Preparing the Laboratory for a Gas Chromatograph

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This month in “GC Connections,” John Hinshaw examines basic laboratory heating, ventilation, cooling, electrical and space requirements for the successful installation of a gas chromatograph.

Modern gas chromatographs, and in particular capillary gas chromatographs, are highly sensitive instruments that require the proper environmental conditions to deliver the best results. Without the right heating, ventilation and air conditioning (HVAC); electrical supply; and benchtop layout, a gas chromatograph can exhibit excessive noise or instability, fail to meet performance requirements and even cause a hazardous condition. Most instruments include standard or optional computer control and network connections; additional requirements must also be met for the local-area network and the computer infrastructure to support a new instrument. Of course, gas chromatograph operators also need appropriate training on the chromatography system and in the applications to be performed.

Establishing the Right Environment

Gas chromatography (GC) instrument manufacturers provide site preparation and installation manuals for their gas chromatographs. These manuals are also available by request from the manufacturers, some of whom make them available on their websites for downloading. Purchasers of chromatographs should obtain the necessary information and complete any required site preparation work before installation. Instrument manufacturers should also be consulted when an older instrument is moved to a new location, to obtain any recent changes or updates that might affect installation requirements and procedures. In these instances, it is very important to note that certain instruments — those that include radioactive devices or have been used for hazardous chemical or biological service — should not be moved on public highways or transported by public carriers without special clearance and permits. GC users in these situations should consult the appropriate government regulations for guidance. Many common freight carriers can provide useful assistance as well.

HVAC: The temperature and humidity of the air surrounding a gas chromatograph must remain within certain limits for the instrument to deliver its rated performance. Most gas chromatograph manufacturers specify minimum and maximum temperature and humidity ranges as well as a narrower recommended range for the best operation. Table 1 lists typical temperature and humidity ranges for some commercial instruments. The narrower ranges should be adhered to if the absolute best performance is an important consideration.

Temperature: In general, try to keep the temperature near the instrument within the narrower optimum limits listed in Table 1. Operating the instrument near the minimum or maximum temperature limits is permissible if the short-term temperature fluctuations are kept to less than approximately 63 °C. Otherwise, run-to-run retention time repeatability can be compromised. A cycling air conditioning or heating system that vents directly onto the gas chromatograph can cause larger local temperature fluctuations than the controlling thermostat indicates and subsequently create an apparent problem with instrument performance. In locations below roughly 40° latitude, daily exposure to direct sunlight can cause similar short-term heating effects and should be avoided.

A gas chromatograph generates a significant amount of heat, especially when operated with frequent oven temperature programming. In addition to the normal allowance for external heat input, lighting and personnel, a laboratory HVAC system must be sufficiently powerful to remove the instrument-generated heat and prevent the laboratory from becoming too hot. A typical laboratory gas chromatograph is rated at 2000 W peak power consumption, but the instrument never uses its peak power more than momentarily. At the end of each GC cycle, the heat that has accumulated in the oven is dissipated to the surroundings before the next run can begin. With oven temperature programming, the power draw can approach a continuous 75% or so of maximum during the highest and fastest temperature programme sections, but much of that time is spent between runs cooling the instrument and waiting for the next run to begin. If a very active instrument consumes an average of 40% of its full power for each hour of active use, then it will release 0.40 × 2000 W × 1 h = 800 W-h or approximately 2730 Btu worth of heat into its environment. An associated computer, monitor and printer can dissipate an additional 250 Btu/h of heat, so a rounded up allowance of approximately 3000 Btu per installed gas chromatograph should be taken into consideration when rating the heat load for a laboratory air conditioning system.
This cooling overhead should be designed in the system even if the laboratory has no immediate requirement for temperature programming, so that it can meet future needs easily. Major accessories, such as mass spectrometry (MS) detectors or high-speed temperature programming options will increase the power dissipation accordingly.

The cooling of the laboratory air is more important in warmer climates and seasons, although a laboratory full of gas chromatographs can become very warm even on cool days. Consult an HVAC professional to evaluate the suitability of existing or planned installations.

**Humidity:** If too much moisture is present in the laboratory atmosphere, some water can condense on the instrument components, which will reduce their performance, possibly render them useless or even cause hazards, in rare instances. The humidity must remain below the condensing level, which depends upon the laboratory temperature. At the other extreme, too little moisture can encourage the buildup of static electricity beyond the static-shock limit that the instrument was designed for and can cause erratic operation or system crashes when the instrument or its keypad is touched. When an instrument is moved inside from a cold area, such as a parking lot or unheated storeroom, place the instrument on its destined bench, wait 1 h or so, check that any temporary condensation has evaporated fully, and only then plug the instrument into the electrical supply.

Some instrument components, such as cryogenic oven cooling accessories and thermoelectric coolers, can become cold enough for condensation to form during normal operation. These devices can tolerate small amounts of condensation, but gas chromatograph operators must avoid excess water dripping from them. Instead, install appropriate air conditioning or a dehumidifier to keep the humidity level under control.

