How to Convert from Helium to Hydrogen as a Carrier Gas in Gas Chromatography

The Benefits of using Hydrogen from an In-House Gas Generator

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climate control
electromechanical
filtration
fluid & gas handling
hydraulics
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process control
sealing & shielding

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Table of Contents

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This How to Guide will take you though the steps necessary to convert from Helium to Hydrogen as a carrier gas for Gas Chromatography. The use of Hydrogen from an in-house generator will lead to considerable benefits in cost, safety and convenience in the laboratory. For a detailed explanation of benefits, costs savings, time savings and many other factors affecting the benefits of converting to Hydrogen please see page 8. The order of the steps is important to the successful conversion to Hydrogen. Please follow these steps carefully and you will benefit from a quick and easy conversion to Hydrogen as a carrier gas.

Step 1 Review and document all existing run conditions

1. Leak check the system; leaks may affect the determination of the actual flows you are using for your analysis.
2. Measure and record the existing dead volume time and calculate the Linear Gas Rate (LGR).
3. Measure and record the Septum flow at the initial run temperature.
4. Measure and record the Make-up Gas rate.
5. Measure and record Vent flow at initial run temperature.
6. Measure and record the Fuel gas (Hydrogen) flow rate.
7. Measure and record the Air gas flow rate.
8. Document any flow changes that take place during the run.
9. Document any temperature program rates used.
10. Obtain a good sample chromatogram for comparison with the chromatogram obtained after conversion.

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Step 2

Perform all routine maintenance before switching to Hydrogen

1. Change purifiers - Add purifiers to lines as needed to obtain at least 99.9999% pure gas.
2. Change septa - Use a good low bleed septum.
3. Change Injection Port Liners/Inserts and Seals - Clean as needed and avoid contamination with oils. Clean parts with acetone before installation.

⚠ **Caution: Acetone is flammable and can cause health issues. Avoid open flames in the laboratory.**

4. Clean Detector/Detector inserts/Jets.

Step 3

Installation of new lines and purifiers

1. Carrier gas lines – Depressurize and vent the Hydrogen line. Then cut the fuel gas line (Hydrogen) and add a tee. Extend a line into the Carrier Gas in-port behind the GC from the other side of the tee. (See Figure 1).
2. Add purifiers to this line if gas purity does not meet at least 99.9999% purity. Use hydrocarbon, oxygen and moisture removing purifiers or a combination purifier to obtain the needed gas purity.

   Hint: Add purifiers that have indicators to show the percentage of usage of the purifier so that you know when to change the purifiers.
3. Add new make-up gas line preferably for use with Nitrogen. (See Figure 2)

