

Ask the Experts:

# Airflow Equipment for Animal Research Facilities

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## Introduction

Animal research facilities play a critical role in advancing scientific knowledge, particularly in biomedical research, drug development, and disease modelling. These specialized environments ensure that research involving animals (e.g., mice and rats) is conducted ethically, safely, and in compliance with regulatory requirements. Facility design is paramount to maintaining high standards of animal welfare, researcher safety, and experimental integrity.

Effective vivarium design is guided by core principles that prioritize both animal welfare and scientific rigor. These principles shape the facility's layout, operations, and equipment selection, as the right tools are essential for achieving reliable outcomes.

This article explores the types of equipment commonly used in animal research facilities and key selection criteria, beginning with foundational design principles.



Class II Type A2 Animal Handling Biosafety Cabinet

## 1. Ensuring Animal Welfare

In designing such facilities, animal welfare must always come first. Every design decision, from airflow systems to temperature control, to equipment selection, must prioritize the health, comfort, and well-being of the animals. As the cornerstone of ethical research and housing practices, ensuring optimal living conditions is not just a technical requirement but a moral obligation.

Optimal airflow systems are essential for maintaining animal welfare by regulating temperature, humidity, and air exchange rates. Poor ventilation can lead to heat stress, respiratory issues, and increased ammonia buildup from waste accumulation. To prevent such risks, HVAC (Heating, Ventilation, Air-Conditioning) systems must be designed to provide a steady supply of fresh air, minimize drafts, and maintain stable environmental conditions.

Individually Ventilated Cages (IVCs) have become the standard for housing small animals due to their ability to maintain controlled microenvironments within individual cages. However, no IVC system can compensate for a poorly designed HVAC system. Without proper temperature and humidity control at the facility level, even the most advanced IVCs will fail to create optimal conditions. This underscores the importance of a designer's thorough knowledge of HVAC design parameters and equipment for animal care and use. More on IVCs later.

It is also essential to recognize that different animal species and models have unique optimal housing temperatures to ensure their comfort and well-being. Tailoring environmental conditions to meet these specific requirements is key to promoting animal health and supporting reliable research outcomes.

## 2. Controlled Environment

A controlled environment is essential not only for ensuring reproducible research outcomes but also for meeting the specific needs of SPF (Specific Pathogen-Free) and/or biocontainment facilities. Pressure regimes in such facilities must be established during planning, and appropriate laboratory equipment must be provided.

For SPF facilities, the design aims to prevent the contamination of animals from the external environment. In biocontainment, the pressure regime should be in cascading negative pressure to prevent the accidental release of biological agents into the environment.

More importantly, the design of these systems must be tailored to the specific requirements of the institution, whether the focus is on SPF, biocontainment, or a combination of both. "One size does not fit all"—each facility must balance its unique operational needs with the overarching goal of creating a safe, controlled, and ethical environment for animals and researchers alike.



### 3. Allergens and Odor Abatement

Proper airflow management and the use of appropriate laboratory equipment are essential for reducing airborne allergens and odors, both of which pose significant challenges in animal facilities. Animal care and use activities, such as direct contact during experiments or cage changes, inevitably generate allergens. These allergens can be transferred to laboratory staff during routine tasks, and inadequate equipment or HVAC design may worsen the problem by recirculating allergens, leading to cross-contamination between rooms. To address this, it is critical to control allergens at their source by selecting and utilizing the right equipment.

