Standard Operating Procedure (Guidance)
Gas Cabinets

General:

This document provides guidance on the proper selection, installation, and operation of gas cabinets. This document does **not** cover the installation of the process piping from the gas cabinet to the experiment or gas cylinder.

There are five primary reasons to use a gas cabinet for the storage and use of hazardous gases in a laboratory:

1. The planned amount of hazardous gas exceeds the maximum allowable quantity (MAQ) for the control area as indicated in by National Fire Protection Association (NFPA) 400 and NFPA 45 and any other required regulation. The use of a gas cabinet for the hazardous gas allows the amount of the MAQ to be doubled.
2. If there is a concern that an accidental release of a gas will potentially cause a health concern, such as the release of an irritating or toxic gas.
3. If there is a concern that an accidental release of a gas will cause a physical hazard, such as the release of a flammable or oxygen-displacing gas.
4. The use of highly toxic gases as required NFPA 400 and NFPA 45. See the table at the end for a general list of gases for reference.
5. The use of gases that have a health hazard rating of 2 without physiological warning properties as required by NFPA 45, "Laboratory Chemicals".

Whatever the reason a gas cabinet is chosen, installation and operation should follow manufacturer requirements.

Listed below are considerations for selection and use of a gas cabinet.

SELECTION

Gas cabinets have many features; therefore, it is necessary to know the intended use of the cabinet so that the correct features can be selected prior to purchase. This section breaks down these features and provides guidance on which ones should be considered versus required.

Manufacturer

There are many manufacturers of gas cabinets. Select a reputable manufacturer that provides on-site installation and training support, documentation, and a warranty. When possible, select a manufacturer that currently has gas cabinets installed on-site so that our Facilities Management n is familiar with its operation.

Often the selection of the gas cabinet manufacturer will depend on whether they sell a cabinet that is capable of meeting current and future scientific and safety needs. Evaluate the components to ensure that they are necessary for the planned usage. Manufacturers sometimes promise more than they can deliver, sell “standard components” that are unnecessary, or use parts that are not universally available. Review allthese factors with vendors.

Gas Cabinet Capacity

Gas cabinets come in a variety of sizes, which include single, double, and triple cylinders, as well as lecture and small capacity cylinders. Select the appropriately sized cabinet based on current and potential future use and the installation space available.

Local Exhaust Ventilation

The manufacturer determines the amount of local exhaust ventilation required to operate the cabinet. Per the CFC, the minimum average face velocity shall not be less than 200 feet per minute (fpm) or 150 fpm at any point across the access port. For a single cylinder cabinet, this usually equates to a volumetric flow rate of 150 cubic feet per minute (cfm). Most manufacturers will require at least 200 cfm and some may require 300 cfm, or more, depending on the cabinet size.

The ductwork materials used must be compatible with the intended gases (e.g., galvanized steel versus stainless steel) and shall not be made from a combustible material. The duct installation shall include an exhaust controlling device – preferably a blast gate. The blast gate should be located as far away from the cabinet as possible while still being before any upstream branch within the same workspace so that it can be easily accessed. The area of ductwork attached to the cabinet exhaust should be used to install necessary exhaust monitoring devices, such as a pitot tube for a Magnahelic gauge.

The standard size exhaust connection from a gas cabinet is six inches. The exhaust air shall not be re-circulated into occupied spaces but rather exhausted to the roof in a manner protective of both people working on the roof and those walking nearby. In addition, for toxic and highly toxic gases, a calculation will need to be performed to determine if, in a realistic worst-case release of gas, the concentration of the gas is less than ½ the immediately dangerous to life and health (IDLH) concentration. These requirements may drive the need for an air-scrubbing device and/or restricted flow orifice. The exhaust stack height must be at least 7 feet above the rooftop,or at least 2 feet above the top of a parapet wall, whichever is greater. Furthermore, the exhaust shall not be located in an air that could result in reintrainment of contaminant into occupied spaces through doors, windows, or HVAC air intakes.

Cabinet exhaust inlet and outlet shall be designed for good sweep through the entire volume. The inlet louver should have adjustability to aid in balancing the exhaust and achieving required static pressure in the cabinet and duct.