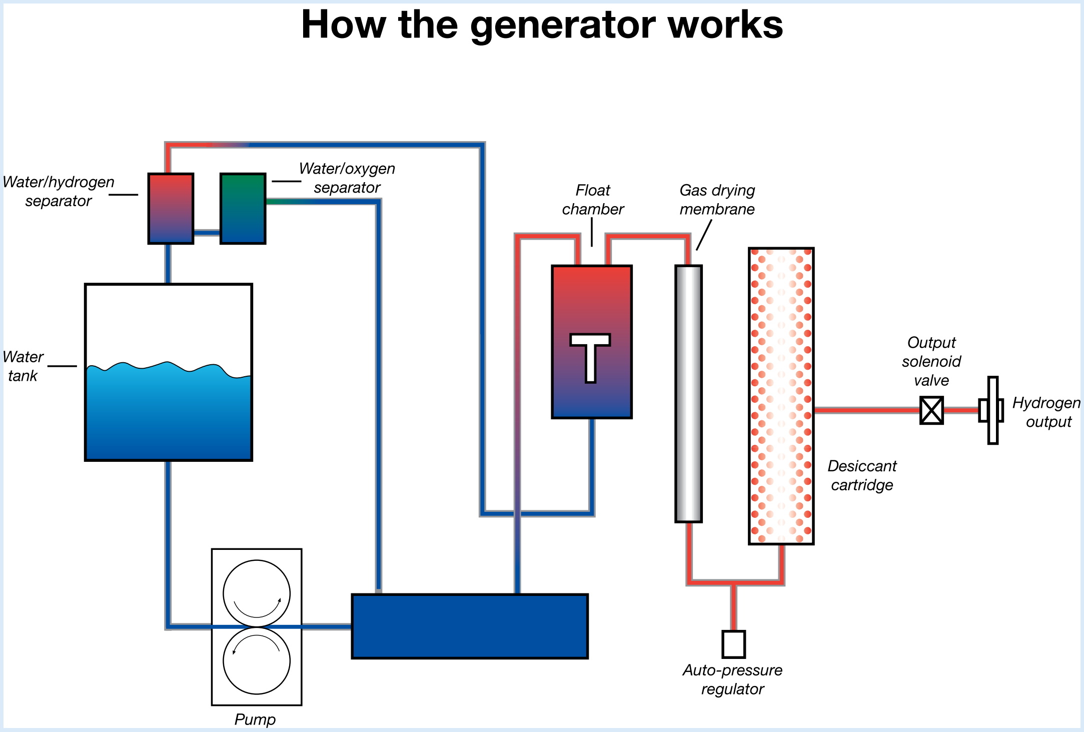

Figure 1: Hydrogen Technology

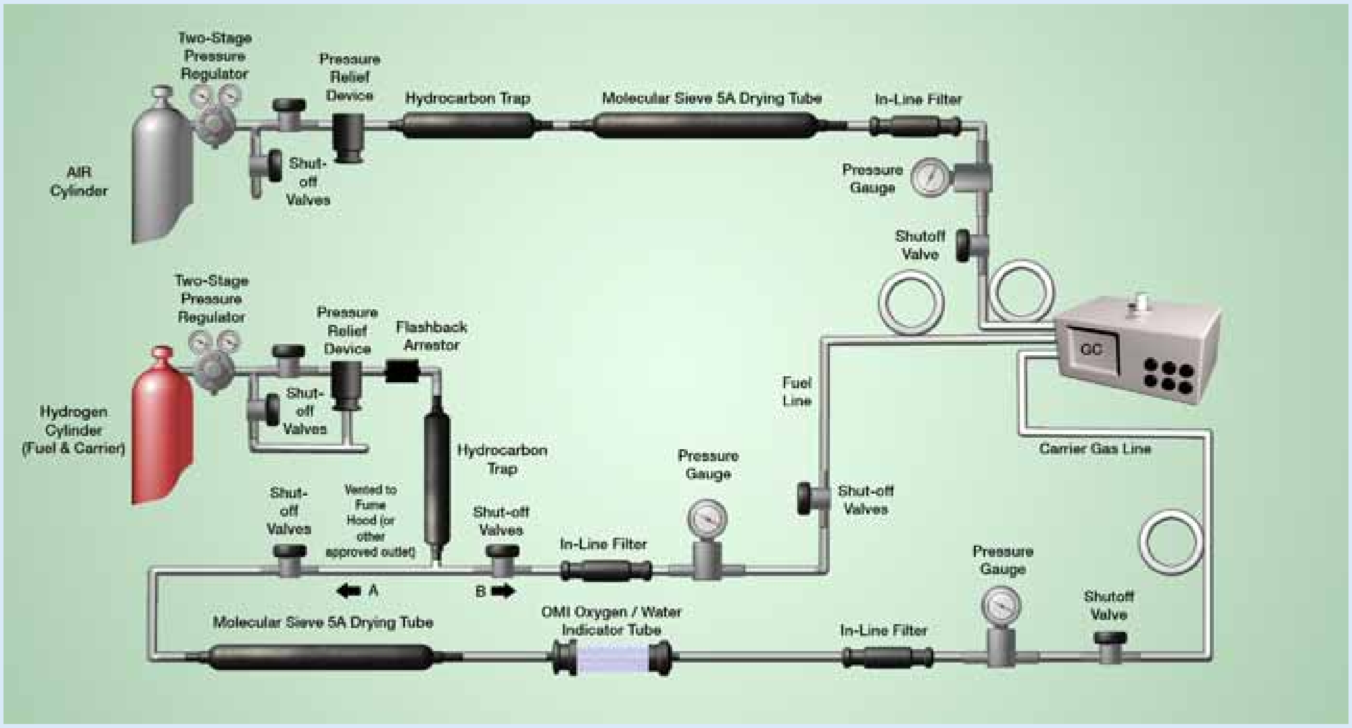

Figure 2: Ideal Configurations for a Single-GC System: Hydrogen Used as Carrier and Fuel Gas

