

HEATING, VENTILATION, AND AIR CONDITIONING

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The following is a selection of frequently asked questions (and their respective answers) concerning *Heating, ventilation, and air conditioning: Addendum to the CCAC guidelines on laboratory animal facilities – characteristics, design and development* (CCAC, 2019).

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1. Why was the addendum developed?

CCAC program participants requested that the CCAC consider revision of guidance concerning heating, ventilation, and air conditioning systems to address the operation of newer systems aimed at maximizing energy efficiency and lowering operating costs. The addendum focuses on performance standards, rather than a specified air change rate, to help institutions utilize technological advancements while ensuring clean air is provided for the animals and personnel.

2. Are all institutions expected to implement an air quality monitoring system in accordance with the addendum?

Institutions are expected to follow either the requirement specified in the [*CCAC guidelines on: laboratory animal facilities – characteristics, design and development*](#) (CCAC, 2003) (i.e. 15-20 air changes per hour) or implement the infrastructure and monitoring and generate the documentation necessary to ensure clean air is provided for animals and personnel at all times, as described in the addendum. As noted in the addendum, monitoring is required when facilities operate at less than 15-20 air changes per hour, but it is also encouraged as good practice for facilities operating at 15-20 air changes per hour as there is still the potential for air quality problems.

3. What is “clean air”?

Clean air in a laboratory environment refers to air that supports the health and well-being of the animals maintained within the facility and the staff who work there. The composition of clean air meets the supply air target values noted in the addendum: 0 ppm ammonia, 350-600 ppm carbon dioxide, <28.2 million particulates (PM 2.5)/m³, and 0 ppb total volatile organic compounds.

4. What is the basis for the performance standards defined in the addendum?

The performance standards for air quality specified in the addendum are the result of the work of the expert volunteer subcommittee to assimilate evidence gathered from the published literature, an online survey, and the extensive feedback received from three external reviews of the draft addendum.

5. Why do the performance standards include total volatile organic compounds when there have been articles showing it does not reliably predict air quality in buildings designed for human occupancy? Wouldn't a single volatile organic compound (e.g., formaldehyde, toluene, etc.) be a better indicator?

The guidelines are intended to not only protect animals and personnel, but also the integrity and repeatability of the research. It is therefore important to ensure a stable environment as well as a safe environment. Monitoring total volatile organic compounds is appropriate to indicate any change or trend that requires further investigation.

Measurement of total volatile organic compounds is supported by green building standards such as [LEED](#) and has also been used in the [WELL](#) standard. The total volatile organic compounds limit noted in the addendum is widely accepted as indicative of good indoor environmental quality. Although it is not perfect and not usable directly as a health measure since different volatile organic compounds have different

threshold limits, total volatile organic compounds is easily measured and the best general, comprehensive measure available, particularly as a diagnostic tool.

It is possible to get a high total volatile organic compounds reading that is not a health problem due to the volatile organic compounds involved, but it does indicate an abnormal change that is worth investigating. By only measuring some individual volatile organic compounds, other compounds of interest could be missed, as there are a large numbers of volatile organic compounds and it is difficult to measure more than a few compounds continuously.

6. What are episodic events and why is it important to consider them in determining appropriate ventilation rates?

Episodic events are unexpected problems that influence air quality. Examples of such events include the following:

- improper training of an individual or human error – e.g., dropping a cage while changing cages, or opening a cage outside of a biosafety cabinet or change station;
- failing to plan for research procedures that cannot be conducted in a biosafety cabinet or change station, such as stereotaxic surgery; or chemicals that are used in conjunction with research procedures;
- procedures that do not follow best practice – e.g., using different chemical products to clean the room; bottom-only cage changes that stack dirty cage bottoms outside the biosafety cabinet or change station without cage tops; and
- broken or failing equipment – e.g., malfunction of individually ventilated cages; improper cage connections and failure to maintain cage top filters that may be worn or torn.

In each of these examples, contaminants would be released into the air of the room. Depending on the type and amount of contaminants released, this could affect the health and well-being of the animals and personnel, and/or the scientific studies being conducted.

When an episodic event occurs in a room with a ventilation rate of 15-20 air changes per hour, the air in the room is diluted with the source air, and the air quality components return to acceptable levels within a reasonable amount of time. However, when an episodic event occurs in a room where the ventilation rate has been lowered, dilution of the air in the room with the source air will be slower, relative to the air changes per hour of the room. In such situations, the ventilation rate needs to be increased to the maximum rate to efficiently remove the contaminants.

7. Why is there a lower limit of 12 air changes per hour for facilities that do not have a demand-based system?

Responding to episodic events through increased ventilation is most efficiently achieved through a demand-based heating, ventilation and air conditioning (HVAC) system, in which air quality is continually monitored and the ventilation rate is automatically increased when set criteria are detected, while maintaining air pressure differentials. For these systems there is no prescribed minimum air changes per hour.