**Ventilation:** Some detectors, namely the non-destructive types such as an electron-capture detector, might need dedicated ventilation to remove toxic compounds in their effluent from room air circulation. One solution is to install the entire instrument in a ventilated hood. Another method involves positioning a 4 in. or larger flexible hose above the detector vent and connecting it to an appropriate exhaust system and filter.

When using an inlet splitter the sample fraction and solvent that are not injected into the column will be vented from the inlet system. A chemical trap should be installed in the inlet vent line when necessary. Many gas chromatograph inlets include a trap as standard equipment, and it is an accessory for others.

### Electrical system requirements:
Gas chromatographs consume enough electrical power that they each require a separately wired and protected electrical circuit. Accessory equipment such as external detectors and samplers, computers, printers and monitors must have their own additional dedicated power supplies that meet their individual requirements as well.

**Power consumption and voltage:** A gas chromatograph requires 2000–3000 volt-amperes (V-A), depending upon the instrument and its configuration. This amount of power consumption will require different amounts of current, as dictated by the supply (mains) voltage. Some accessories, namely high-speed oven options for some gas chromatographs, are available only at higher supply voltages to limit the current requirement.

The alternating current supply circuit rating is obtained by choosing the next highest current level, as specified in local electrical codes, above the maximum instrument demand. At 120 V of alternating current (V ac) with an instrument rated for 2250 V-A, the actual current can be as high as 18.75 A, so a 20 A circuit is necessary. The same gas chromatograph requires half the current at 230 V ac.

### Table 1: GC laboratory preparation checklist.

<table>
<thead>
<tr>
<th>System</th>
<th>Feature or Variable</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC</td>
<td>Temperature</td>
<td>Maximum range: 5–40 °C; optimum: 23±3 °C; avoid direct sun or strong drafts</td>
</tr>
<tr>
<td></td>
<td>Humidity</td>
<td>Range: 20–80% relative humidity; non-condensing</td>
</tr>
<tr>
<td></td>
<td>Ventilation</td>
<td>Ventilate toxic effluent from detectors and inlets as required or install in ventilated hood</td>
</tr>
<tr>
<td></td>
<td>Air conditioning</td>
<td>Additional 3000 Btu capacity per installed or anticipated gas chromatograph and an extra 1000 Btu for major accessories</td>
</tr>
<tr>
<td>Electrical</td>
<td>Power consumption (consult individual gas chromatograph specifications for exact values)</td>
<td>Typical values range from 2000–3000 V-A</td>
</tr>
<tr>
<td></td>
<td>Voltage and current (some instruments may vary — check manufacturer’s documentation)</td>
<td>120 V ac: 20 A; 200–230 V ac: 15 A; 40 V ac: 10 A (15 A for fast-heating ovens)</td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td>50–60 Hz ± 2 Hz</td>
</tr>
<tr>
<td></td>
<td>Plugs, sockets and wiring</td>
<td>Must match each other and instrument power rating; must adhere to local electrical codes</td>
</tr>
<tr>
<td>Benchtop</td>
<td>Weight capacity</td>
<td>Minimum: 250 lb/6 linear ft; recommended: 400 lb/6 linear ft</td>
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<tr>
<td></td>
<td>Space allotment</td>
<td>5–6 linear ft per instrument and computer plus additional space for accessories; at least 10 in. rear clearance for oven venting</td>
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</tbody>
</table>
240 V for a 10 A circuit rating. A 15 A circuit is required at common intermediate international voltages from 200 to 230 V. Certain areas of Japan have a 100 V system that can be used directly only with instruments specifically manufactured for that voltage. All other instruments should use the related 200 V supply. I do not recommend the use of a step-up transformer in any circumstances.

Avoid connecting an instrument into a branch circuit that also carries large inductive loads such as air conditioners, elevators or other motor-driven devices. Modern gas chromatographs include over-voltage protection circuitry that will help prevent permanent damage if the wrong voltage is applied, but large electrical spikes tend to find their way into the chromatographic data.

**Alternating current frequency:** Most modern gas chromatographs and associated data systems can operate safely at electrical supply frequencies of 48–62 Hz. Instruments built before 1980 or so might rely upon a line frequency of either 50 or 60 Hz to drive the internal system clock that controls the instrument’s timing. Check the instrument manual or consult the manufacturer if there is any doubt. A mismatch here is easy to spot: If a stopwatch says that 10 min have elapsed, but the instrument indicates 12 min or 8 min and 20 s, then the line frequency is indeed in control, and the wrong frequency has been supplied to the instrument.

**Wiring:** Electrical codes vary from one country to another, as well as from location to location within many countries. The local electrical codes will specify exactly how the intended voltage and current-rated circuit is to be brought out from the main supply through one or more circuit breakers and into the laboratory. Different current phasing arrangements are found throughout the world. In the US, light industrial supplies are most often single-phase, three-wire systems from which 120 V and 240 V are derived. Another common configuration derives 240 V from a three-phase, four-wire supply. The number of wires is for those that bear current: the ground or earth wire is considered separate from the others. The same electrical codes also dictate the gauge or diameter, composition, insulation and colour coding of the wires, as well as the type and configuration of the surrounding conduits and their permissible lengths. The only safe and permissible way to address this aspect of the electrical supply is to hire a competent electrician to do the necessary work.

