/4" **22681**	500	250	26.3	114

[1] Based on 9" x 51" cylinders (218 cubic feet) of carrier gas containing 50ppm of contaminants supplying 1 chromatograph with 2 capillary columns. Ask your supplier for specifications for the cylinders you use. To correct for other volumes of gas per cylinder, multiply values for *Stated Life (cylinders)* by the number of cubic feet in your cylinders divided by 218.
[2] Quantity of adsorbent material - dimensions of fittings - **catalog number**.
[3] Heat required (tube must be installed in a specially designed heater).
[4] Holder required.
* At a flow rate of 1000cc/min.

Table 4. Carrier Gas Purifiers for Oxygen Removal[1]

Name of Purifer	Carrier Gases Purifed	Contaminants Removed	Product Description[2]	Maximum Flow and Inlet Pressure (cc/min)	(psig)	Capacity (grams O_2 x 75%)	Stated Life (cylinders)
OMI	He, H_2, N_2, Ar/CH_4 *not compatible with* air or O_2	O_2, H_2O, CO_2, CO, NH_3, alkynes, halocarbons, halogens, hydrogen halides	OMI-2, 15cc tube[3] 1/8" **23906**	1000	150	0.16	0.4
			OMI-4, 90cc tube[3] 1/8" **23909**	1000	150	1.19	2.9
High Capacity Heated Purifier	He, N_2, Ar/CH_4 *not compatible with* air, O_2, H_2	O_2, H_2O, CO_2, CO	32cc tube[4] 1/8" **22396** 1/4" **22398**	1100	150	15.0	36.5
Supelpure-O	He, H_2, N_2, Ar/CH_4 *not compatible with* air or O_2	O_2, H_2O, CO_2, CO, NH_3, alcohols, alkanes, alkenes, amines, aromatics, diethylether, halogens, sulfurs	120cc tube 1/8" **22449** 1/4" **22450-U**	250	100	0.45	1.1
			750cc tube 1/4" **503088** 1/2" **503096**	10,000	250	2.4*	5.8
GateKeeper	He, H_2, N_2, Ar *not compatible with* air or O_2	O_2, H_2O, H_2, CO_2, CO (removes H_2 as a contaminant, also can purify H_2 carrier gas)	35cc cartridge **24970**	1000	200	0.77	1.9
			500cc cartridge **24971**	60,000	200	9.56	23.3
Oxisorb	He, H_2, N_2, Ar/CH_4	O_2, H_2O, CO_2, CO	52cc cartridge[3] **20631**	5000	90	NA[5]	1.0[5]
Oxiclear	He, H_2, N_2, Ar/CH_4	O_2, H_2O, CO_2, CO	180cc cartridge 1/8" **22992** 1/4" **22993**	3000	250	NA[5]	3.5[5]
UOP Inert Gas Purifier	He	O_2, H_2O, CO_2, CO, halocarbons, hydrocarbons, sulfurs	364cc tube 1/8" **22680-U** 1/4" **22681**	500	250	2.14	5.2

[1] Based on 9" x 51" cylinders (218 cubic feet) of carrier gas containing 50ppm of contaminants supplying 1 chromatograph with 2 capillary columns. Ask your supplier for specifications for the cylinders you use. To correct for other volumes of gas per cylinder, multiply values for *Stated Life (cylinders)* by the number of cubic feet in your cylinders divided by 218.
[2] Quantity of adsorbent material - dimensions of fittings - **catalog number**.
[3] Holder required.
[4] Heat required (tube must be installed in a specially designed heater).
[5] Data for determining oxygen capacity was not available from the manufacturer. Stated life in cylinders is the manufacturer's recommendation.
* At a flow rate of 1000cc/min.

From Table 4 we can see that at 50ppm oxygen in the system, a High Capacity Heated Purifier would purify approximately 36 cylinders containing 218ft^3 of gas. Therefore, if you are using 4 cylinders per month, you must change the purifier tube every 9 months.

Trademarks
GateKeeper – Aeronex, Inc.
OMI, Supelcarb – Sigma-Aldrich Co.
Oxiclear, Oxisorb – MG Industries

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