



HYGIENIC ASSESSMENT OF INDOOR AIR IN MAGNETIC RESONANCE IMAGING SUITES FOR PATIENT AND STAFF SAFETY

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Abstract

Indoor air quality in magnetic resonance imaging (MRI) suites requires an assessment that integrates environmental hygiene with magnetic resonance safety. This narrative review examines ventilation, thermal conditions, particulate pollution, cleaning-related chemical exposure, airborne infection control, and oxygen displacement associated with cryogenic systems. Selected guidance from the American College of Radiology, the Centers for Disease Control and Prevention, the World Health Organization, ASHRAE, and the Occupational Safety and Health Administration was considered. A practical monitoring framework is proposed for scanner rooms, control rooms, and patient preparation areas. The central recommendation is to interpret measurements alongside room function, occupancy, outdoor conditions, equipment requirements, and the applicable ventilation design. Carbon dioxide should support ventilation assessment rather than serve as a stand-alone measure of air safety. Routine environmental monitoring and emergency oxygen protection address different hazards and should be managed separately. No original measurements or patient outcomes are reported.

Keywords: Magnetic resonance imaging; indoor air quality; environmental hygiene; ventilation; carbon dioxide; oxygen deficiency; infection prevention.



Introduction

MRI suites combine enclosed diagnostic spaces with strict equipment and access requirements. Patients may spend prolonged periods lying inside the scanner, while technologists and other personnel experience repeated exposure over a working shift. A hygienic assessment should therefore address both short-term patient conditions and recurring occupational exposure. Scanner rooms, preparation spaces, and control rooms have different occupancy patterns and should not be treated as one uniform environment.

The absence of ionizing radiation during MRI does not remove the need to assess the room atmosphere. Potential concerns include insufficient outdoor-air delivery, dust entering from outside or adjacent spaces, emissions during cleaning, and respiratory aerosols generated by occupants. Superconducting systems introduce a further concern when a cryogenic release could affect occupied space. The ACR provides a dedicated framework for MR safety [1], while healthcare environmental guidance addresses ventilation and infection prevention [2,3]. This review brings these perspectives together in a proposed hygiene protocol without claiming that a particular MRI facility is noncompliant.

The aim is to identify the main indoor-air assessment domains in MRI suites and develop a practical framework for measurement, interpretation, and preventive action.

Review approach

This article is a focused narrative review, rather than a systematic review or an experimental study. Official online guidance was consulted on 9 October 2026. Sources were selected for their relevance to MR safety, healthcare air handling, particulate exposure, carbon dioxide interpretation, and oxygen deficiency. Older foundational recommendations were retained where they remain useful; their online availability does not imply that their original evidence is recent.

The synthesis distinguishes published guidance from the assessment procedures proposed by the authors. The proposed sampling schedule and reporting structure have not been validated in an MRI facility. No participant recruitment, environmental dataset, statistical hypothesis testing, or ethics approval is claimed.



Local legal requirements and the installed scanner manufacturer's specifications must be established before any numerical compliance decision.

Ventilation and thermal conditions

Ventilation assessment should begin with a review of the room function and commissioned air-handling design. Routine diagnostic scanning, anesthesia-supported examinations, and interventional procedures may require different environmental provisions. Consequently, a single air-change or pressure requirement should not be assigned to every MRI room. ASHRAE healthcare ventilation guidance distinguishes imaging spaces by function and classification [4]. The applicable current edition and locally adopted requirements should be checked for the actual service provided.

A proposed site assessment should record room volume, supply and extract locations, occupancy, operating hours, filter maintenance, and changes to the ventilation system. Measured supply and exhaust flow should be compared with design records. Temperature and relative humidity should be logged during operation and interpreted against the combined requirements of the scanner, clinical activity, and local standards. Cooling that maintains equipment temperature does not, by itself, establish adequate outdoor-air delivery. Door opening and patient movement should also be documented because they can alter short-term measurements.

Carbon dioxide and particulate monitoring

Carbon dioxide monitoring can help identify periods when ventilation is poorly matched to occupancy. Its interpretation depends on outdoor concentration, occupant activity, sensor placement, and the time required for the room to approach steady conditions. ASHRAE addresses the limitations of using indoor carbon dioxide to characterize ventilation and indoor air quality [5]. A low reading cannot demonstrate the absence of particles, chemical vapours, or infectious aerosols. An isolated elevated reading should trigger investigation rather than an unsupported declaration that the room is unsafe.



For the proposed protocol, indoor and outdoor CO₂ should be recorded together, with time-stamped occupancy and ventilation status. Measurements near supply outlets, open doors, or a person's immediate exhaled plume may not represent the occupied zone. Trend analysis is generally more informative than a single spot value.