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Step 4 Establish Flows for Hydrogen and Nitrogen (Make-up Gas)

Carrier Gas

1. Turn gas on and establish column flow with the oven off. With some computer controlled systems, it may be necessary to change the carrier gas input to indicate you are using Hydrogen so that the system makes the correct flow adjustments based on the density of Hydrogen.
2. Turn Oven, Injection port, and Detector on after one hour of flow. (It is important to purge all lines and purifiers before establishing temperatures in the various zones of the GC. It takes a considerable amount of time to purge lines and purifiers.

   Hint: If time permits, it would be best to purge the system overnight.
3. Establish Split Vent flow and measure Septum Vent flow.
4. Bring the column/oven up to run temperature and again measure the column flow.

Detector Flows

1. Establish the correct flow of Hydrogen to the detector (this includes the sum of all sources of hydrogen going into the detector).
2. Establish the correct Make-up gas flow.
3. Establish the correct Air flow.

System Adjustments

1. Ignite the detector and turn on any needed detector electronics. Give the system one hour to stabilize.

   Hint: A longer warm up period (e.g. overnight) may lead to a more stable response.
2. Recheck the system to make sure that all run conditions and temperatures are correct.
3. Inject and measure the dead volume time using methane and calculate the Linear Gas Rate (LGR). Make corrections to the LGR as needed.

$\text{Flow} = \pi r^2 L / t_m$

Where $\pi = 3.1416$

r = radius of the column in cm (convert from mm)

L = Length of the column in cm (convert from meters)

T_R = Retention time of a non retained peak typically methane

Where $LGR = L / t_m = L / \mu$

Simplified

$\text{Flow} = \pi r^2 \mu$ (Remember to use units in cm.)

First Run

- Inject sample and compare run to previous Helium run.
- Consider if you want to speed run up by doubling LGR or if your goal is just to duplicate the Helium analysis times and separation.

Calibration

- Re-establish peak identification – there should be no changes unless you are using very polar columns.
- If the run is as you desire, proceed to run your Calibration Standards.

Step 5 Changing from Cylinders to Gas Generators

1. Install gas generators on bench following instructions provided in the installation manuals.
2. Reduce tubing line lengths as much as possible. (See Figure 3).
3. Use high quality GC grade stainless steel tubing or clean new lines with solvents and bake dry under nitrogen flow.
4. Add gas purifiers as needed. Different makes and models of gas generators provide different purities of hydrogen. You will need to add purifiers if the delivered gas is not at least 99.9999% pure.
5. Consider adding Nitrogen generators and high quality air generators to eliminate cylinders and the use of high-pressure gases in the laboratory. A schematic diagram for a typical system using an inhouse generator is shown in Figure 4.