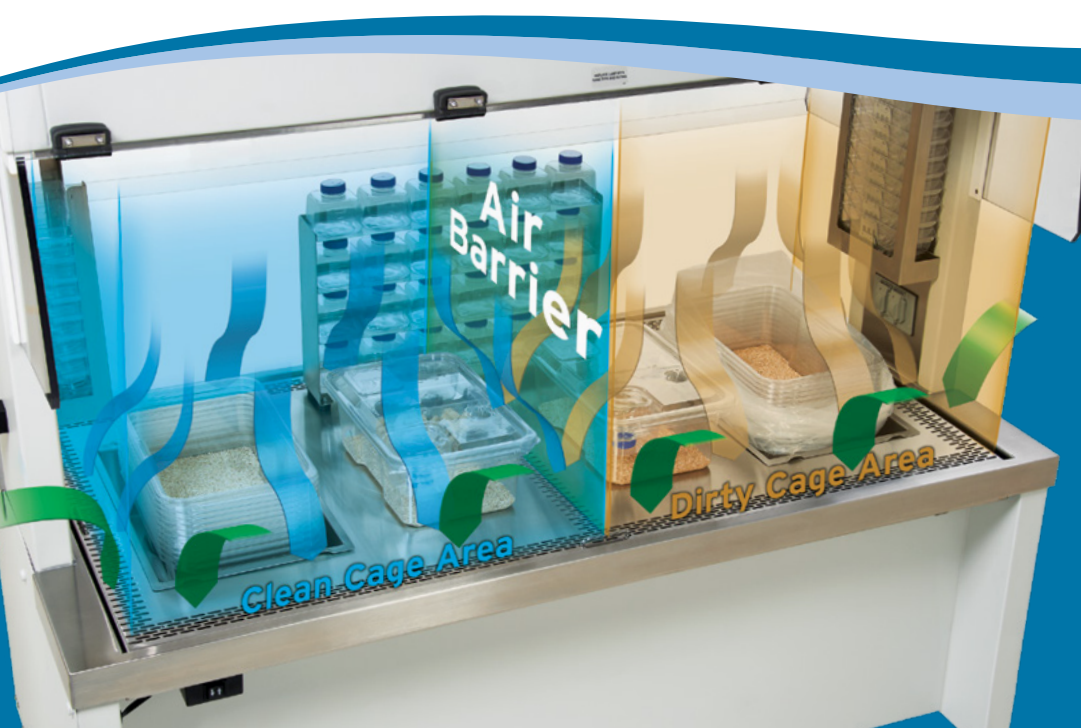
Similarly, odors in these facilities should neither be acceptable nor tolerated, as they can have significant negative impacts on human health and operational efficiency. These unpleasant smells are often associated with harmful compounds, including volatile organic compounds (VOCs), ammonia, and particulates, which can cause a range of health issues. Prolonged exposure to such odors can lead to decreased worker productivity and increased absenteeism. From an operational perspective, persistent odors can result in community complaints and potential regulatory scrutiny. Fortunately, these challenges can be effectively addressed through the implementation of proper ventilation strategies and the use of advanced odor control technologies, ensuring a safer and more pleasant working environment.

### 4. Animal Care and Use Equipment

The animal care and use equipment market offers countless brands and options, making selection a challenging task. Whether for safety, allergen control, or housing solutions, selecting the appropriate equipment guided by the principles above is a good start.

**Narrowing it down to the equipment that can serve the functions and meet users' needs for years to come, there are several factors to consider:**

- Meets internationally recognized standards
- Fit-for-purpose design
- Ease of maintenance
- Ease of use
- Ergonomics
- Cost-effective customization



Example of a custom configured work zone on an animal transfer station.

The following equipment can be good examples of these considerations:

## 1. IVCs (Individually Ventilated Cages)

Individually Ventilated Cages (IVCs) are advanced housing systems that provide a controlled microenvironment for laboratory animals. Featuring HEPA-filtered air supply and exhaust, they effectively manage airborne contaminants, allergens, and odors. With high air change rates (often over 70 per hour), IVCs maintain optimal air quality, enhance animal welfare, and protect personnel from potential biohazards. Their design also prevents cross-contamination, making them suitable for SPF (Specific Pathogen-Free) and bio-containment uses.

IVCs can be configured for positive or negative pressure depending on application. Some systems use the same model for both, allowing users to switch pressure modes. However, if not airtight and paired with a simplified HMI (Human Machine Interface), switching modes—especially in containment settings—can pose safety risks.

Disposable cage options are available, reducing washing needs and contamination risks. Both disposable and reusable IVCs have pros and cons, so selection should match the facility's purpose. Cage design should prevent air chill; this can be assessed by checking the air inlet direction. Durability is also key—how many autoclave cycles a cage can withstand affects long-term value. Facilities should aim for systems that balance performance, cost, and reliability.