If the amount of air exhausted is enough to affect the air balance in the room, a mechanical engineer should determine the amount of make-up air that needs to be added to the room where the gas cabinet is installed; this will ensure the room remains air balanced and the cabinet operates efficiently.

Gas Manifold

A gas manifold is an assembly of gas piping, regulators, and devices designed to safely dispense gas at controlled flow rates. Gas manifolds are installed inside gas cabinets and are usually purchased with the gas cabinet from the same manufacturer. There are many options for a manifold, ranging from fully automated to manual or simple to complex. Therefore, it is important to understand your needs and consider potential future needs before finalizing your selection. A typical gas manifold is shown in Figure 1 below.

Referring to Figure 1 below in the lower right hand corner near the gas cylinder, the first option to consider is the emergency shutoff valve (ESO), which should be installed on the gas line. A fail-close, pneumatically operated ESO is preferred. If flammable gases will be used inside the cabinet, the pneumatic supply line to the ESO shall be made of thin-walled plastic tubing, which will melt when heated and automatically shutoff gas flow in the event of fire. The ESO shall be connected to the gas detection system (if required), exhaust detection, and external emergency off buttons and should stop the flow of gas when a substandard condition is detected.

The main regulator is installed downstream from the ESO. This regulator should have a high (cylinder) and low (line) pressure gauge. To select the proper regulator, calculate the required flow rate of the experiment. This flow rate determines the appropriate pressure regulator by referring to the manufacturer’s specifications. Select a regulator based on the required maximum flow rate, with minimal additional capacity - this will limit the amount of gas release should a leak occur after the regulator. Another consideration of regulator selection is the pressure rating of the cylinder manifold components and downstream experimental components. The regulator requires reevaluation with any new gas or new experiment; one size does not fit all.

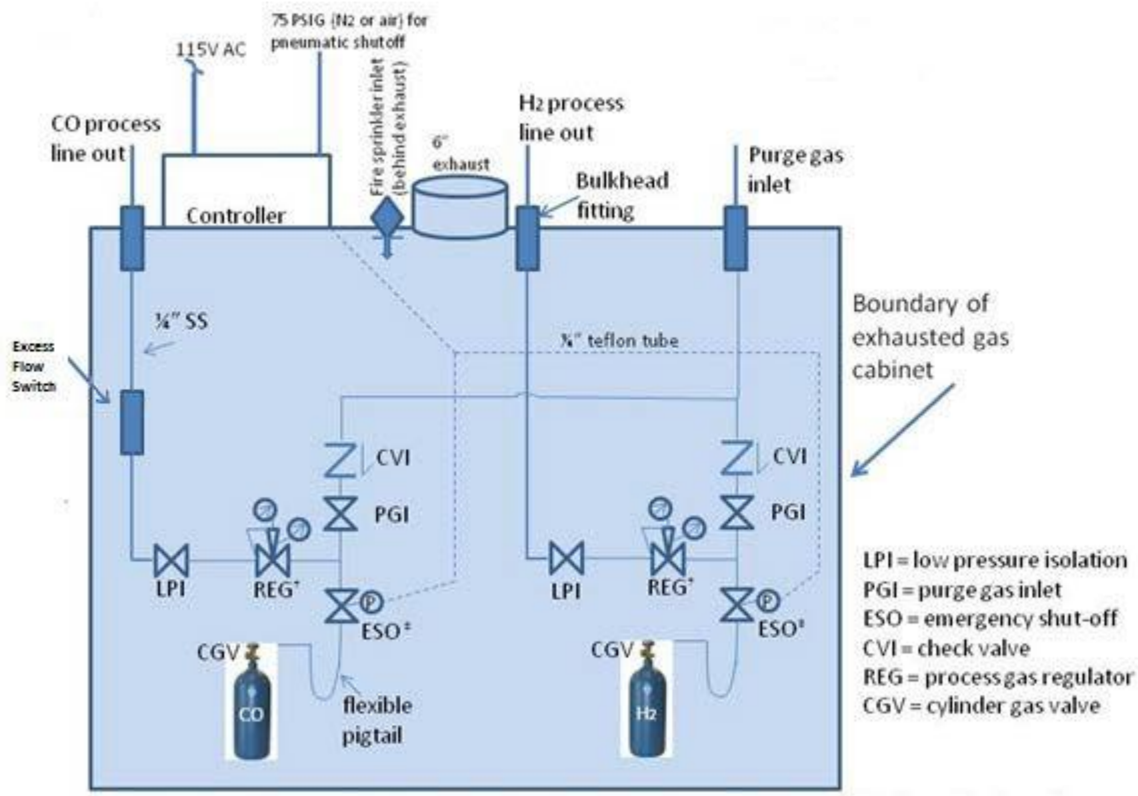

Figure 1 Typical Gas Manifold, in this case for Carbon Monoxide and Hydrogen Gases