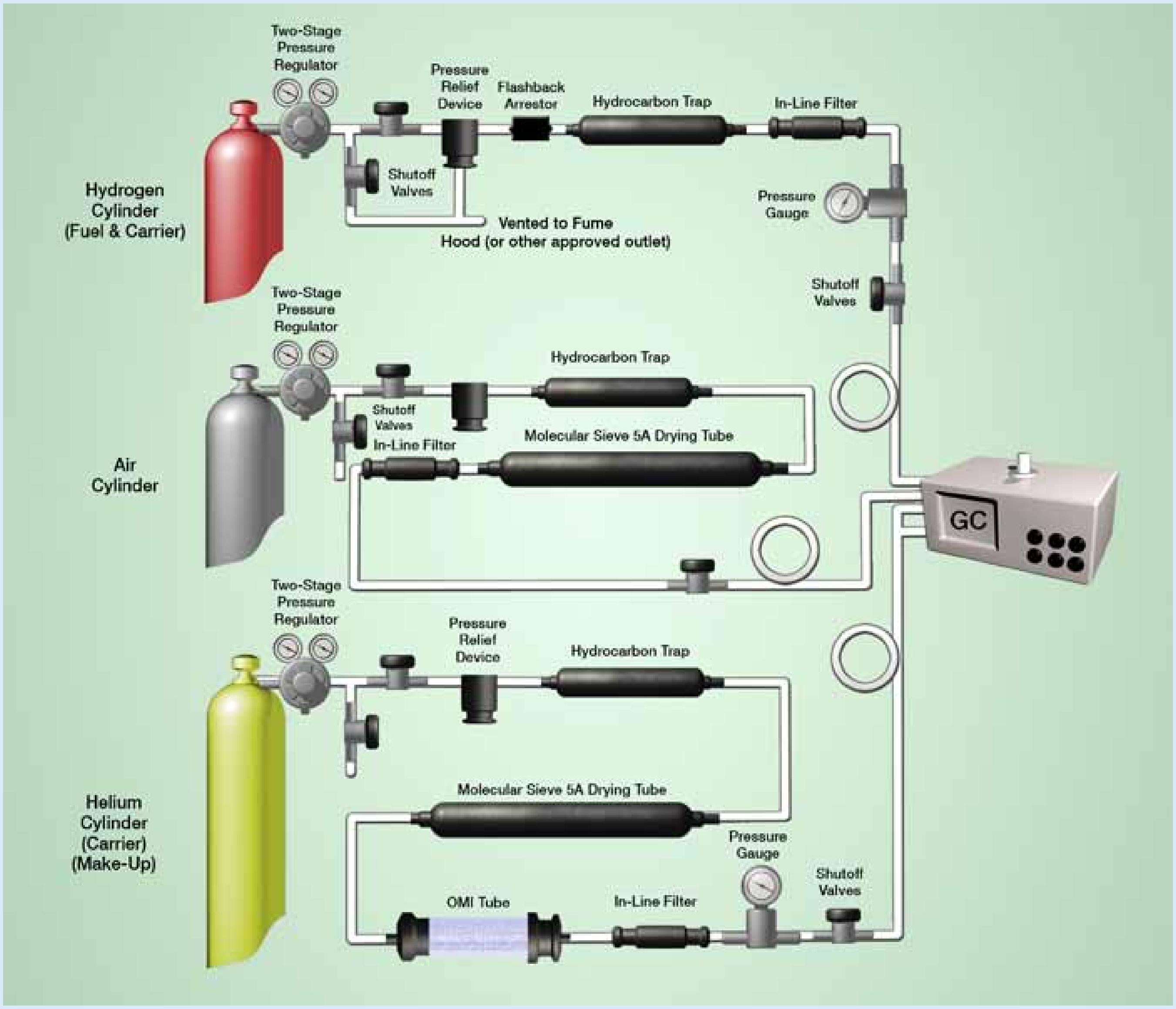
