

Adequate and comfortable ventilation with good air quality and stable conditions

The M.I.C.E.[®] system of microisolation cages uses HVAC-assisted, direct exhaust venting to assure microenvironmental comfort, isolation, containment, and enrichment at the cage level. Cage ventilation is assisted by the thermodynamics of low air inlet and high air exhaust. The caged animals' metabolic heat warms the air, which rises towards the top and exits through the vent located at the highest end of the cage. As warm air exits at the rear of the cage, cooler air enters through the filtered bottom port at the front of the cage. M.I.C.E.[®] cages deliver a one-pass airflow at low velocity from the large filtered air inlets across the cages to the exhaust ports. The inlet and exhaust ports each pass filtered air through openings exceeding three (3) square inches. The M.I.C.E. system thus eliminates the high turnover of dry air, the noise, and the vibration inherent in individually ventilated caging systems that are pressurized by blowers pumping air through small air jets. Our unique cage and rack closed-system provides adequate air changes per hour without drafts, metabolic contaminant buildup, or any need of mechanical ventilation.

AIR DISTRIBUTION: Rivard et al. published a paper titled: "A Novel Vented Microisolation Container for Caging Animals: Microenvironmental Comfort in a Closed-System Filter Cage" in *Contemporary Topics*, 2000, Vol. 39, No. 1, pp. 22-27. We studied air distribution and movement inside the cage, and used smoke tests in a wind tunnel with a laser light sheet (Fig. 1) and computational fluid dynamics (Fig. 2) to assess the air distribution pattern and movement. Our findings showed a low velocity air movement of thermals toward the top and the back of the cage. All the air was removed at each air volume exchange; with no stale air and no high turnover of dry air as seen with forced-air ventilated caging systems (Fig. 3). To further study the complete air volume exchange rate, cage venting was adjusted to 30 air changes per hour (ACH). The measured maximum air velocity at the exhaust port was only 5 feet per minute (fpm) (Fig. 4). Breeders in M.I.C.E. cages build their nest in the back of the cages, away from human observation (a normal behavior) and in the healthy and quiet microenvironment provided by our gentle, one-pass airflow. The ventilation performance of M.I.C.E. cages allows an extended cage-changing period up to three weeks, minimizing disturbances to breeding mice and avoiding aggressive behaviors in males.



Figure 1: Smoke tests in a wind tunnel at CSU.

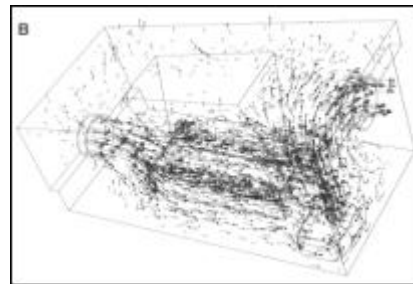


Figure 2: Velocity vectors shaped by a feeder-trough assembly and a 5-mice model near the air exhaust.

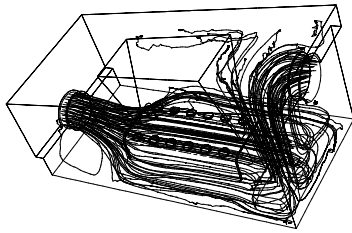


Figure 3: Particle traces spreading around a feeder-trough assembly

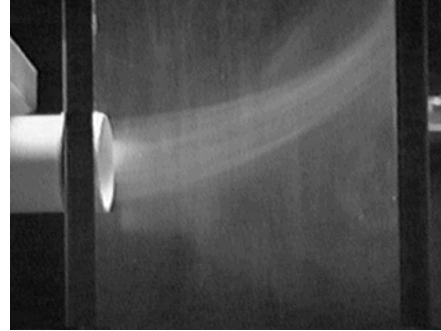


Figure 4: Air velocity measurements at CU-Denver.

AIR FLOW: We compared rates of air exchange and air velocity inside the cage between the three types of caging system:

- SMIC :** Static Microisolator Caging
- VMIC :** Ventilated Microisolator Caging with forced-air ventilation
- M.I.C.E. :** Vented Micro, Isolation, Containment, and Enrichment caging.

Figure 5 compares the air changes per hour (ACH) between the three types of caging systems. As expected, **SMIC** static cages show the lowest air change rate, with a reported 0.82 ACH. Animal room conditions have no effect on the ACH inside these cages. Air change rate inside **VMIC** forced air-ventilated cages varies from 40 to 120 ACH depending on the manufacturer, with an average of 77 ACH. The **M.I.C.E.** cages have 15 ACH. This setting promotes animal comfort level and results in cage-changing period of up to three weeks.