When using toxic and/or flammable gases, an excess flow switch must be installed downstream of the regulator to detect flows that exceed a trip point. Again, the required maximum gas flow rate and pressure for the experiment must be calculated in order to select the proper excess flow switch. The downstream safety considerations should also be evaluated in the selection of the excess flow switch. This excess flow switch is always connected to the controller in order to shut down gas supply in the event that excess gas flow occurs.

The manifold shall have the ability to be purged of toxic, reactive, or flammable gases when needed. The purged gas is then directed to the experiment, inside the enclosure exhaust, or to another appropriate exhaust system. For positive pressure purges, the tie-in for the purge gas should be near the cylinder to allow purging of the entire manifold. For vacuum purges, such as the use of a venturi setup, the tie-in point should be immediately after the pressure regulator and before the process gas leaves the cabinet. Purge gas connections shall contain a check valve to prevent process gas from entering the purge line. Appropriate isolation valves shall also be installed to properly direct the purge flow. If purged gas is located outside the gas cabinet, then a pass-through will be required in the bulkhead. Purge gases cannot be shared between incompatible hazardous gases (e.g., an oxidizer and a flammable). Purge gases shall be delivered from a cylinder source and not from house nitrogen or other house gases.

All manifold fittings and piping must be compatible with the potential gases used inside the cabinet. If the manifold originates from a different manufacturer than that of the gas cabinet, it must be compatible with the cabinet fittings. All connections for toxic, flammable, or reactive gases shall be highgrade standardized Swagelok or VCR fittings. A flexible pigtail connection to the cylinder shall be utilized to allow cylinder replacement.

It is important to note that not all gas cabinets need a gas manifold. Some cabinets simply need a regulator. This is determined by the gases dispensed. Toxic, flammable, or reactive gases need a manifold assembly; inert gases require a regulator only.

Controller

To automatically monitor and control the operation of the gas cabinet, a controller is needed. The controller is normally anchored to the top of the cabinet and comes with a standard set of inputs and outputs. Controllers must have an emergency shutoff button, a local audible alarm, a local visual alarm,and pneumatic connections for input and output for emergency shut off valve control.

Typical controller sensors include

- Hi Delivery Pressure
- Excess Flow
- Exhaust Fail
- Gas Detector Warning
- Gas Detector Alarm

All controllers are cord and plug, usually requiring about 25 Watts. Some controllers can power gas detection monitors, but this needs to be verified with the manufacturer.

Pneumatic Supply

The automatic shutoff valve is pneumatically operated by either nitrogen or compressed air. The choiceof the two is dependent on the manufacturer’s requirement, the scientific experiment, and the availability of plumbed house gases. If a plumbed house gas is selected as the pneumatic source, then the gas purity needs to be verified with the building manager. When flammable gases are used, it is a best practice to use an inert gas (e.g., nitrogen) so leaks would not exacerbate a fire.

Gas Detection

Gas detection inside the cabinet shall be installed for toxic gases and may be required for flammable gases. Ideally the sensor should be located inside the cabinet; however, it is acceptable outside as long as the sensor is a draw type connected by tubing to the inside of the cabinetor cabinet exhaust. The sensor shall be specific for the gas and have the ability to detect concentrations below the permissible exposure limit (PEL) or 25% of the lower explosive limit (LEL). The gas detector system is

set to detect the presence of gas at 25 percent of the LEL for flammable gases or the PEL, orceiling value, for toxic gases.
A local alarm shall initiate and automatically shut off the gas at the source when these limits are detected. When cylinders of highly toxic gases are used inside the cabinet, it is a CFC requirement that asignal is transmitted to a constantly attended control station whenever a hazardous condition is detected.

