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Components of Successful Gaseous or Vapor Decontamination System

Ten Critical Details to Consider for Proper Decontamination

Effective decontamination procedures offer more than just peace of mind for principal investigators and others working in research facilities. In fact, the success of the research itself often hinges upon having an environment that is completely free of biological and structural contamination.

Providing the safest environment requires strict attention to decontamination details with no tolerance for error. Architects and engineers at Research Facilities Design (RFD) in San Diego use a 10-point checklist that outlines areas where special care must be taken to ensure that room decontamination is successful and safe.

The approach to decontamination varies from facility to facility, depending on the type of research being performed. The RFD list begins with the fundamental issue of the various agents currently being used in the United States for gaseous and vapor decontamination.

1. Agent Comparisons

The three agents used for decontamination at U.S. facilities are paraformaldehyde, vaporized hydrogen peroxide (VHP), and chlorine dioxide. Paraformaldehyde and chlorine dioxide are gases when they are in use, while VHP in its dry or wet mode is a vapor or mist. This difference is essential since a gas distributes more vigorously than a vapor.

“There is a lot of discussion about which agent is safer and which possesses a higher level of inherent risk,” notes Lloyd Fisk, architect and laboratory consultant at RFD. “All of these agents are dangerous at their operational concentrations, making it imperative that facility design and protocol ensure they are adequately handled when being used.”

The cycle time for each agent to decontaminate a typical laboratory varies with paraformaldehyde taking 12 or more hours, VHP requiring six to 12 hours, and chlorine dioxide being able to do the job in as little as three hours. The cycle times are much faster for small enclosures, such as pass-through chambers.

Engineered systems are available for local and central distribution of VHP or chlorine dioxide. However, paraformaldehyde is a more crude operation with no engineered system available in the marketplace. Therefore, VHP and chlorine dioxide are the focal points of the remaining concepts on the check list.

2. Local Delivery Systems

This type of decontamination delivery system utilizes a portable machine on wheels that is typically located directly outside the space being decontaminated. In other cases, the portable machine may be located directly above a room in a penthouse or mezzanine, or directly inside the room being decontaminated. This type of system can be designed with the flexibility to use either VHP or chlorine dioxide, minimizes potential points of failure, and requires little or no pre-installed infrastructure. The pre-installed infrastructure that is recommended is limited to delivery ports at each room to accommodate agent delivery.

There are also disadvantages to this type of system. For example, the unit often occupies space in the corridor, potentially impeding access, material movement, and egress.

Another disadvantage concerns consumables. “If we assume the unit is never leaving containment, the consumables that are involved always have to come in and out of containment whenever they must be changed out, so that adds to the operational complexity,” says Fisk. “If the unit is placed inside the room being decontaminated and a problem occurs with the system mechanics, no one can enter the room until the cycle is complete and the agent has been dispersed.”

3. Central Distributed Delivery Systems

This system features a manifold input outside the containment space with piping built into the facility to distribute the agent to individual rooms. RFD’s design recommendation is to connect empty PVC piping from the central manifold to each room. To distribute chlorine dioxide, small tubes are pulled through the PVC piping to carry the agent to each space. VHP requires a larger delivery volume and, therefore, is often distributed directly in the PVC piping.

“One of the biggest advantages is that a portable unit can be used with this system and it can be taken elsewhere in the building,” says Fisk. “The strategy is easiest to accomplish with chlorine dioxide because the units can push an agent quite a long distance, but the VHP centralized systems require a dedicated head-end system.”

This method of delivery is advantageous because consumables will always be outside containment and there is no need to occupy valuable floor space with equipment. The disadvantages include the installation cost and multiple potential points of failure. Furthermore, these types of systems are agent-specific, meaning decisions must be made in the planning stage to determine which agent will be used.

4. Casework Systems

Conventional fixed casework can present problems, making it difficult to decontaminate the pipe chase behind the base cabinets, as well as voids within double-wall metal casework. Fisk says that although taping or sealing the joints in the casework is a method to address this shortfall, it is still difficult to validate the effectiveness of the decontamination.

Instead, the use of fixed-base cabinets with traditional double-wall metal construction should be minimized or avoided in biocontainment facilities. Movable casework units with cantilevered or bracketed countertops made of solid phenolic resins are the best option.

5. Room Finishes and Materials

Conventional BSL-3 finishes and construction methods are sufficient for spaces that will be decontaminated. Fisk notes that good investments include epoxy resin or seamless vinyl floors, as well as epoxy-painted walls and ceilings.