## 2. Biosafety Cabinets

Class II Biosafety Cabinets (BSCs) are essential equipment in animal facilities, providing both allergen protection and biosafety. These cabinets create a controlled environment for animal handling and procedural work, ensuring the safety of both personnel and research subjects. Among the various Class II BSCs, the Type A2 is frequently preferred for its optimal balance of safety and functionality. This model recirculates HEPA-filtered air within the cabinet while exhausting approximately 30% of air through the exhaust HEPA filter, offering superior protection against particulates and allergens. Consequently, it is ideally suited for tasks such as sample preparation and other procedures requiring a sterile and secure workspace. In a small facility, cage changes may be performed within a BSC.

While HEPA filtration in BSCs effectively addresses biohazard mitigation, it is ineffective against fumes and odors. To address this limitation, a canopy connection is often necessary to ensure the safe removal of fumes and odors via the facility exhaust system. It is important to note that not all manufacturers provide canopy transitions that fully comply with NSF/ANSI 49 standards. A compliant canopy transition must maintain inward directional airflow at the connection point and provide an alarm when it does not. A flexible interface between the exhaust duct and the canopy connection is recommended to mitigate vibrations, which could potentially compromise the BSC's structural stability and performance.

Although the typical sash height for NSF/ANSI 49 BSCs is 8 or 10 inches, some manufacturers offer higher window heights that are fully NSF/ANSI 49-compliant. Extra sash height (e.g. 10 or 12 inches) can allow users more vertical workspace, making it easier to handle animal cages, thus improving overall user ergonomics.



Class II Type A2 Animal Handling Biosafety Cabinet

### 3. Cage Change Stations/Animal Transfer Stations

In large facilities, frequent cage changes are essential to maintaining hygiene and animal welfare. Depending on the facility size and animal population, husbandry staff may spend four to six hours per day on cage-changing activities. Given this significant time commitment, ergonomics, convenience, and allergen protection become critical factors when selecting cage change stations. While biosafety cabinets (BSCs) provide certain versatility for cage changing, they are not designed to support the high-frequency workflow required for efficient cage changing. A dedicated cage change station ensures a controlled work environment, minimizes exposure to allergens, and enhances staff productivity.

Proper downflow and inflow controls are crucial for containing fine dust and allergens generated when disposing of used bedding. As staff empty cages, airborne contaminants can pose respiratory risks if not effectively managed. A reputable manufacturer should be able to demonstrate its capability in containing these hazards through advanced airflow design, ensuring that HEPA-filtered downward airflow captures contaminants at the source, preventing their escape into the surrounding environment.

Maneuverability is essential, with high-quality casters that allow for easy relocation, even in tight spaces. On some occasions, customizations may be required. Experienced manufacturers anticipate these potential requests and design their equipment to be modified cost-effectively.



Animal Transfer Station

## 4. Animal Refuse Workstations

An animal refuse workstation is essential in facilities where frequent cage dumping and waste handling occur. It is designed to provide a controlled environment that minimizes the spread of allergens, dust, and odors, ensuring the safety of personnel. To meet these requirements, the workstation is designed like a Class I BSC where there is consistent inflow with HEPA filters. If exhaust air is being recirculated in the facility, activated carbon filters for odor control should be considered. Adjustable working height for ergonomics and a sensor system to detect waste load, are options a manufacturer should be able to offer.

When selecting between an animal handling Biosafety Cabinet (BSC), an Animal Transfer Station, or a Cage Dumping Station, users should first assess the type of hazards involved—whether biohazards, allergens, or both. A Class II BSC is required when handling biohazardous materials or when sterile conditions are necessary, as it offers protection for personnel, the product, and the environment.

An animal transfer or cage change station provides a controlled, HEPA-filtered airflow environment that helps protect personnel and animals from allergens and particulates during routine procedures. However, these stations are not intended for biological containment and do not provide the full level of protection required for work with infectious or biohazardous agents. For such procedures, a Class II biosafety cabinet (BSC) is necessary to ensure adequate biocontainment for personnel, animals, and the environment.

