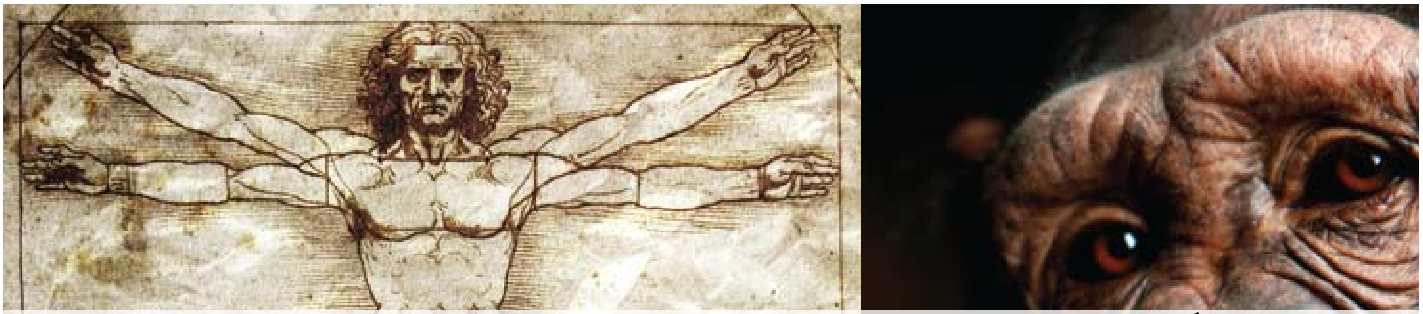


Designing an Anthropology Research Laboratory

by Timothy W. Zimmerman

As specifying plumbing engineers and designers, we must understand our clients' specific needs. Following is a detailed discussion of the design issues encountered on an anthropology research laboratory project. The goal of this article is to introduce fellow engineers and designers to the types of plumbing systems in such a facility, how to gather the necessary information to design them, and some design parameters.

WHAT IS AN ANTHROPOLOGY RESEARCH LAB?

The main interest and goals of this type of research laboratory focus primarily on various aspects of the biology and ecology of infectious diseases, including the human and non-human primate physiological adaptations to these diseases, as well as the impact of environmental changes on zoonotic disease transmission potential, specifically between human and non-human primate populations. (Zoonotic diseases are those that are transmissible from animals to humans.)

Part of this involves characterizing hormone-mediated tradeoffs between the immune and reproductive systems, using life history theory to explain the evolutionary basis for these tradeoffs, and developing theoretical and empirical models to cultivate an explanatory framework for differential susceptibility to infectious diseases, specifically parasites and viruses.

First Step: Gathering Information

The first thing to do with any project is to gather as much information as possible. This includes holding meetings with key personnel involved in the project, including the architect, user or user group, building owner, and building utility personnel, as well as local code officials. For facilities with which you are unfamiliar, it is best to spend some time upfront researching the project and even the client or owner. This may provide you with a list of questions that you wouldn't have considered before doing the research. This also helps with your creditability in front of the client, owner, and architect since you now can ask well-formulated questions. Be sure to bring up as many concerns as possible, because assumptions frequently result in change orders.

As you start your quest for information for a research laboratory, some key elements to ask are:

- What kind of equipment needs to be specified?
- What kind of equipment will be owner furnished or contractor installed?
- What are the requirements of each piece of equipment?
- Will the sinks be specified by the casework contractor?
- Will the specialty faucets be specified by the casework contractor?
- Will acid waste be a component of the design?
- Will the design have any deionized or ultra-pure water requirements?
- What kind of specialty or laboratory gases will need to be provided?
- What needs to be coordinated with the biosafety hood manufacturer and/or specifier?

The following sections reference a local university research laboratory project as an example of the plumbing requirements for some specific equipment. For each system, you must learn from the user exactly how the laboratory will be used to specify the correct piping systems. You also must make the electrical designer aware of any specific electrical requirements and the HVAC designer aware of any specific exhaust requirements.

ULTRA-LOW-TEMPERATURE FREEZERS WITH CARBON DIOXIDE BACKUP

Liquid carbon dioxide can be used as an emergency backup, ultra-low-temperature coolant when the emergency battery UPS or emergency generators have stopped running.