“We always insist on drywall, solid-lid ceilings in biocontainment spaces. I would caution against any sort of hung ceiling, if you are building a new facility,” suggests Fisk. “It will be very difficult to validate the effectiveness of the decontamination in the void above the ceiling.”
High-performance finishes, such as stainless steel wall panels, fiberglass reinforced plastic wall

systems, and powder-coated steel wall panels, should be considered for use in dedicated pass-through rooms to achieve shorter cycle times.

It is important to ensure that all penetrations are sealed around electrical back boxes, lights, and piping fixtures.

6. Sealing the Doors

Doors present penetration problems that must be addressed. The traditional approach to dealing with perimeter weaknesses during decontamination is to close the doors and tape areas of potential penetration. The closing mechanisms located at the top of doors are cumbersome to tape, so hinges with built-in, self-closing mechanisms are an option.

Compression-gasketed and pneumatically compressed-air sealed doors are expensive alternatives, which can cost as much as $100,000 each.

7. Sealing the HVAC Ducts

HVAC systems also present penetration challenges.

The HVAC system is vital to the operation of a facility, but it also creates one of the biggest challenges relevant to decontamination. Leak-tight isolation dampers provide a permanent installation solution in areas where frequent decontamination will occur. They also enable the installed HVAC systems to purge the room once the decontamination is complete. These dampers cost thousands of dollars, but are effective at sealing the room.

A more cost-efficient, but less effective, solution is to seal diffusers and registers with tape and visqueen. While there are no additional upfront costs, there are ongoing operational costs associated with preparing rooms for decontamination and also no guarantees to prevent a failure in the sealing. This method, which requires the positive shutoff of the HVAC supply and exhaust systems to the room, does not permit the use of installed HVAC systems to purge the rooms once the decontamination is complete. Rather, it requires a carbon scrubber or catalytic converter to purge the space prior to personnel access.

8. HVAC Design Considerations

Many factors, such as risk assessment, must be taken into consideration during the design phase when planning a new BSL-3 facility.

“A major consideration would be to determine what kind of air valves are being used, especially on the exhaust side where you would potentially need to decontaminate this leg of the exhaust system,” says Paul Lemestre, director of engineering at RFD. “The coating of the valves must be compatible with the agent. We don’t want to have raw galvanized steel which can act as a catalyst for VHP and reduced concentrations for decontamination. Stainless steel can be used on the exhaust and supply air systems, which are going to be exposed to normal room decontamination.”

Stainless steel coil headers should be used on the reheat coil system, if there is the potential of decontaminating the supply duct.

9. HVAC Controls

The HVAC control system can be designed to allow switching from normal operating mode to decontamination mode by installing a local control switch to shut off the supply and exhaust and

shut the leak-tight dampers. When a central distributed delivery system is used and the agent is piped from a remote location, there must be a proper exhaust air manifold system to balance the exhaust air flow from rooms and avoid over-pressurizing the room during decontamination.
“You need to consider what room the central equipment will be in and whether you will have to run an exhaust system to that room to control room pressurization,” says Lemestre.

10. Using Pre-Manufactured Chambers

There are three types of pre-manufactured chambers available today (rack washers, autoclaves, and dedicated decontamination pass-throughs), that are capable of accepting gaseous or vapor decontamination agents. These chambers have either integrated dedicated generators or ports so they can be connected to portable generators.

Since these chambers are engineered solely for handling agents, they optimize cycle times, pose fewer construction issues, are more reliable, have pneumatically gasketed doors, and feature integrated controls. Therefore, they offer a turnkey solution to addressing design and construction issues of building a BSL-3 facility.

The only disadvantages are that the chambers can cost more than $200,000 and are often only available in limited sizes.

Key Design Decisions

To correctly design a facility, decisions about decontamination requirements must be made early in the planning phase. A key question is whether a local system will be acceptable or whether a central distributed system will be worth the additional expense for the enhanced operational convenience.

If a distributed system will be used, an agent must be selected during the design stage to ensure proper construction. Essential infrastructure must be included in the design, taking into account that the distribution network and the HVAC controls vary from one agent to another. The HVAC control system needs to be designed to accommodate the cycles and gasketed doors should be considered at dedicated pass-through rooms.

Making important decisions at the beginning of a project eliminates the potential for problems after the facility is constructed.

By Tracy Carbasho

This report is based on a presentation by Fisk and Lemestre at Tradeline's *2010 International Conference on Biocontainment Facilities* in March.

Project Data

Location:

Decontamination Agents
Credit:
Image courtesy Research Facilities Design.
Local delivery systems typically utilize built-in ports to deliver the decontamination agent into each space.

Decontamination Challenges
Credit:
Image courtesy Research Facilities Design.
Conventional fixed casework presents decontamination challenges with respect to chases and the interior of double-wall construction. Movable casework is preferred in order to allow for thorough decontamination that can be validated.

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