Select a gas detector that is compatible with the controller and one in which the manufacturer provides on-site support as well as a warranty. Detectors must be regularly calibrated, so it is best practice to select a detector type/brand that is currently used on-site at SLAC.

Exhaust Detection

Exhaust is also monitored to ensure that the cabinet is ventilated when in use. The monitor shall be connected to the controller to automatically shut off gas when the ventilation drops below a set point. Ideally, a continuous visual indicator, such as a Magnahelic gauge, would be installed so the user can visualize that adequate ventilation is being provided to the cabinet.

Fire Sprinkler

An automatic fire sprinkler is should to be installed inside each gas cabinet, except for half-size cabinets for only lecture bottle size or smaller compressed gas containers as long as the control area MAQs are not exceeded. The sprinkler extinguishes fires that may develop inside the cabinet and keeps the gas cylinders cool when fires occur outside the cabinet. The sprinkler must be connected to a building fire sprinkler line. The building fire suppression system must be properly evaluated to ensure that it has the capacity to handle the additional load.

If current experimental needs only require lecture size or smaller compressed gas cylinders and they are used in half-size gas cabinets, it is a good idea to order cabinets with an installed sprinkler so that potential future needs of larger size cylinders can be accommodated. Un-sprinkled half-size cabinets need to have a sticker or sign cautioning UNSPRINKLERED GAS CABINET; NOT SUITABLE FOR TOXIC OR HIGHLY TOXIC COMPRESSED GAS CYLINDERS LARGER THAN LECTURE BOTTLE SIZE.

Fire Detection

Use of certain gases, such as pyrophorics, may warrant the installation of a flame detection system. Unless required by the SLAC fire marshal, use of a flame detection system is not recommended due toadditional cost and maintenance.

General Requirements

Gas cabinets shall

- Be made from at least 12 gauge cold rolled steel
- Contain self-closing and latching doors, cylinder restraints, and a reinforced safety glass viewport
- Have the ability to be anchored to the floor or wall without penetrating the enclosure

Cabinet exhaust inlet and outlet shall be designed for good sweep through the entire volume. The inlet louver should have adjustability to aid in balancing the exhaust and achieving required static pressure inthe cabinet and duct.

OPERATION

Standard operating procedures (SOPs) should be developed before operation. These must detail the safe operation procedures of the gas cabinet. At a minimum, these procedures shall address the following:

- Installation, removal, and securing of gas cylinders inside the cabinet
- Operation of the controller, including the by-pass setting for purge operations and emergencyshut-off button
- Response to alarm activation
- Purging of the manifold
- Maintenance requirements, including calibration of gas detection equipment and ventilationchecks

SOP training must be provided for all affected workers before operation and tracked for compliance purposes. Should the experiment change in any way, the SOP must be updated and this informationcommunicated to affected workers.

A preventive maintenance program should be implemented to ensure the integrity of connections and piping, adequacy of ventilation, and the functionality of alarms, sensors, valves, controllers, and other hazard mitigations.

Brief Storage Guide Based On Specific Hazard

Pure Gas	Flammable Limits in Air (Vol. %)	Hazard	Storage in gas cabinet required R = recommended; Y = yes; N = no
Acetylene	2.5-82	Flammable	R
Ammonia	15-28	Toxic	Y
Argon		Inert	N
n-butane	1.6-8.4	Flammable	R
Carbon Dioxide		Inert	N
Carbon Monoxide	12.5-74	Toxic	Y
Chlorine		Oxidizer, Toxic, Corrosive	Y
Dichlorosilane	4.1-98.8	Flammable, Toxic, Corrosive	Y
Ethylene Oxide	3-100	Flammable, Toxic	Y
Helium		Inert	N
Hydrogen	4.0-75	Flammable	R
Hydrogen Sulfide	4-44	Flammable, Toxic	Y
Methane	5.0-15.0	Flammable	R
Nitric Oxide		Oxidizer, Toxic, Corrosive	Y
Nitrogen		Inert	N
Oxygen		Oxidizer	N
Propane	2.1-9.5	Flammable	R
Silane	1.37-96	Flammable Pyrophoric	Y
Sulfur Hexafluoride		Inert	N

Note: The gases in the table are considered in their pure form. Mixed gases may have differing requirements.