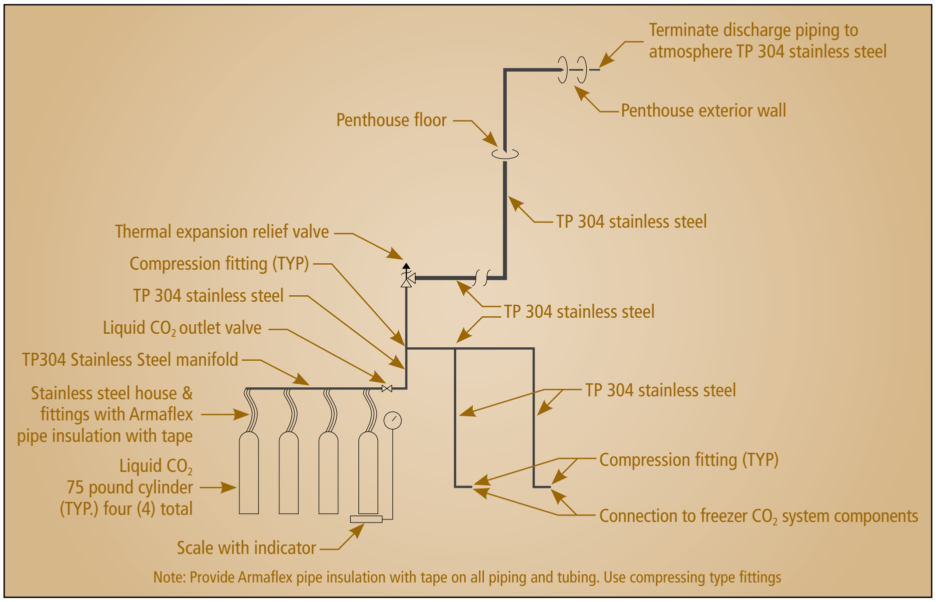


Figure 1 Emergency liquid carbon dioxide manifold for freezers—simplex header with weight indicator

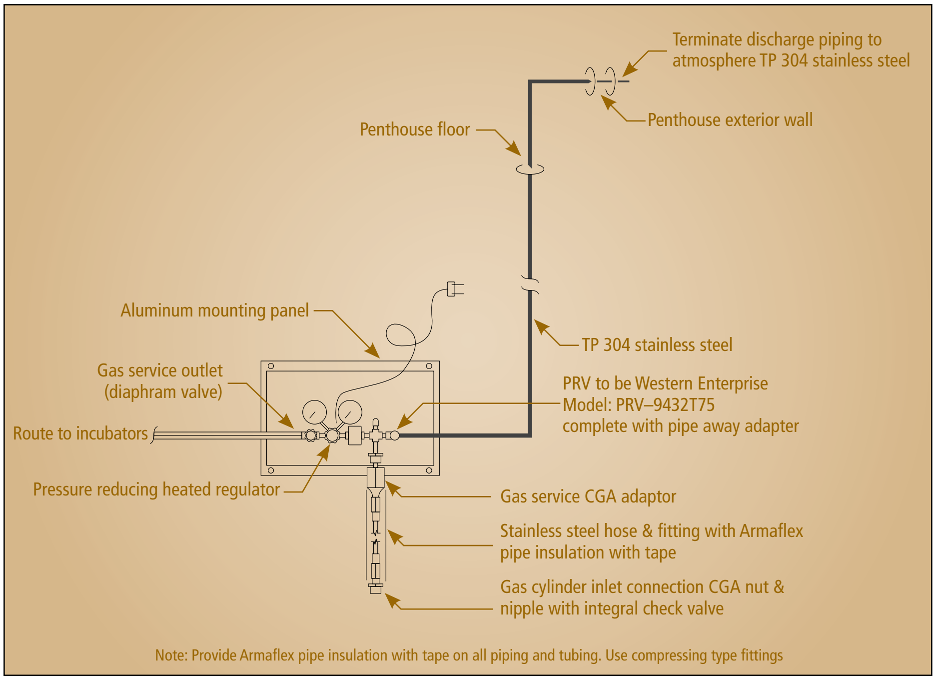


Figure 2 Carbon dioxide protocol station

When designing a carbon dioxide system indoors, you need to route piping from a thermal expansion relief valve located on the manifold to the outdoors. Be sure to think about where you will terminate the carbon dioxide relief discharge, so you don't allow it to come into contact with humans, animals, plants, small rocks or pebbles, and other material that can be damaged due to the extreme temperatures or go airborne due to the excessive relief pressures. You also need to check with your local and national codes to verify an acceptable termination point.

