Division of Technical Resources
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News to Use
Design Requirements Manual
The formulae $\frac{\partial \rho u_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho u_j u_i)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial u_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ 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 $\frac{\partial}{\partial x_i}(\rho\overline{u}\overline{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial T}{\partial x_i}-\rho\overline{u'H'}\right)$ biomedical research facilities.

'Design Requirements Manual (DRM) News to Use' is a monthly ORF publication featuring salient technical information that should be applied to the design of NIH biomedical research laboratories and animal facilities. NIH Project Officers, A/E's and other consultants to the NIH, who develop intramural, extramural and American Recovery and Reinvestment Act (ARRA) projects will benefit from 'News to Use'.
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Facility Design Criteria for Electron Microscopes – Part I

Electron microscopes (EM) use a beam of electrons to illuminate a specimen and produce a magnified image and can currently achieve magnifications of up to about 10,000,000X. Transmission electron microscopes (TEM) and scanning electron microscope (SEM) are high resolution instruments that are extremely sensitive to environmental instabilities such as *temperature, vibration, acoustic noise, pressure and magnetic fields*. Slight changes in any one of these parameters can cause distortion in the microscopic image. These and other high resolution instruments are sensitive to very low frequency noise sources.

General Design Criteria:

In designing rooms for high resolution equipment, it is important to ensure reliability and repeatability in the experimental results. To achieve optimal instrument performance, environmental instability should be reduced to the greatest degree possible. It is important to know the sensitivity of the instrument to be housed in the facility. The room housing a high resolution instrument should be considered an extension of the instrument.

High resolution equipment facilities (for TEM, SEM and other EMs) should meet as many of the following criteria as possible:

- The environmental control system shall have N+1 redundancy on ALL major components to keep the environmental chamber at constant temperature, pressure and humidity. The Control system shall utilize a full proportional-integral derivative (PID) controller. PID controller must be tuned using numerical method such as simplified first order plus dead time (FOPDT) process models.
- Located far away from roads, parking lots, elevators, and air handling equipment to minimize ground-borne vibrations from automobile and railway traffic, construction equipment, blowers and pumps, etc.
- Room should ideally be remote from corridors to avoid foot fall and moving cart vibrations.
- Isolated structurally from the main building to the greatest extent possible to mitigate the propagation of transient vibrations.
- Provided with restricted access.
- Ideally located below ground to facilitate constant temperature and be equipped with an adjacent control room that houses much of the electronic instrumentation.
- Air handling designed to prevent building air from blowing directly on equipment.
- Carefully regulated temperature and humidity control.
- Air that is typically filtered to reduce particle concentrations by roughly a factor of 10 below that of air circulating throughout the building. This should be verified based on research protocols.
- Far removed from high-voltage transformers and high-current electrical power lines.
- Independent and distributed, quiet electrical grounds should be available throughout the lab. Any required 110-V power lines should be filtered, regulated, and distributed by twisted wires to reduce stray magnetic fields.
- Minimize use of discharge lighting and ballasts.
- Use of electromagnetic shielding or a cancelling system to reduce the influence of outside electromagnetic interference (EMI).
- Sound-absorbent walls, ceilings, and floors which reduce background acoustic noise to a minimum and which are appropriate for clean environments.

Specific Design criteria:

Electromagnetic Fields - Keep Electromagnetic fields to less than 0.1 mG RMS (root mean square).

EMI can cause beam deflections in both the scanning system and the spectrometer.

Sources of electromagnetic fields from inside the room:

- Small pieces of metal moving near the equipment (such as the steel wheels on a chair).
  - Consider the use of plastic or all wood furniture inside the room.
- Electrical distribution and equipment.
  - Careful design of power routing and isolation of transformers and electric motors, background fields will help in reducing electromagnetic fields inside the room.
  - In a retrofit, overhaul existing wiring and install dedicated supplies for the microscope.
  - Route power conduits as far as possible from the microscope column.
  - The AC fields (mostly from computer monitors) should be 1 milligauss or less. Shielding for top performance, high resolution spectrometers and microscopes often specify ~ 0.2 milligauss (20 nT) p-pin x,y and z direction.
- Place monitors away from the column.
- Consider field cancellation systems at the specimen, gun, viewing chamber.
- Black and white TV monitors and computer monitors used on older model EM scopes.
  - LCD monitors are recommended.
  - Magnetic shielding can be used to provide a low reluctance path for external fields. The shielding has to close the instrument on all sides.
- Sources of electromagnetic fields from outside the room.
- Movement in a corridor, elevators or escalators near the equipment room.
- Roads, auto traffic and railroads.
- Loading dock, machine shop or room with cryo-pumps.

Details on Temperature and Humidity Control, Airflow across the column, Control of air pressure changes, Vibration Considerations, Acoustic Noise, Room Layout and Architectural Features will be discussed in next month's News to Use.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/DesignRequirementsManualPDF.aspx
DRM Appendix J