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PLUMBING SYSTEMS AND DESIGN

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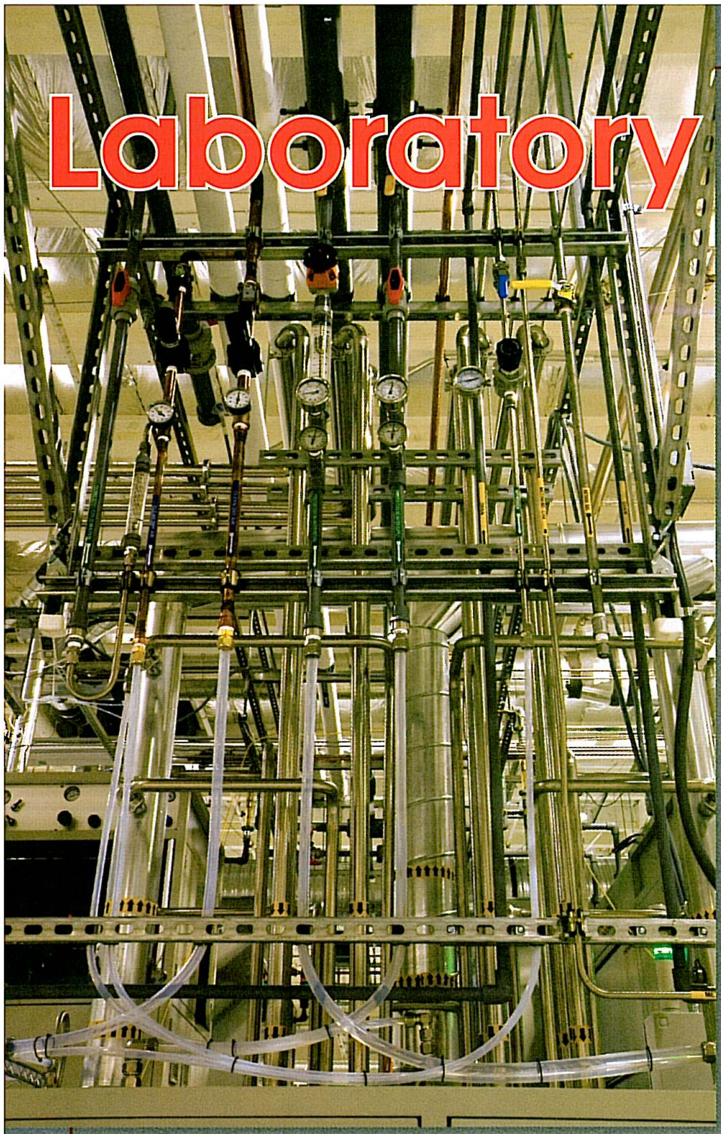


Laboratory Plumbing 101

Some things to consider when designing a laboratory for an educational facility

by Jim J. Williams

An old saying about what it takes to be a plumber goes something like this: "Water flows downhill, and payday is on Friday." If that is all you know or believe, then don't even consider attempting to design a laboratory plumbing system.

I am not saying that only a few select or gifted designers can provide a good design, nor am I belittling those who protect the health of our nation. However, laboratory plumbing design involves many issues that the average plumber or plumbing designer seldom sees or has knowledge of, and these issues cause the numerous headaches that will and do occur in laboratory design and construction. In a laboratory project, coordination between the client and the trades, as well as a vast knowledge of the various systems, is required from start to finish. This knowledge and the extensive coordination of product and space are the keys to installing a working system—one that is trouble free and lasts for years of safe operation and use.

One common issue in educational laboratories is that the school lacks the highly trained maintenance staff required to ensure trouble-free use or quick repairs to a system failure. As a result, the designer must apply the old "KISS" (keep it simple, stupid) philosophy, while still ensuring the safety of all who come in contact with the laboratory's systems.