For the carbon dioxide system in this particular project, four 75-pound carbon dioxide cylinders with dip tubes and a carbon dioxide gas simplex header with weight indicator and heated gas pressure regulator were specified. The freezer manufacturer's recommended supply pressure was 900–1,000 pounds per square inch gauge (psig). The header is stainless steel piping connected to four cylinders. The cylinders were specified with dip tubes to ensure that the coldest gas enters the manifold. Because carbon dioxide remains in its liquid state in a cylinder, the cylinder pressure will remain the same until fully dry. Therefore, the only way to determine how much liquid is left in a cylinder is by its weight. Since all four cylinders empty at the same time, measuring the weight of only one cylinder is necessary.

You must determine how long (in hours) emergency backup deep freezing is required to calculate how many tanks are needed for the system. To do so, ask the users about their emergency action plans. Typically when you are asked to design a system like this, you are trying to keep infectious materials from reaching a certain temperature.

To determine the amount of carbon dioxide required for emergency backup deep freezing, follow these steps:

1. Determine the size of the interior of the freezer in cubic feet. In this example, the freezer was 12.8 cubic feet.
2. Determine the temperature required. This particular laboratory required -70°C.
3. Determine the flow rate of carbon dioxide in pounds per hour. This information can be found in the product literature and the ambient temperature, which for this project was 12.8 pounds per hour at 75°F.
4. Determine the required operating pressure of the carbon dioxide system. In this example, it was 900 psig.
5. Determine the length of time required to provide cooling at the set temperature beyond the time after the emergency generators or batteries have expired. In this case, the required cooling time was 24 hours.

Thus, for a 24-hour emergency run, the amount of carbon dioxide required was: 12.8 required pounds/hour x 24 hours = 307.2 pounds.

The next step is determining the size of the tanks you want to manifold together. On this project, 75-pound tanks were specified instead of 50-pound tanks to provide the necessary amount of carbon dioxide using four cylinders due to the lack of available floor space. (307.2 pounds ÷ 75 pounds = 4.09). Refer to Figure 1 for an example of a simplex header with weight indicator.

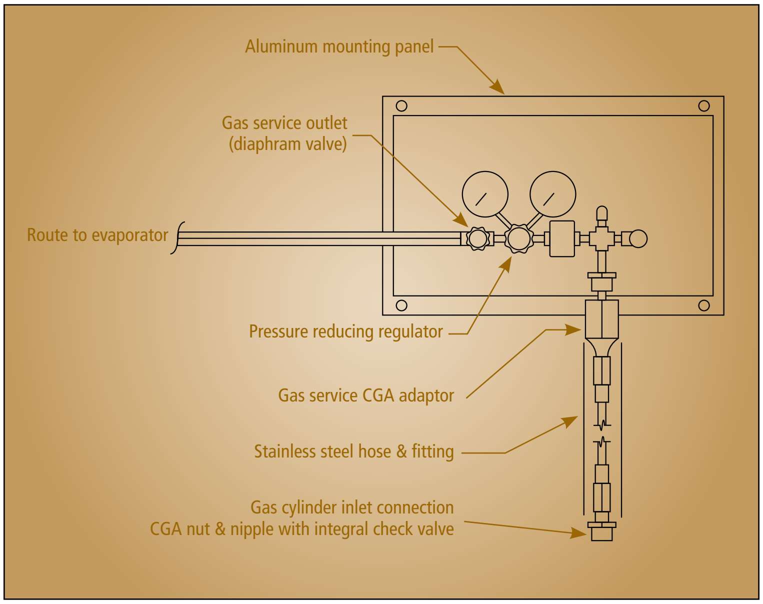


Figure 3 Nitrogen protocol station

Figure 4 Cylinder wall bracket

INCUBATORS

The incubator is used for contamination-free cell cultivation and precise temperature maintenance. For this project, the incubators required gaseous carbon dioxide to help ensure stable pH values. One 75-pound carbon dioxide cylinder and a carbon dioxide gas manifold at 28 psig were specified. The pressure-relief valve on this type of system must be a heated-type valve as to not allow freezing, and you must route piping from the PRV located on the manifold to the outdoors. For this application, the user group dictated the cylinder size. Refer to Figure 2 for an example of a carbon dioxide gas manifold.