Never try to adapt or modify an instrument for a voltage range other than that stated on its nameplate. The main oven heater as well as the inlet detector and other heaters are selected for the rated instrument voltage. Operating them at higher voltages can cause a serious safety problem or a fire, and lower voltages will cause the instrument to perform below specification because of insufficient available heating power. In either instance, such action will void the instrument’s warranty immediately.

**Outlet configuration:** When shipping an instrument to a specific country, instrument manufacturers will generally attach a suitable line cord and plug, which vary significantly from country to country and instrument to instrument. In general, the plug dictates the current and voltage rating of the instrument and determines the size and number of conductors in the line cord. Occasionally, the plug will not match the available socket. In such instances, it is never permissible to construct an adapter — a so-called cheater cord — to defeat the purpose of the plug and line cord supplied by the manufacturer. Instead, call back the electricians who installed the supply outlet and have them make the necessary modifications, in consultation with the instrument company’s service technicians, if necessary.

**Powering up:** When powering up an instrument for the first time in a new location, carefully monitor the thermal performance of each heated zone. Check that the oven heats at its specified rate and not too rapidly or too slowly. The inlet and detector heaters should rise to their normal set points in less than approximately 5 min and should not oscillate around their set points. A slight burning odour is normal when heating a new instrument for the first time or after an instrument has been inactive for several months. Any smoke, sparking or red-hot glowing elements signify a serious problem; the instrument must be turned off and unplugged from the ac supply immediately. The only safe remedy in these situations is to call the manufacturer’s service technician.

**Bench and surroundings:** In addition to getting the electrical supply configured correctly, the instrument bench and its surroundings must meet certain requirements. Most gas chromatographs are almost 2 ft wide. Analysts should allow approximately 1 ft of additional linear bench space on either side of an instrument for easy access to its sides and another 3 ft for a computer. Thus, a single gas chromatograph with one computer will occupy almost 6 ft of linear bench space. Accessories such as MS detectors and headspace samplers will occupy additional space.

Sufficient clearance of approximately 10 in. must be arranged at the back of the gas chromatograph where hot air is exhausted from the oven. If the gas chromatograph must be installed closer to a wall or backsplash, then workers should use an oven air deflector to redirect the hot air upward. Take care to avoid placing heat-sensitive objects near the oven exhaust area.

The bench itself must be capable of supporting the weight of the instrument and any accessories, and it must be stable so that falling over is impossible. A gas chromatograph and a computer weigh approximately 150 lb. A major accessory can add another 100 lb, so the bench should be able to support more than 250 lb/6 linear ft. If the bench has no access space behind, I often find myself sitting or crawling on top of the bench, so I like to use benches rated for 400 lb or more. I prefer a centre-island back-to-back bench arrangement with a 2.5 ft access

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**Measure First, Plug in Second**

I often helped set up gas chromatographs for display at Pittcon in the 1980s. One year, a new line of instruments was to be introduced. My colleagues and I arrayed six of them in a row in the booth and plugged them into the electrical lines provided by the exhibit centre, only to find that the power was off. It was getting late on Sunday afternoon, and we wanted to check out the instruments before the Monday morning exhibit opening. An electrician was located and sent off to apply power. Suddenly, we heard a loud humming and sharp, cracking noises issued from the back of each instrument, followed by the acrid smell of burning insulation. We jumped back and screamed “Turn it off!” The embarrassed electrician admitted later that he had connected our new 120 V instruments to a 480 V line by mistake. I inspected one of them and found that the surge protector — a small aluminium box into which the line cord disappeared — was basically vaporized, but additional damage had been avoided by having left the power switch off. We were able to obtain and install replacement surge protectors Monday morning, so the display went on without a problem. Now, I always measure the voltage first and plug in the instrument second.
aisle between the backs of the benches and ceiling drops for electrical and gas supplies.

Never use a portable table with collapsible legs for any instrument, even temporarily. Only use a rolling cart for transportation, not for operation. Also, beware of the narrow 2 ft deep tables often used in conference rooms set up in a classroom configuration. Their legs are too close together to provide enough stability to support any kind of instrumentation.

Conclusion
Gas chromatographers need to be aware of the basic electrical, HVAC and benchtop requirements for their laboratory instruments. The most important considerations are arranging the correct supply voltage and circuit breaker, dissipating the instrument’s excess heat and ensuring that the instrument is physically stable on the bench. Gas chromatograph electrical requirements vary from one location to the next with available voltages, currents and local regulations. HVAC professionals, electricians and architects can provide essential information about the suitability of existing installations and can assist with upgrade plans or new designs when necessary.

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For an on-going discussion of GC issues with John Hinshaw and other chromatographers, visit the Chromatography Forum discussion group at http://www.chromforum.com