KNOW THE CHEMICALS

The most important place to start is learning what types of operations and/or experiments will be performed and what types of chemicals (not just dirty water) will be used and disposed of down the sewer and in the acid waste and vent system. The chemicals used in high school labs vary widely based on the age or knowledge of the users. Lower-level grades might use only some types of sodium and formaldehyde, which most all marketed acid waste piping should handle. However, upper-level grades might utilize more explosive chemicals, which requires extensive research on the designer's part to specify acid piping capable of containing them safely. The chemicals must be known to specify the correct acid waste and vent piping materials, as many of the more corrosive chemicals or gases may eat through some materials and/or melt some sewer piping almost on contact. Other chemicals that are not as corrosive still may destroy certain types of materials over a longer period. All of these cases can cause unimaginable troubles from leaks to lawsuits.

This is one place not to attempt to value engineer, and you should err on the conservative side. Even if you know all the chemicals being used, review the test results, and examine the product claims for the piping, you cannot anticipate the unexpected situations that may occur in an unsupervised laboratory. During experiments, students love to explore the unknown, and often two substances mixed together create a new chemical that was not on the original list of accepted products. **This definitely is not a situation where saving the owner upfront materials costs is the primary consideration. Staff changes occur, and new teachers may devise a curriculum using chemicals not included in the original lab design. Hence, erring on the side of extreme caution is always the base design level for safety and security.**

KNOW THE PIPING

When specifying the materials for the acid waste and vent system, the designer must be sure to examine the fine print. A piping manufacturer may claim that their pipe will handle a certain chemical, but only as long as the user provides a clean water flush to wash the chemical down the drain and begin the dilution process. However, we all know that when the bell rings for class to end, students most likely think, "Dump it. What could possibly happen?" Cleanup is never a top priority, especially right before lunch or at the end of the day.

No matter how many copies of the material safety data sheet are handed out or posted, a student in a rush to see his girlfriend before the next class most likely won't take the time to properly dispose of his experiment, so the designer must provide piping products that ensure safety in all situations. Even the most vigilant teacher or lab supervisor cannot guarantee that every student is properly handling the chemicals or the gases they produce. Ultimately, it is the plumbing designer's No.1 duty to prevent a gas or chemical from eating through a pipe and possibly causing an explosion or hazardous situation. Another top priority should be to design the system as simple and yet as user friendly, and to some extent as fool-proof, as possible.

Piping materials vary from iron to poly to glass, and all have their advantages and disadvantages. Material and labor costs no doubt will be two of the primary reasons to decide for or against any particular product. **I've actually had contractors ask me if I've ever used glass pipe in a laboratory. I want to ask them if they've ever given testimony on why they *didn't* use glass pipe.**

A short list of piping would include double-contained systems, which are expensive for both materials and labor, as well as a single-pipe system made out of glass, which is almost invincible but also has high material and labor costs. Iron is slightly lower in applicable chemical conveyance and total costs. Once again, it is up to the plumbing designer to investigate the chemicals being used and to find the best product for everyone to win in the end.

Are you scared yet? Good! This is serious stuff. I have seen cast iron eaten to pieces and various plastic pipe melted to the point of being unrecognizable. Of course, once a pipe is damaged, the chemicals leak out and start eating cabinet work, floors, and just about anything else in the way. I have read the accident reports and lawsuits for all sorts of sicknesses and physical ailments caused by unnoticed leaks, resulting in unknown and unseen harmful gases or noxious odors. Just think of what would happen if one of those mad scientist types performed one last experiment just before winter break, and that super mix of stuff had several weeks to sit stagnant in the piping or eat through it. If the plumbing designer did his homework, this would not result in a catastrophic event.

As another note, the system design should include multiple cleanouts, not only to aid in cleaning, but also to allow visual inspection of the piping conditions. Also, increasing the pipe slope helps ensure that the chemicals don't stand in the piping, but flow as quickly as possible to the dilution basin.

