The National Institutes of Health | Division of Technical Resources | Office of Research Facilities

Design Requirements Manual **News to Use**

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The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_i U_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho \overline{U}_i \overline{U}_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \overline{U}_i}{\partial x_j}-\rho\overline{u_i' u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho \overline{U}_i \overline{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \overline{T}}{\partial x_i}-\rho\overline{u_i' h'}\right)$ *biomedical research facilities.*

Radio Frequency/Electromagnetic Attenuated Design

When designing a room to house equipment that is sensitive to radio frequency (RF) and electromagnetic (EM) energies, architects and engineers should never assume the equipment can adequately filter and/or self-shield from exterior signal sources. The design team must understand the source of these external signals; their power, frequency, and periodicity; and the thresholds at which attenuation is required, either by siting (e.g., distance) or attenuation (achieved through source or receiver shielding or other construction).

RF/EM Signals and Sources

RF/EM signals degrade over distance in accordance with the inverse square law, meaning that signal intensity decreases at a rate equal to the square of the distance from the source. This type of signal reduction is referred to as free space loss. Understanding free space loss is useful during site selection, where proximity to motors, transformers, and similar high-energy electromagnetic sources can be a site selection criterion. Where adequate standoff distance cannot be achieved, the source may be able to be relocated or attenuated. However, not all sources of electromagnetic radiation are obvious. Any large moving ferrous metal mass, like elevator cars, trucks, or dumpsters, may generate detectable interference. When dealing with instruments sensitive to RF/EM fields, such as MRI patient scanners or NMR research magnets, it is often necessary to perform an RF field survey (some equipment may be self-shielding, but a survey is always recommended).

Attenuation Design

Attenuation is measured in decibels (dB) and varies with the frequency of the RF signal source as well as the type and density of intervening materials. This type of attenuation, referred to as path loss, is measured by comparing the signal power on both sides of a material/assembly. A typical office wall, consisting of a 16 mm (5/8”) layer of gypsum board on each side of a 92 mm (3-5/8”) steel stud, will reduce an RF signal by approximately 3-6 db. Path loss may be calculated to generate an approximation of the attenuation; however, this can become complex in some indoor conditions, as typically design must also account for signal reflection (also known as obstacle attenuation). All components of the attenuation barrier must be bonded to each other and to a common ground to minimize voltage potential between components while effectively reducing signal strength from exterior sources. Penetrations through an attenuated assembly can potentially create pathways for signals of specific wavelengths to penetrate the attenuated construction into the room. Large openings for HVAC supply and return/exhaust ducts may be protected by installing waveguides in the airstream at the point the duct crosses through the attenuation barrier. Waveguides used for this purpose are typically a honeycombed metal grating with a specific cross section intended to block the passage of the frequencies requiring attenuation. However, waveguides contribute to duct pressure drop, which must be considered in the HVAC design. Small openings for plumbing pipes and electrical conduits are typically equipped with dielectric unions/connectors/filters to prevent transmission along conductive paths. Fluids carried within these pipes are generally inefficient at re-radiating RF energy and are ignored, except in cases involving the most sensitive receivers. Windows through attenuation barriers are generally fixed and filled with metallic screening, which is bonded to the attenuation barrier. The inside and outside window frames are electrically decoupled to prevent transmission of RF signals through the frame itself.

Doors serving RF/EM attenuated rooms can be very complex systems. Typically, doors/frames utilize conductive “fingers” that are engaged, either mechanically or pneumatically, on all four sides of the door to create a continuous enclosure (e.g., Faraday cage). These doors must be configured to open outward to minimize the risk of trapping personnel inside due to a sudden overpressure “quench.” A quench occurs when cryogen, which is used to supercool magnets that are often installed within these types of enclosures, overheats and rapidly sublimates from liquid to gas, explosively expanding in volume (e.g., overpressure) which could prevent opening of a door configured to open inwards.

Summary

Continuity of attenuation barriers, grounding, and sensitivity of the receiver and site selection (determined via RF survey) are all critical considerations in the design of RF/EM attenuated rooms. Designing with these factors in mind ensures that attenuation is thorough and effective, and that sensitive equipment can operate with full efficacy.

Further Reading/Resources

1. The National Institutes of Health (NIH). *Design Requirements Manual,* https://www.orf.od.nih.gov/TechnicalResources/Pages/DesignRequirementsManual2016.aspx
2. National Institute of Standards and Technology, NIST Construction Automation Program, Report No. 3, Electromagnetic Signal Attenuation in Construction Materials nist.gov/publications/electromagnetic-signal-attenuation-construction-materials