Containment and Sustainable (Green) Design

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When I was asked to contribute this guest editorial, at the front of my mind was the fact that containment facilities are designed to provide safety and security for the work that is done inside the lab. At no time should safety or security be compromised to promote sustainability. However, I believe there are many steps that you can take when you design a containment facility to make it a more environmentally responsible facility to operate during its planned life, and that these ideas should be shared with a broader audience. As Paul Jeanette eloquently explains in a course we teach, the most common words in containment facility design are "it depends." In other words, a single answer rarely covers all of the issues for all containment facilities. Be sure to examine the applicability of the information provided below for your specific project needs before you implement them.

Sustainable design deals with a broad spectrum of design issues that reduce the impact of a facility on the environment. The U.S. Green Building Council, which administers the LEED certification process for facilities, categorizes the issues in five ways: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality. I will address how each one might impact on containment facility design.

Sustainable Sites

Sustainable sites refer to site selection and design to minimize a facilities impact on the environment. As this is not specific to containment facilities, I will not try to address these issues here.

Water Efficiency

Efficient use and reuse of water can be important in laboratory facility design; however, it has limited application in containment facility design and operations. One can take advantage of the sustainable water design features of a normal building such as low flow fixtures and minimized irrigation of plant materials. When you get to the specific water uses in a containment facility, such as showers and handwashing sinks, the appropriate flow is important when you need it. One heavy user of water in a containment facility is the autoclave during the cool-down cycle. Chilled water coils can be substituted for this water cool-down system and can significantly reduce the water used by the autoclave. This has an added benefit when you have an effluent decontamination system of reducing one of the major loads on the system. This reduces chemical use if decontamination is by chemicals, and energy use if decontamination is by heat treatment.

Support areas outside containment can provide areas of sustainable design. For example, the condensate from air handling units can be collected and used as grey water for toilet flushing or irrigation.

Energy and Atmosphere

Laboratory facilities use a high level of energy and other non-renewable resources. Significant design responses for containment facilities can greatly reduce the impact of these facilities. This is the area where containment facility design can have the biggest impact on the environment. When you study the energy use in laboratories, the energy used by fans to move air into and out of the facility is often a major contributor to overall building energy use. Fan horsepower, which is the energy it takes to move the air, can greatly be reduced by a good HVAC system design involving two factors: 1) reducing the static pressure loss in the system; and 2) reducing the quantity of air exhausted (and supplied).

Designing to minimize pressure loss can play a large factor. You may want to consider providing a low pressure system by increasing duct sizes to reduce friction loss, and using HEPA filters with lower pressure drop for the same quantity of air. Small changes in pressure loss can result in big energy savings, as energy use increases by the square of the pressure in the system.

In containment facilities, the quantity of air exhausted is driven by three factors: air change rates, local ventilation requirements, and the internal heat load that needs to be overcome by outside air. Studies over the past 25 years have shown that air change rates are not effective at reducing biological contamination in laboratories. One study demonstrated that increasing air changes from 6 to 30 per hour had a minimal impact on potential aerosols in the room. It is becoming generally accepted that lower ranges of air changes per hour (e.g., six to eight) are acceptable in containment facilities. If you use higher air change rates, consider reducing the air changes when the laboratories are unoccupied. This may represent a significant energy savings. Take care, however, that you do not create a system that is difficult to balance and maintain. For Biosafety Level 3 (BSL-3) facilities, particularly rodent facilities with containment caging, provide the air changes for animal welfare within the cage, not the room. This can reduce the amount of air exhausted by half.

Local ventilation requirements in a BSL-3 laboratory are driven by the selection of the biological safety cabinets (BSC). For energy savings, use recirculated BSCs if your risk assessment allows. If you are required to exhaust BSCs, make your selection based on need. Canopy connected A2 cabinets require 20-100% more exhaust than a hard connected A2 cabinet; however, Annex E of NSF49 states "No type A cabinet should ever be hard connected to an exhaust system." B2 cabinets require 250-300% more air (at much higher static pressure) than an A2 cabinet. Moving from an 8-inch high sash opening to a 10-inch high sash opening can add another 25% exhaust requirement. Moving from a 4-foot cabinet to a 6-foot cabinet will increase the exhaust requirement by 50%. To sum it up, two 6-foot B2 BSCs in a small room may require over 120 air changes per hour to produce the exhaust required, up to 20 times a reasonable minimum. A type B1 cabinet with an 8-inch opening would have about 1/3 the exhaust flow requirement of a B2. BSC selection should be based on the real risk assessment of the facility and should be made carefully. This is also an area where environmentally responsible design can reduce the initial construction costs.

Containment labs can have greatly varying heat loads; from BSCs to mechanical freezers, the laboratory air conditioning has to overcome a lot of heat. Instead of using outside air to provide all of the cooling, consider using local supplemental cooling such as fan coils, chilled beams, and radiant ceilings. Some of this technology may be new to containment; you'll want to carefully evaluate the advantages and disadvantages and look carefully at maintenance issues.

For overall energy savings, consider recovering the heat and cooling from the exhaust stream. Many technologies are available and most would be appropriate in biocontainment with little, or no carryover from one air stream to another.

Lastly, correct system operation plays an important part in energy savings. Containment laboratories are usually highly commissioned; this savings is usually gained as an integral part of the containment laboratory delivery process.

Materials and Resources

The category relates to recycled content, local availability and renewable materials. As the materials in containment facilities often have specific requirements for performance, there are limitations on the options available to you.

Indoor Environmental Quality

The last LEED category is impacted both positively and negatively by containment facility design. One hundred percent ventilation, generally low chemical use, and the primary containment of biological hazards, translate to very good indoor air quality in containment labs. However, the need for flooring and wall coatings to be highly resistant to disinfectant chemicals limits choices for these materials. Depending on the actual needs of the facility, coatings may have a higher content of volatile organic compounds than green design would dictate.

Other indoor environmental issues, such as daylighting and views, can be incorporated into containment facilities with appropriate design. This can make these facilities very pleasant places to work. Task lighting, which comes automatically with BSCs, can improve work effectiveness and lower the overall light levels required in the space reducing operating costs.

While the above information does not represent all of the sustainable design options in a containment facility, it does argue strongly that sensitivity to green design, while planning a containment facility, can reduce first costs, reduce operating costs, and contribute to a sustainable world without compromising safety. That makes it an option that is hard to resist.