NEUTRALIZATION

Coupled with the acid waste and vent piping is the acid neutralizing basin, where acids are diluted before they continue on to the sanitary sewer. Neutralization is critical to prevent the discharge from damaging the sewer system or the municipal sewer treatment plant. Obviously, we are talking about a very small amount of chemicals for a high school laboratory, and not hour after hour of chemical waste or discharge as from factories or manufacturing plants. However, I want to emphasize the importance of the neutralizing basin in the piping system.

Most acid waste piping manufacturers offer comparable neutralizing basins made of like material, and most also provide sizing guides to ensure proper sizing for the number of sinks connected to a basin. This sizing includes a built-in retention time for the neutralizing process to work. The retention time is key to providing downstream protection. Proper function of the neutralizing system requires determining the gallons per hour (gph) of acid waste. The recommended rate is 1 gph per fixture unit, but this does not include the high flow rates from some pieces of equipment. Select a tank with a liquid capacity (after filled with limestone) that is greater than the gph of designed flow into it. The initial rate of neutralization is rapid; however, as the pH of the acid waste rises, the rate of neutralization slows down, requiring a minimum of one hour of retention time. In very small applications, a point-of-use neutralization tank is most cost-effective and simple to maintain in most cases, since if issues occur the maintenance staff can remove and replace it. However, it is up to the maintenance staff to ultimately keep system flowing smoothly.

Most municipalities require sample wells or ports after the basins to monitor the level of wastes passing through the system.

Some of these automatically take samples at certain times, while others require a manual retrieval of wastes from the sample well. For small systems, the manual-style port is the norm, as the discharge is usually not so high that a long period of non-monitored flow could cause any harm.

FUME HOODS AND VALVES

The next item to consider is the equipment to be installed. Another old saying that comes from a popular auto manufacturer—"You can have it in any color as long as it is black"—doesn't apply here at all. An almost endless variation of equipment can be found in the various laboratory designs.

One of the items that almost always causes grief is a laboratory equipment standard: the fume hood. This is where experiments are conducted when it is known or suspected that the mixture of chemicals will produce a gas or a fume. They come in every variation imaginable and serve many different purposes with just as many requirements or supply needs. Some require acid waste, while others may not. However, you should provide acid waste anyway for added precaution. Compressed air, vacuum, and natural gas may or may not be included, and each has several different nozzle options. Water most certainly will be provided as well—cold, hot, tempered, distilled, softened, or deionized—again with numerous fitting options.

You also must provide isolation or point-of-service valves for each service. If equipment must be serviced or replaced, isolation valves allow the supply to be turned off only to that particular piece of equipment rather than the whole area or lab. Point-of-service valves are vital in minimizing the damage caused by sudden leaks because service can be quickly turned off. Also, maintenance and repairs are much easier when valves are just an arm's reach away from each piece of equipment.

While on the subject of valves, automatic shutoff or solenoid valves for emergency shutdown of supplies to the area also are critical, and most codes require them. The concern here primarily is the supply of natural gas, but some programs require a lockout of all services into the lab with a single panic button at or near the exit door. More often, schools are requiring the "killing" of utilities or services with a single shutoff and a single keyed reset. This usually is controlled by the teacher or lab supervisor, to return service once the all-clear is sounded or the problem is corrected.

In island sink installations, the gas piping is run either in vented sleeves or vented trenches to ensure that the gas is not emitted into space or collected into explosive pockets in case of piping leaks.

COORDINATION WITH OTHER TRADES

Fume hoods also need an exhaust and supply air ducts to remove the harmful chemical gases created in or under the hood, as well as electrical requirements and outlets. I mention these items only because if more supplies are needed to one point, less space is available in walls, floors, and ceilings to route piping, conduit, and ducts, which requires coordination of space with the other trades. The mechanical, electrical, and plumbing trades coexist very closely in labs where space is at a premium. In real estate, the phrase "location, location, location" dominates, whereas in laboratory design, it is "coordination, coordination, coordination." Everyone must communicate during design and installation to result in the best use of the space and eliminate extra costs for the owner.