NITROGEN EVAPORATION SYSTEM

The nitrogen evaporation system typically is used for quick drying of samples. On this project, the nitrogen evaporator was located inside a biosafety cabinet. One 75-pound nitrogen cylinder and a nitrogen protocol station with a gas pressure regulator were specified. You must verify the gas pressure requirements and required cubic feet per minute with the manufacturer of the nitrogen evaporation system. For this application, the user group dictated the cylinder size.

The evaporator typically has a vent. The vent piping from the evaporation system unit was terminated inside the biosafety cabinet. Refer to Figure 3 for an example of a nitrogen protocol station with a gas pressure regulator.

VACUUM CONCENTRATOR SYSTEM

The vacuum concentrator system uses a combination of centrifugal force, vacuum, and heat to speed the evaporation of multiple small samples. In this project, the vacuum concentrator was located inside a biosafety cabinet. You typically need a vacuum gauge located inside the biosafety cabinet at the concentrator, and you should verify the vacuum gauge requirements with the manufacturer of the vacuum concentrator system.

Vacuum Pump for Vacuum Concentrator System

For this specific application, the vacuum pump was remotely located and connected via stainless steel tubing.

WATER PURIFICATION SYSTEM

The water purification system is for producing pressurized pure and ultra-pure water from a domestic water source. This gives the user control over the quality and volume of the water provided to the laboratory. You must coordinate with the manufacturer to determine the contractor's exact responsibilities and detail this on your construction drawings. You also must coordinate with the architect about holes in countertops for remote pieces of equipment and holes for routing piping from one remote piece to another.

For this specific application, the building already had a centralized deionized water system, but the existing system could not be modified to meet the quality and quantity of water required for the laboratory's specific needs. A deionized water line from the building system riser was extended to the water purification system, and from that point the water purification system controlled every aspect of the water quality.

GLASSWARE WASHER

The glassware washer operates based on five parameters: wash time, water temperature, water circulation, spray patterns, and specific cleaning agents. The main requirement for a glassware washer in a laboratory is removal of a wide range of substances including metals, and it must do this without leaving trace levels of the substances or cleaning agents.

For this project, the glassware washer had multiple plumbing connections: one ½-inch inside diameter hose for the hot water wash cycle, two ½-inch inside diameter connections for cold water wash cycles and steam condenser, one ½-inch inside diameter hose for the deionized water rinse cycle (which was provided from the water purification system), and two drain lines routed to a nearby floor sink.

Glassware washers have minimum and maximum inlet water temperatures, water pressures, and discharge water rates, so you must make sure to verify all connections with the specific manufacturer. In this case, the backflow preventer was built into the glassware washer.

AUTOCLAVE

The autoclave creates pressurized steam to prepare culture media, reagents, and equipment. It also is used for decontaminating biohazardous waste materials.

The specified autoclave on this project had access for manual filling and draining; thus, no water, waste, or steam connections were necessary. Autoclaves typically require acid-resistant floor sinks or funnel drains, a backflow-protected water supply, and a steam and condensate connection.

PIPE, VALVES, AND FITTINGS

For tubing specific applications, type 304 or 304L seamless stainless steel tube with 0.035-inch tube wall thickness, grade ASTM A269 were specified. Verify with the tubing manufacturers that the tubing has been properly cleaned, packaged, and stored for oxygen service prior to installation.

For tubing from pressure-relief valves to atmosphere-specific applications, type 304 or 304L seamless stainless steel tube with 0.035-inch tube wall thickness, grade ASTM A269 were specified.

For compression fittings, type 316L tube fittings with front ferrule, back ferrule, and nut were specified. (Take caution when specifying imported fittings as quality control tends to be poor, and many such fittings fail.)

For the liquid carbon dioxide pressure-relief valves, proportional relief valves were specified. You must provide a safety relief valve each time liquid can be trapped between two valves. The set pressure should be the lowest maximum allowable working pressure of any component in the system. Because the pressure of a siphon carbon dioxide cylinder is 810 psig at 70°F, the pressure-relief valve's set pressure cannot be lower than 1,000 psig. The extra 200 psig allows the PRV to reseat if it ever opens. Proportional safety relief valves must be set in the field by a trained installer. Verify that the installer has the proper equipment to set the PRV pressure properly.

Again, it is extremely important to not trap any carbon dioxide between two valves. The problem is not the gas or the liquid state; it's the dry ice. Dry ice applies an extraordinary pressure on any material if it is trapped. It also makes most materials brittle, which may cause failure.

The liquid carbon dioxide supply tubing from the supply source to the freezer was specified with closed-cell elastomeric (Armaflex) insulation with insulation tape to prevent the insulation from falling off the tubing and to maintain the vapor barrier.