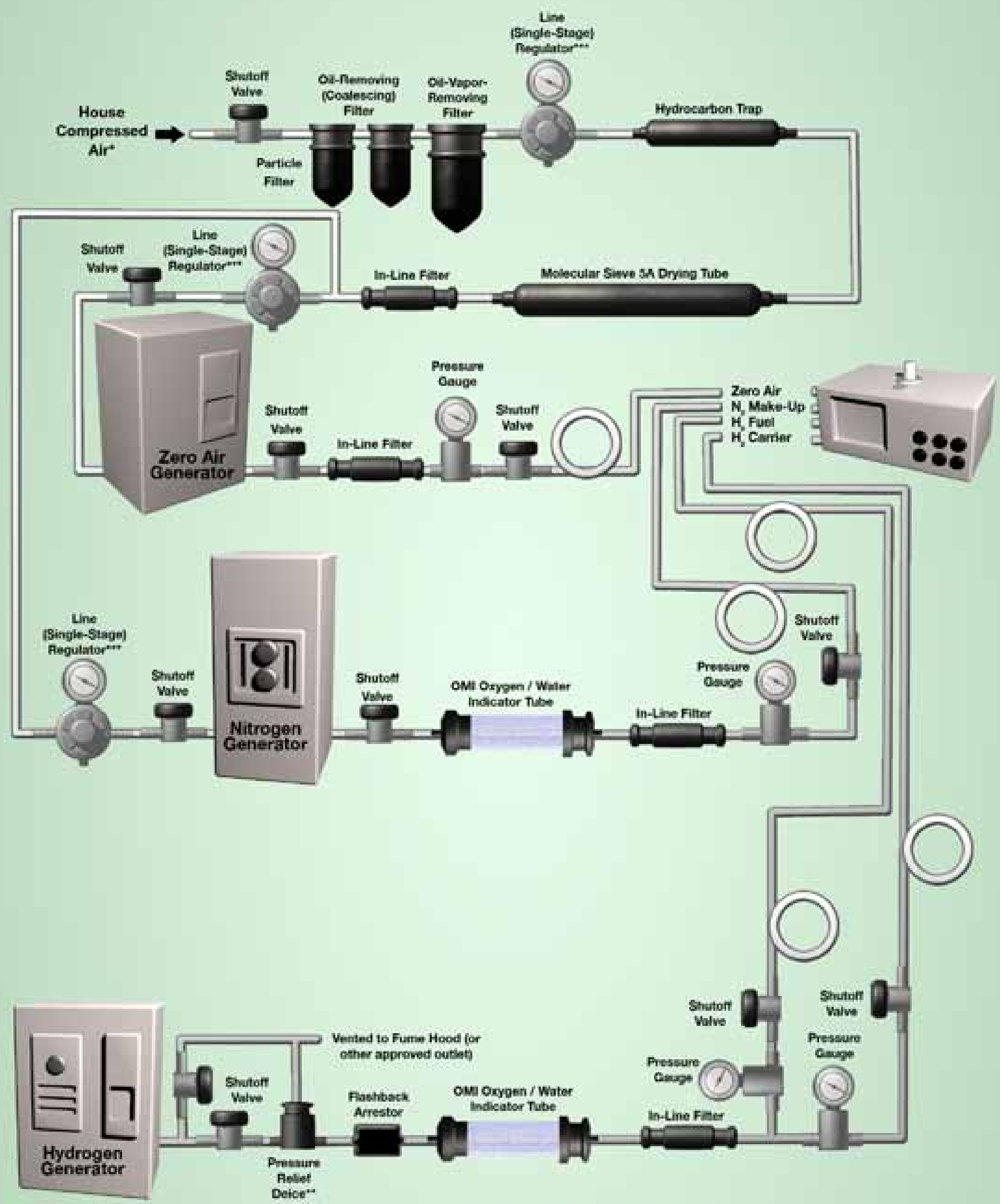