Figure 6 lists maximum air velocity in feet per minute (fpm) at the ACH noted above in the three types of caging systems. The Air velocity in **SMIC** cages is too low to be recorded. Air velocity has been recorded at up to 150 fpm in **VMIC** caging systems. This is due to the forced-air and small air jets typical of many mechanically ventilated systems. In a **M.I.C.E.** cage, the maximum air velocity is 5 fpm at the exhaust port. This gentle air flow provides a comfortable and stress-free microenvironment.

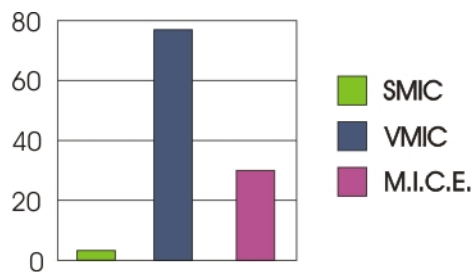


Figure 5
Air Changes per Hour (ACH)

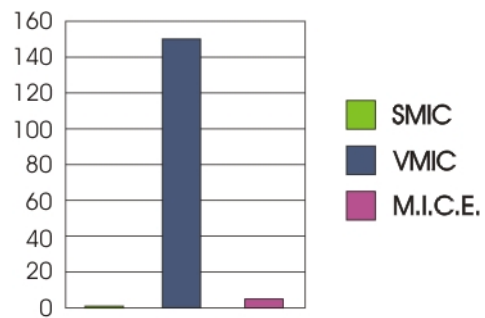


Figure 6
Air Velocity (feet per minute)

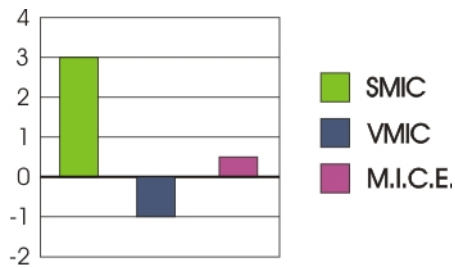


Figure 7
Cage Temperature
(Deg. C. relative to room)

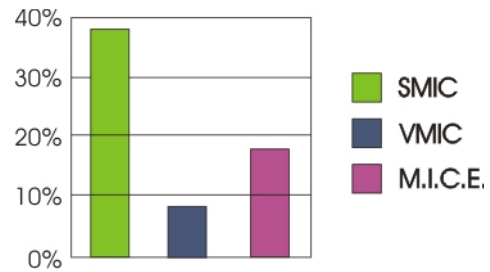


Figure 8
Relative Humidity (%)

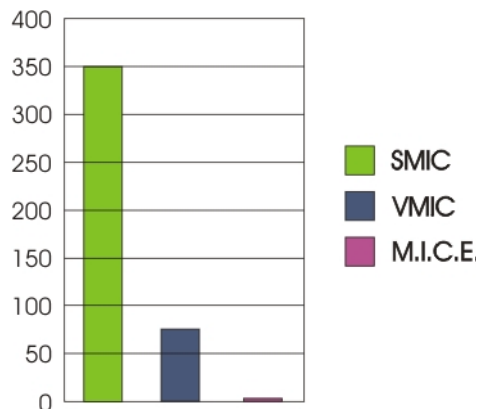


Figure 9
Ammonia Concentration (ppm)

GOOD AIR QUALITY: We compared temperature, relative humidity, and ammonia concentration between the same three types of caging systems.

After 5 DBA mice had occupied a vented M.I.C.E. cage for a week, its average temperature gain was 0.5 °C, relative humidity was 18%, and ammonia concentration was 3 ppm higher than the room. Figures 7, 8, and 9 compare this data with similar data of studies conducted using SMIC and VMIC occupied with 5 DBA mice. SMIC had an average temperature gain of 3 °C, relative humidity of 38%, and ammonia of 350 ppm above room. VMIC had an average temperature of -1.0 °C, relative humidity of 8.5%, and ammonia of 75 ppm above room. High levels of ammonia were recorded in VMIC due to excessive air recirculation and dead air spaces.

The vented M.I.C.E. caging system solves the problems related to individually ventilated caging systems such as high turnover of dry air, noise, and vibration. It provides a stable, healthy and stress-free microenvironment without noise and vibration, making it ideal for difficult-to-breed transgenic, knockout, and immunocompromised strains. In M.I.C.E. cages, reproductive performance increases significantly, with more pups per litter, higher pup survival rate, faster weaning, and much healthier and docile mice. Stable cage conditions result in less inter-animal variability, thus fewer animals are needed to reach statistical significance.

Overall, the M.I.C.E. caging system reduces to a minimum microenvironmental variables and biological consequences of air quality, thus providing better science.