If valves are required anywhere on the liquid carbon dioxide piping system, make sure the packing is suitable for liquid carbon dioxide. The valves must be able to withstand cold temperatures.

Due to the high-purity requirements and the high system pressures, refrigeration technicians or master plumbers typically are tasked with the installation of these tubing systems.

BOTTLED GAS CYLINDER STORAGE

The gas cylinder space requirement is something that must be coordinated with the project architect, who need to know how much room is required and how many tanks will be provided. Be sure to follow all the requirements of local and national codes and take into consideration the ease of transporting, storing, maintaining, and connecting the tanks.

These types of laboratories are typically nonmedical, so the bottled gas storage code requirements fall under the Compressed Gas Association and ASTM, not NFPA 99, unless it is specifically referenced.

For this project, a cylinder wall bracket like the one shown in Figure 4 was specified. Other models can attach to secured pieces of furniture.

SINKS

The sinks, foot pedals, and faucets were provided by the casework manufacturer. This was an owner decision—they found a product they liked, and it just happened to include everything required. Cold water, hot water, waste, and vent were specified as on other typical sink specifications, and the sink and trim were specified as "owner-provided equipment."

This project required no acid waste or acid venting, due to the user already having a collection and disposal system.

EMERGENCY PLUMBING FIXTURES

As in most laboratory projects, an emergency eyewash was specified in one location and an emergency shower in another. The university's laboratory safety manager dictated the type of emergency devices provided and their locations.

Typically, a floor drain would be specified at an emergency shower, but in a few specific locations, the owner and/or the city did not want contaminants being washed off bodies or clothing and going into the city or private treatment plant. Thus, wastewater was allowed to collect on the floor, and the owner had a plan in place to provide on-site cleanup as required.

BIOSAFETY CABINET

You need to be aware of several coordination issues when a biosafety cabinet is in the design. The most common coordination issues are gas service valves, water valves, and drain or acid waste connections. Be sure to show the connection points and valves required in detail on the drawings and who provides them. Another coordination point is knockout locations for routing piping or tubing from one piece of equipment to another that is remotely located near the biosafety cabinet. Biosafety cabinets typically come with standard knockout locations. If this is the case, show on your drawings the piping or tubing routing through the cabinet at the correct locations.

FIRE PROTECTION

To design the fire protection system, you need to identify the type of research being performed in the laboratory to determine the type of system and the system design requirements such as hazard classification. You also need to contact the owner's property insurance company to determine if, as was in this case, the requirements of the laboratory's insurance underwriter are more stringent than those of NFPA.

This specific laboratory is involved in groundbreaking research and advances in medicines and treatments. In addition, it has very expensive equipment, robots, and computer hard drives where the research is stored. Thus, to protect the large financial investment in equipment and data, this research laboratory required a double-interlock preaction system or a clean agent fire extinguishing system.

Preaction sprinkler systems typically are installed where there is a need to eliminate the danger of water discharge resulting from accidental damage to automatic sprinkler heads or piping. Preaction systems are hybrids of wet, dry, and deluge systems, depending on the exact system goal. The three subtypes of preaction systems are single interlock, double interlock, and non-interlock.

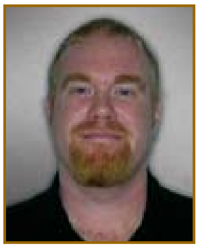
Clean agent fire extinguishing systems are used either as an alternative or as an addition to a traditional fire protection sprinkler system for rooms or areas considered special in nature from a fire protection point of view or of high value because of the equipment or materials housed in those areas. Specific requirements and applications must be reviewed with the local fire authority having jurisdiction and the owner's insurance underwriter.

SUMMARY

On a project such as this that is so detail oriented, you must gather as much information as possible from every source at your disposal. Be sure to do your research on national and local codes along with design standards and past projects. Meet with the client, user or user group, equipment manufacturers, maintenance personnel, and contractor to determine their needs, and then meet with the building owner to ensure that you can meet the user group's requirements from a plumbing systems standpoint, such as ultra-pure water, acid waste, or natural gas systems. If you cannot, then address these issues using innovative designs. PSD

RESOURCES

1. *Plumbing Engineering Design Handbook, Volume 3: Special Plumbing Systems.* American Society of Plumbing Engineers (2006–2007).
2. Western Enterprises, a Scott Fetzer Company.



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