Figure 3: Standard Configuration for a Single GC System: Gas Delivered from Cylinders

All Gas Generator System Flow Schematic



* Replace an oil-sealed compressor with an oilless unit to eliminate the need for the particle filter, oil-removing / coalescing filter, and oil vapor-removing filter.
**Not needed if the hydrogen generator has a buil-in relief device.
***Consult generator manual for correct injet pressure.

Figure 4: Ideal Configurations for a Single-GC System: All Generator System

Figures 5 to 7 demonstrate the equivalence of Helium and Hydrogen in typical separations.

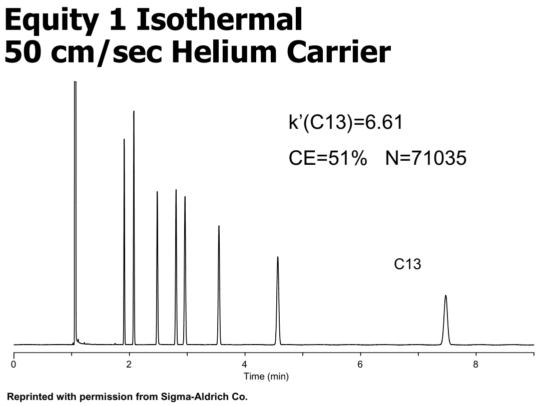


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Figure 5: Equity 1 Isothermal 50cm/sec Helium Carrier

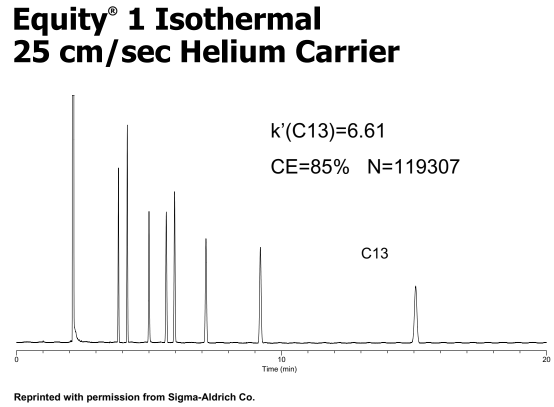

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Figure 6: Equity 1 Isothermal 25cm/sec Helium Carrier

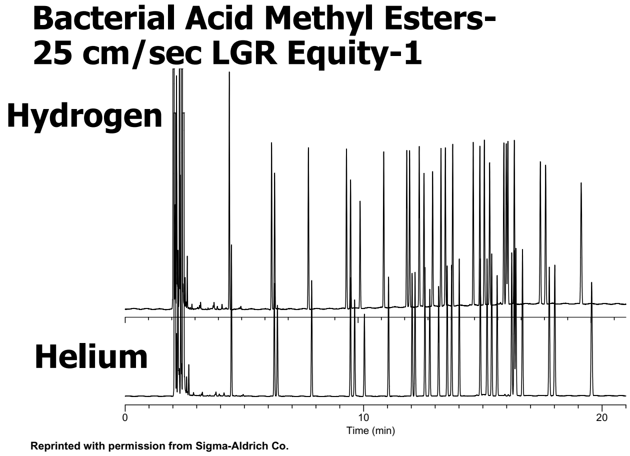

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Figure 7: Bacterial Acid Methyl Esters - 25cm/sec LGR Equity-1

Benefits of in-house gas generators

In-house gas generators provide a number of significant benefits to the laboratory, including a dramatic improvement in safety, an increase in convenience, and a lower cost.

Minimizing safety hazards

An in-house generator is considerably safer than tank gas; only a small amount of the generated gas is present at low pressure at a given time and the gas is ported directly to the instrument. If a leak occurred, only a small quantity of gas is dissipated into the laboratory. In contrast, serious hazards exist if gas is supplied using a high-pressure gas tank. If a full tank of hydrogen were suddenly vented into the laboratory, up to 9000 L of gas would be released, displacing laboratory air and reducing the breathable oxygen content. An in-house gas generator also eliminates the possibility of injury or damage from the transportation and installation of a gas tank. A gas tank is heavy and can be a hazard to staff and facilities if the valve is compromised during transport (in many facilities, specially trained technicians replace gas tanks). A leaking hydrogen tank could lead to an explosion.

Maximizing convenience

An in-house gas generator can supply gas on a 24 hr/7 day/week basis with no user interaction (other than routine annual maintenance). In contrast, when tank gas is employed, the user must monitor the level of gas in the tank and ensure that there is sufficient gas for the desired analyses. The in-house system obviates the need to obtain replacement tanks; when it is necessary to get a replacement gas tank, the chromatographer may need to get an individual who is qualified to handle the tanks. Tanks are typically stored outside in a remote area for safety reasons and replacing tanks can be a significant inconvenience, especially in inclement weather. In addition, a pressurized tank could be a significant hazard if the laboratory is located in a seismic zone.
A major benefit of in-house gas generators is that once they are installed, you don't have to worry about the gas supply. Maintenance requirements are minimal, simply replace the filters and perform routine maintenance and monitor the water in the hydrogen generators.