For systems that do not have an automatic response to changes in air quality, it will take longer to dilute contaminants if the air changes per hour is lowered. For these systems, if air quality monitoring of a room indicates that a reduction in air changes per hour is acceptable, maintaining a minimum operating level of 12 air changes per hour will allow for some energy savings while still maintaining the ability to flush contaminants from the room at a reasonable rate.

8. Do the same air quality standards apply to rooms where animals are housed in ventilated racks?

Yes, the air quality standards for the room are the same, regardless of the equipment in the room. Although individually ventilated cages have a much higher air change rate (i.e. 30-70 air changes per hour) than the room, the air supply for ventilated cages is often drawn from the room. In these cases, the animals are susceptible to the air quality conditions of the room. Even if the air entering the cages is high efficiency particulate air (HEPA) filtered, there is no protection for the animals against the organic and inorganic gases present in the room air, or from the heat load created from equipment and people working in the room.

Individually ventilated cages connected directly to the outside do exist; however, unless they are completely sealed (which is rare) there is still some air exchange with the room at the top of the individually ventilated cages, which is used to maintain pressure differentials.

9. Does the addendum apply to situations where animals are taken from animal facilities to labs for procedures, surgery, imaging, etc. or where animals are housed in an investigator's lab?

The intent of the addendum is to ensure that the health and safety of the animals and personnel are protected at all times. The CCAC expects institutions to adhere to the principle of the addendum, with the critical requirement being that clean air is available to all animals and personnel at all times, with minimal or no potential for cross-contamination; however, for short-term holding and for areas external to the laboratory animal facility where procedures are carried out, it is recognized that the air changes may not meet the standards described in the [*CCAC guidelines on: laboratory animal facilities – characteristics, design and development*](#) (CCAC, 2003) and addendum. Animals may only be held in these conditions for up to 12 hours, provided that their health and safety are not affected. It is also important to recognize that there may be some impact on research results if animals are moved from a controlled environment into an uncontrolled one. If there is any question about the negative impact of such a move, it should not be carried out.

10. Do the same air quality standards apply to institutions that hold animals for teaching purposes?

The intent of the addendum is to ensure that the health and safety of the animals and personnel are protected at all times. However, for small teaching programs where the animals are held for a maximum period of 12 hours, it is recognized that the principle stated in the addendum may be difficult to achieve. In these cases, the air changes may be lower than the required 15-20 per hour, provided that the health and safety of the animals are not affected. This does not apply to institutions where only some of the animals held in the general animal facility are included on teaching protocols.

11. Does the addendum apply to aquatic rooms?

The conditions in aquatic rooms differ significantly from rooms that house terrestrial animals, and therefore the air quality of aquatic rooms is addressed in separate guidelines for fish and other aquatic species.

12. Are there requirements for air quality within cages?

The limits for each of the components (ammonia, carbon dioxide, particulates, and total volatile organic compounds) within enclosures depend on the species. Therefore, these will be described in each of the guidelines on particular types of animals based on the available evidence.

13. When air quality monitoring is required, how long should records be retained?

Records for air quality monitoring should be retained for the same period as required for other records that can have an impact on the animals, personnel or research. Section 12.1, “Access to Records and Record Retention” in the *CCAC guidelines: Husbandry of animals in science* (CCAC, 2017) states “Health records and records for food, water and bedding should be retained for a period of time suited to the type of research and institutional requirements; a minimum of one year is required, or as long as necessary to meet the requirements of the government, relevant professional associations and the research.” In keeping with this, air quality records should be retained for as long as necessary to meet the needs of the research and other requirements, with a one year minimum. However, retaining records for up to five years can be useful for gaining an understanding of the overall system performance.

14. The *CCAC guidelines on: laboratory animal facilities – characteristics, design and development* (CCAC, 2003) includes Appendix C excerpts from the *CCAC Guide to the Care and Use of Experimental Animals* (vol. 1, 2nd ed., 1993) listing recommendations for air changes per hour for different types of animals. Do these still apply?

Heating, ventilation, and air conditioning: Addendum to the CCAC guidelines on laboratory animal facilities (CCAC, 2019) applies to all types of animals within a laboratory setting and supersedes the recommendations currently listed in Appendix C of the CCAC guidelines on laboratory animal facilities. The *CCAC guidelines on: laboratory animal facilities – characteristics, design and development* (CCAC, 2003) is currently undergoing review, and Appendix C will be removed once the document is updated on the CCAC website. Where recommendations related to air quality for different types of animals are necessary, these will be included within the individual animal-type guidelines, as they are developed.