For facilities dealing with frequent cage dumping and high waste volumes, a refuse workstation is best suited to manage odors, allergens, and particulates. When choosing equipment, consider the level of containment needed, frequency of use, ergonomic demands, and type of work performed. This structured approach helps ensure equipment is fit-for-purpose, without compromising biosafety or workflow efficiency.



Animal Refuse Workstation

## 5. Modifying Equipment for Vivarium Needs

While standard equipment with optional features meets most requirements, some equipment may need further customization. In such cases, modifications must be made without compromising performance—and only with the manufacturer's explicit authorization.

Operators should collaborate closely with the manufacturer to tailor equipment to their specific workflow. **Examples of potential modifications include:**

- Resizing the unit for better maneuverability within the facility
- Adding deep wells in the work surface to accommodate preferred cage brands
- Integrating a waste chute or feed hoppers
- Other adjustments to enhance functionality

Since these customizations are often unique, partnering with an experienced manufacturer is highly recommended to avoid design pitfalls.

For equipment requiring significant modification, testing and commissioning protocols may differ from standard models. Operators must ensure that all modifications undergo rigorous validation to verify performance, safety, and compliance with industry standards (e.g., ISO, GLP, or facility-specific guidelines). Functional testing should include stress tests, fail-safe evaluations, and compatibility checks with existing workflows. Additionally, documentation—such as updated manuals, risk assessments, and certification records—must be maintained to ensure traceability. Since modified systems may introduce unforeseen operational risks, close collaboration with the manufacturer during post-installation reviews is critical to address any performance gaps or safety concerns proactively.

## 6. Gnotobiotic Research Facilities

A gnotobiotic facility is a highly specialized environment designed for breeding, housing, and maintaining animals that are entirely free of microorganisms, including bacteria, fungi, viruses, and parasites. These facilities employ stringent isolation techniques and sterile conditions to create and sustain germ-free or defined-flora animals. Breeding occurs in sterile isolators, where germ-free parents produce offspring that inherit their microbe-free status.

Gnotobiotic facilities employ advanced airflow management and HEPA filtration technologies to maintain a sterile environment for breeding and housing microorganism-free animals. These sophisticated air handling systems typically operate at a much higher air change per hour (ACH) of HEPA-filtered air rate. This high level of air purification is crucial for maintaining the germ-free status of the animals and preventing contamination from external sources.

The transfer of gnotobiotic animals from their housing to experimental areas presents unique challenges that require careful consideration and specialized equipment. Facilities often utilize sterile transfer ports or docking systems for germ-free shipping containers to ensure the animals remain in a sterile environment during transport. For experimental procedures, dedicated sterile workstations or modified biosafety cabinets are employed to maintain the required aseptic conditions. These setups must be carefully designed to allow for necessary manipulations while preserving the sterile status of the animals.

Given the stringent requirements of gnotobiotic research, equipment often requires customization to meet specific research needs while adhering to fundamental sterility principles. Specialized housing units such as flexible film isolators or rigid isolators with built-in gloves and transfer ports are common in these facilities. These units may be modified to accommodate particular experimental protocols or animal species while maintaining their essential sterile functionality. The design and implementation of such customized equipment demand a deep understanding of both the research requirements and the principles of maintaining a germ-free environment, highlighting the complex and precise nature of gnotobiotic animal research. Consulting the right manufacturer is the first step.

## Conclusion

In conclusion, the design and selection of equipment for animal research facilities are fundamental to ensuring the welfare of the animals, the safety of researchers, and the integrity of scientific research. A well-designed facility must incorporate systems and tools that maintain a controlled environment, promote animal health, and facilitate efficient operations. Thoughtful consideration of factors such as contamination control, ergonomics, and hygiene is essential to creating an environment that supports both ethical standards and high-quality research outcomes.

As research requirements continue to evolve, the demand for highly specialized, customizable equipment will only increase. Manufacturers who understand the unique challenges of animal research and can deliver tailored solutions are key to meeting the needs of these dynamic environments. Ultimately, a commitment to quality design, effective airflow management, and tailored equipment solutions ensures that animal facilities remain safe, ethical, and productive, fostering advancements that benefit science, healthcare, and society as a whole.



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