PIPE SIZING

Of course, all of the services mentioned above occur at other various points along the walls or on desks and demo tables, where once again you must verify the type of outlet required. Remember that more often than not, the equipment supplier already has the proper products in the package, which helps you specify the correct fittings. However, you still must know where the outlets are located and how many of each are provided so they are properly connected during installation.

We all have a safety factor in our calculations when sizing piping, and in laboratories the safety factor is especially important due to the possibility of outlets being added at the last minute. One of the worst issues I've come across is designing a system to one set of specifications, only to realize that the supplier has delivered the newer version of a product that has different sizes, locations, and outlets requiring different demands. Oh my, where is the acid relief medicine?

The piping for most laboratory gases is relatively easy to size. Typically, a ½-inch pipe will suffice for most applications. However, here again you must know where to route the piping, how many outlets are required, and each outlet's demand (including future demand) to size it correctly. Sizing for gases seem to be most forgiving due to varying demands and/or loadings. However, this is where you must know what the lab is used for, the normal operation times, and equipment demands.

WATER NEEDS

I mentioned water earlier, and some laboratories require several types, from domestic cold and hot water to deionized water in both low and continuous flows. Point-of-use water softening or reverse osmosis systems may be required to treat the water on site. If the project requires a treated water supply, the issue is not only the piping to the outlets, but also providing service, locating equipment, and then sizing it all.

As I said in the beginning, this is not a simple exercise in plumbing. Planning and prior knowledge about what you are working with, as well as the client's present and future needs and goals, are essential.

SAFETY EQUIPMENT

One last very important element of any laboratory is the safety equipment—primarily the emergency eye wash and emergency shower, whether they are individual items or a combination unit. This is one item no one hopes ever has to be used, but it must work if needed. You must know the design use of the lab to know which of these safety measures to provide.

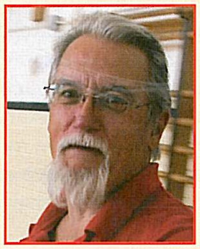
For instance, for a middle school lab, you mostly likely would need to specify an emergency eyewash unit at or on a utility sink in the room. For a high school lab, you would include an emergency eye and shower combination unit, with a floor drain or a direct drain to the sewer from the unit. Such units come with various ways to operate them, such as hand or foot operated or sensor triggered. They also are available in several different configurations, including hand-held and rigid mounted.

To specify the code-required equipment, You must know who the governing agent is in your area. Most of my work is in the state of Texas, and one of the main governing bodies and authorities is the Texas Accessibility Standards, but OSHA, for instance, might have more stringent rules to which you must comply. I mention this because the placement and number of units required will vary by the authority having jurisdiction.

Regarding the water supply to the emergency shower and eye wash, most codes now require water to be delivered in a "tepid" temperature range, typically between 60°F and 100°F, which seems to be the minimum and maximum in most printed ranges. I agree with this requirement for the most part, but I have an issue with the requirement for a hot water heater supply to provide the demand listed by some agencies, specifically ANSI and the Texas Education Agency. For example, the eyewash demand typically is 0.4 gallon per minute (gpm) for 15 minutes or 6 gpm at a maximum of 60 minutes, which could be provided from a small heater easily since only a tepid water mix is required. However, the emergency shower demand will cripple this logic: 15–25 for 15 to 60 minutes in various listed criteria. This requires 225 to 1,500 gallons an hour of supply when one works on a worst-case scenario, such as during a winter in North Dakota or neighboring states, where groundwater may be below 38°F.

KNOW BEFORE YOU GO

My main point is that it takes thinking and then more thinking before designing laboratory work at any level. In the same breath, I will say that the labs I have worked on are why I enjoy what I do. I am not saying that run-of-the-mill plumbing jobs are a no brainer, but laboratory design requires vast knowledge of the required systems before the experiments ever start. Hopefully the insights provided in this article give you a starting point for your learning. PSD



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