Minimizing the cost

An important advantage of an in-house generator is the dramatic economic benefit compared to the use of gas tanks. The running cost of an in-house generator is extremely low; since the gas is obtained from water and maintenance is a few hundred dollars a year for periodic filter replacement.

In contrast, when a gas tank is used, the actual cost is significantly greater than the cost of the tank. In addition, the time required transporting the tank, installing it, returning the used tank to storage, and wait for the system to re-equilibrate must be considered. While the calculation of the precise cost of the use of gas from tanks for a given user is dependent on a broad range of local parameters and the amount of gas that is used, significant potential savings can be obtained by the in-house generation of gas. A comparison of the cost of supplying gas via tanks versus the cost for use of an in-house gas generator is presented in Table 1. In this analysis, a tank of gas costing $60 is consumed/week and four are in-house (i.e., tanks are replaced monthly). In comparison, the maintenance cost of the in-house generator is for replacement of filters at perhaps $1000/year or approximately $20 per week.

Table 1 Annual costs: In-house generation vs. high-pressure tanks (in U.S. $)

	In-house Generator	Tanks
Maintenance	$800	$0
Cylinders	$0	$3120
Demurrage	$0	$336
Labor (changing cylinders)	$0	$1040
Order processing	$30	$360
Shipping	$50	$3720
Invoice processing	$10	$120
Inventory control	$0	$72
Total	**$890**	**$8768**

Specifications and Ordering Information

Hydrogen Generators for Fuel and Carrier Gas Specifications

Hydrogen Generators	Models	Specifications
Hydrogen Purity		99.99999+%
Oxygen Content		<.01 ppm
Moisture Content		<1.0 ppm
Max Hydrogen Flow Rate	H2PD-150 H2PD-300 H2-500 H2-800 H2-1200	150 cc/min 300 cc/min 500 cc/min (1) 800 cc/min 1200 cc/min
Electrical Requirements	H2PD-150, H2PD-300 H2-500, H2-800, H2-1200	120 VAC/60 Hz, 3.15 Amps (2) 100-130 VAC/60 Hz (5.3 Amp@120VAC)
Hydrogen Outlet Pressure		Adjustable, 0 to 60 psig or 0 to 100 psig
Certifications		IEC 1010-1; CSA; UL 3101; CE Mark
Dimensions	H2PD-150, H2PD-300 H2-800, H2-1200 H2-500	12”w x 12”d x 22”h (30cm x 33cm x 58cm) 13"w x 17"d x 15.5"h 15"w x 18"d x 13"h
Outlet Port H2-500/800/1200NA	H2PD-150, H2PD-300 1/4" Compression	1/8” Compression
Shipping Weight	H2PD-150, H2PD-300 H2-500, H2-800, H2-1200	58 lbs (26 kg) 45 lbs (20.4 kg)

1 Does not include automatic waterfeed feature and has maximum pressure output of 90 psig. Outlet port is 1/8" compression.

2 Contact factory for electrical requirements outside North America.

Ordering Information

Description	Model Number
Hydrogen Gas Generator UHP Hydrogen Gas Generator	H2PD-150, H2PD-300 H2-500NA, H2-800NA, H2-1200NA
Electrolyte Solution	920071
Deionizer Bags (2 each, replace every 6 months)	7601132 (for H2-500NA, H2-800NA, H2-1200NA)
Pressure Regulator	W-425-4032-000
Installation Kit	IK7532
Preventive Maintenance plan	H2PD-150-PM, H2PD-300-PM H2-500-PM, H2-800-PM
Extended Support with 24 Month Warranty	H2PD-150-DN2, H2PD-300-DN2 H2-500-DN2, H2-800-DN2, H2-1200-DN2

Note: To ensure consistent product performance and reliability, use only genuine Balston replacement parts and filter cartridges.

Explanation of Warning Symbols

Symbol	Description
	Caution, refer to accompanying documents for explanation.

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