PM_{2.5} and PM₁₀ measurements can support assessment of outdoor infiltration, dust disturbance, and particle-control performance. WHO air quality guidance provides health-based context for particulate exposure [6]. Its averaging periods must be respected: a brief scanner-room measurement cannot establish compliance with an annual or daily guideline. Indoor and outdoor particle measurements collected over comparable periods help determine whether changes are associated with outdoor conditions or local activity. Optical instruments also require consideration of calibration and environmental effects.

Chemical exposure and airborne infection control

Cleaning procedures should be included in the environmental history. Products, dilution methods, application techniques, and timing may influence short-term vapour exposure. A targeted investigation is preferable to measuring a generic total volatile organic compound value and assuming it represents every relevant chemical. Product information should guide selection of substance-specific sampling where needed. Odour complaints can identify a problem requiring investigation, but neither the presence nor absence of odour establishes a safe concentration.

Airborne infection prevention requires attention to filtration, airflow, and clinical pathways. CDC recommendations emphasize correct installation and maintenance of HVAC filters and monitoring of spaces with special ventilation requirements [2]. The CDC also discusses supplemental HEPA filtration and the need to avoid ineffective airflow arrangements [3]. Any proposed air cleaner for an MRI area must undergo MR safety review before use.

Microbiological sampling should answer a defined question, such as investigating a suspected environmental source or assessing a targeted intervention. A universal microbial count should not be invented as an MRI-specific limit. Results depend



on collection method, sampled volume, culture conditions, location, and clinical context. They do not independently quantify infection risk.

Oxygen displacement and magnetic resonance safety

Cryogenic emergencies require a separate assessment from routine indoor-air hygiene. For superconducting systems using helium, the site review should verify the installed cryogen management arrangements, discharge route, alarm provisions, emergency procedures, and maintenance responsibilities against MR safety guidance and manufacturer requirements [1]. The configuration must be established for the actual scanner; it should not be assumed that every MRI installation has the same cryogen inventory or release pathway.

OSHA defines an oxygen-deficient atmosphere as one containing less than 19.5% oxygen in its respiratory protection interpretation [7]. This is an occupational hazard reference, not a complete MRI alarm-design specification or an Uzbek legal threshold. Alarm settings, sensor placement, response actions, and any emergency ventilation should be determined through the facility's engineering and safety process. CO₂ monitoring cannot substitute for oxygen monitoring where oxygen displacement is a credible hazard.

Measurement equipment itself must not introduce risk. Instruments and accessories entering controlled MR areas require assessment for the relevant magnetic field and conditions of use. Where ordinary equipment is unsuitable, measurements may require an approved remote arrangement. Sampling should be coordinated with the MR safety team before installation.

Proposed assessment framework

Table 1 summarizes a proposed set of assessment domains. It is a planning tool rather than a validated score or a list of universal compliance limits. A feasible study could compare the scanner room, control room, and preparation area during low and peak workload in contrasting seasons. Before sampling, investigators should define recording intervals, measurement duration, calibration procedures, and criteria for missing or unreliable observations.



Table 1. Proposed monitoring domains for an MRI suite

Domain	Assessment	Interpretation
Ventilation	Airflow, system status, room use	Compare with applicable design and local requirements
Microclimate	Temperature and relative humidity trends	Check clinical and manufacturer requirements
CO ₂	Indoor and outdoor trends with occupancy	Investigate ventilation performance
Particles	PM _{2.5} and PM ₁₀ indoors and outdoors	Respect averaging time and instrument limitations
Chemicals	Cleaning history and targeted sampling	Use substance-specific assessment where indicated
Biological factors	Targeted air sampling when justified	Interpret with method and clinical context
Cryogenic safety	Oxygen protection and release arrangements	Verify engineering controls and emergency response

Reporting and preventive actions

The proposed report should present time series, occupied and unoccupied summaries, outdoor conditions, and instrument uncertainty. Repeated readings from one room are not independent samples; they should not be used to inflate the apparent sample size. Without clinical outcome data, investigators should avoid claiming that measured air conditions caused infection, discomfort, or reduced work performance.

Corrective action should follow the observed pattern. Persistently inadequate airflow calls for engineering review; particle peaks call for examination of infiltration, filtration, and dust sources; cleaning-related peaks call for review of the product and application method. Findings should be reassessed under comparable operating conditions after corrective work. For implementation at Tashkent facilities, locally applicable sanitary rules must be identified before formal compliance labels are assigned.



Conclusion

Hygienic assessment of MRI-suite air should combine ventilation verification with time-resolved monitoring of thermal conditions and selected pollutants. Results must be interpreted in relation to occupancy, outdoor air, room function, and the applicable design. Oxygen displacement associated with cryogenic systems requires dedicated engineering and emergency protection. A coordinated assessment involving environmental hygiene, infection prevention, engineering, and MR safety can provide a defensible basis for improving patient and staff conditions.

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