Designing Safety Into Site-Wide Gas Distribution Systems

When setting up a gas distribution system in a laboratory or any other type of facility, the safety of all personnel must be taken into consideration. It is important to meet all local and federal codes, such as National Fire Protection Association (NFPA), Uniform Fire Code (UFC), Semiconductor Equipment and Materials International (SEMI), and Building Officials Code Administrators International (BOCA). In addition, the local fire marshal normally has the final say on approval and startup of the system.

All compressed gases have the inherent potential hazard of high pressure. Many gases present chemical property hazards in different categories, including:

- Flammable gases (hydrogen, acetylene, methane)
- Oxidizing gases (oxygen, nitrous oxide)
- Toxic gases (carbon monoxide, hydrogen sulfide)
- Corrosive gases (chlorine, hydrogen chloride)
- Pyrophoric gases (silane).

Many gases have more than one hazardous property. For example, carbon monoxide is both flammable and toxic; hydrogen sulfide is both corrosive and toxic.

The gas industry and equipment companies have developed many different systems to enable safe gas delivery. This article describes gas cabinet enclosures, special source systems with purge mechanisms, and monitors (including alarms, valve shutoffs, excess flow equipment, and gas detection).

Proper labeling of the gas cylinders and equipment is also important in order to document properly which hazards are associated with the gas service, and to prevent imprudent crossover of service (such as changing a system used for oxidizers over to service for flammables). This article focuses on gas safety equipment as part of a site-wide gas distribution system. Materials of construction, selection criteria, general precautions, and other issues are discussed in the context of safety and gas purity.

**Gas cabinet enclosures**

Gas cabinets are designed to contain gas cylinder(s) and their associated control hardware (see Figure 1). The purpose of the gas cabinet is to confine and remedy (normally by venting) the hazard within the cabinet, while preserving the safety of the working environment outside of the cabinet. Gas cabinets are continuously vented at high airflow rates—from the bottom intake up and out the top of the cabinet through an exhaust stack. A negative pressure is created within the gas cabinet when the door is closed. In the case of a leak, the leaking hazard will be carried out the exhaust stack.

The most common hazardous area classification is Class 1, Division 2. This classification assumes that there will be no hazardous gas in the area (inside the cabinet) unless there is an equipment failure resulting in a leak. The interior of the gas cabinet is considered a Class 1, Division 2 area.

Storage of hazardous gas cylinders can follow the usual guidelines, but when in use, all cylinders containing hazardous gas should be enclosed in a gas cabinet. Hazardous gases should not have connections made unless they are in the cabinet with the door closed. All purging operations and connections should be made through an access hatch. This maintains the negative pressure in the cabinet.

Gas cabinets are generally made of cold rolled steel, with a minimum thickness of 12 gauge to provide the necessary fire rating, and painted in a scratch-resistant paint, such as epoxy or powder coat. Cabinets are generally available in sizes for one, two, or three cylinders, with common safety features such as wire-reinforced safety windows, self-closing doors, air intake filters, exhaust stacks, sprinklers, and access hatches. The self-closing door feature should never be defeated, since this provides another measure of safety in case of an accident.

Sprinklers are usually specified to actuate in the vicinity of 155 °F and must be piped to the facility water lines. They are useful if there is a fire in the cabinet. Sprinklers are wax-coated to resist corrosive gases that may be present.
For higher usage of the same gases, a switchover panel may be appropriate (see Figure 3). The switchover allows for uninterrupted flow of gas; it automatically switches from the depleted cylinder to the reserve cylinder. The depleted cylinder can then be changed while the reserve cylinder is supplying the process; this supply/reserve exchange can be continuous. Switchover panels are available with check valves in the pigtails and high-pressure vent valves, as well as many other options. These are suitable for situations in which an outage of gas can ruin a production process or delay the use of an instrument because it must be reequilibrated.

Analytical-grade panels can also be used, and they come in a variety of configurations (see Figure 4). A panel with a single valve is typically utilized for inert gases, which can also be used as the purge supply. A three-valve panel is commonly used for simple flammable gases, and is equipped with a high-pressure vent for removing pressure and air from the panel.

In cases in which a corrosive or highly toxic gas is being used, or where a higher degree of purity is required, a five-valve panel is appropriate. These panels offer multiple functions, such as high-pressure venting, purging, low-pressure venting, and a venturi to assist in the purge function.

Using a five-valve panel with venturi, it is possible to deliver 5.0–6.0 purity gas (i.e., 99.999%–99.9999%), while extending the life of the equipment in corrosive gases service. Proper purging is extremely important for corrosive gases and for UHP purity levels, and will be covered in future articles.

### Alarm monitors

Alarm monitors are available with a variety of features. The simplest annunciators will alert the user that a given source is depleted. Taken to the next level, gas alarms can provide some sort of response, such as shutting down a process gas in the event of a system failure.
Annunciators are typically set up for one or two inputs (single source or a switch-over), with a green light to indicate full or in service status of the cylinder(s) and a red light to indicate a depleted cylinder(s). Many also include some type of audible alarm and output contacts for remote indication. In this case, an alarm is a good thing.

Annunciators can be triggered by input coming from:

- Pressure switches
- Indicating pressure switches (IPS) (see Figure 5)
- Electronic cylinder scales (for monitoring liquefied gases) (see Figure 6).

Regulators, switchovers, and analytical panels can all be configured with pressure switches and indicating pressure switches to monitor the cylinder contents. Cylinder scales can be installed inside the cabinet (see Figure 6). In most cases, the alarm setpoint can be adjusted by the user to suit the requirement of the gas and the application.

When the trigger is used to signal that a hazardous condition may exist, an emergency shutoff (ESO) valve is required to shut down the hazardous gas. This requires an alarm monitor with pneumatic control to operate the ESO valve (see Figure 7).

In situations involving hazardous gas shutdown, not all the triggering events will be gas-related. Monitors will typically have inputs for most, if not all, of the various alarm trigger devices listed below, with lights, horn, and outputs for external notification. Shutdown alarm monitor triggers include:

- Gas cabinet exhaust failure switches
- Fire detectors
- Excess flow switches
- Gas detection equipment.

An exhaust failure switch monitors the negative pressure in the cabinet generated by the exhaust blower. Since the gas cabinet exhaust maintains the Class 1, Division 2 area in the cabinet, it is very important to maintain the exhaust flow to shut off the flow of gas in the event of an exhaust failure.

Fire detectors are typically infrared, and can detect a flame inside the cabinet and trigger an alarm. Excess flow switches are designed for a catastrophic failure, such as a break in the piping system. The switch monitors the flow through the system and triggers an alarm if the flow exceeds the set point of the switch. The switches are available in various flow rate trip points, are not adjustable, and are affected by the gas type and system pressure.

Gas detection equipment is used both in the cabinet itself and in various points around the facility (see Figure 8). Sensors are available in various styles, types, and sensitivity ranges, depending on the gas. They are used for detection of very toxic and corrosive gases, flammable gases, and oxygen deficiency. Typically, the sensors are connected to a control box that displays the real-time reading of the sensor and includes relays to be used for alarms. Specialized sensors may also be used as external triggers; for instance, seismic sensors are useful in areas in which earthquakes may occur.

**Summary**

In any laboratory or production setting, there are numerous circumstances that can lead to an unsafe condition, resulting in injury or even loss of life. There is, of course, no substitute for the “human factor”—personal preparation, training, and vigilance. However, safety equipment is designed to add mechanization and automation to safety programs. Careful attention to gases, applications, and equipment choices will help to ensure safe gas delivery to the point of use.

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