

The formulae $\frac{\partial \rho U_i}{\partial x} + \frac{\partial}{\partial x_j} (\rho U_j U_i) = -\frac{\partial P}{\partial x_i} + \frac{\partial}{\partial x_j} \left(\mu \frac{\partial U_i}{\partial x_j} \right) + g_i (\rho - \rho_0)$ for building $\frac{\partial}{\partial x_j} (\rho U_j H) = -\frac{\partial P}{\partial x_i} + \frac{\partial}{\partial x_j} \left(\mu \frac{\partial U_i}{\partial x_j} - \rho U_i U_j \right) + g_i (\rho - \rho_0)$ state of the art $\frac{\partial}{\partial x_i} (\rho U_i H) = \frac{\partial}{\partial x_i} \left(\lambda \frac{\partial T}{\partial x_i} - \rho U_i H \right)$ biomedical research facilities.

Electrical Work Space

Electrical work space around electrical equipment is required to ensure the safety of maintenance electricians. It is necessary for facilities to be designed to provide all electrical equipment with sufficient access and workspace for safe and efficient maintenance and service of energized equipment in accordance with the latest edition of National Electrical Code (NEC). The following is an excerpt of Chapter 10, Section 2.4 *Electrical Work Space* of the 2016 DRM, which has been revised to consolidate and clarify requirements. Coordination is required with architect and other disciplines to comply with the following requirements.

10.2.4 Electrical Work Space

A. Location: Transformers, secondary substations, distribution switchgears, generators, transfer switches and other electrical distribution equipment shall not be located at the lowest points of the buildings below grade level. In addition, comply with the following requirements:

- 1. Medium Voltage Transformer:** The optimal location for the medium voltage primary service transformers is indoors in a transformer vault, located separately from the service entrance switchgear room, and not in the same room as the emergency power distribution gear. The secondary service bussing shall be kept as short as possible and electrically the same length ($\pm 10\%$).
- 2. Low Voltage Distribution Equipment:** Locate all branch circuit panelboards and distribution panels at the center of the area being served, secured from the general public. Electrical loads shall be served from the panelboards located on the same floor and located closest to the load.

Exceptions: Lighting and power circuits within vertical stairways, elevator shafts, roofs, and interstitial areas.

B. Clearances: Provide the minimum required clearances per code for all equipment. Provide 76 mm (3 in.) minimum separation between panelboards. Lay out the electrical equipment in electrical rooms and closets such that there is an unobstructed exit path out of the room. The following minimum clearances are required for new projects around secondary switchgear:

1. 1,524 mm (5 ft.) in front
2. 1,067 mm (3 ft. 6 in.) in rear
3. 914 mm (3 ft.) on the ends

Consider additional clearance for the equipment being racked out.

C. Electrical Room and Transformer Vault: Install all substations, switchgears, switchboards, transformers, and network protectors in dedicated electrical rooms or vaults. Equipment installation shall meet the following requirements:

- 1. Room Size:** Size electrical rooms to accommodate current electrical equipment and required clearances. Consideration should be given to additional room for future anticipated growth.
- 2. Clearance:** Provide clear working space around the equipment in accordance with electrical code and this manual. Columns shall not encroach on the clear working space required around equipment.
- 3. Other Equipment:** Piping, ducts, or equipment not serving the dedicated electrical rooms shall not be permitted to be installed in the electrical rooms or traverse the electrical rooms.
- 4. Ventilation (and/or cooling):** Rooms with transformers shall have ventilation (and/or cooling) sufficient for 2% of the total transformer kVA expressed in watts of heat load. Coordinate cooling requirement with HVAC system design. Refer to [Chapter 6, Mechanical Design](#).

D. Electrical Closets: Electrical closets shall be provided for every 929 m² (10,000 ft²) of area served by 208/120 V branch circuit panelboards; for every 1,858 m² (20,000 ft²) of area served by 480/277 V lighting panelboards. Locate panelboards so that the farthest 120 V device/equipment served is no more than 30 m (100 ft.) away. General requirements for electrical closets are as follows:

- 1. Stacking:** Vertically stack electrical closets in multistory buildings.
- 2. Sleeves:** Provide sealed, water-tight sleeves, extending at least 76 mm (3 in.) above the floor, through the holes in floors of electrical closets.
- 3. Location:** Closets shall be located away from the mechanical shafts; coordinate location with all other building systems, particularly those located in the ceiling plenum directly adjacent to the closet.

Exception 1: *Shallow closets with full doors on the long wall are acceptable in lieu of electrical closets for smaller renovations.*

Exception 2: *Secure service corridor may be used for the installation of panelboards.*

E. Equipment Removal Route: A permanent exit route shall be provided for the large electrical equipment including transformer, generator, switchgear, etc., to remove the large equipment and bring in new replacement units. A faulty transformer shall be capable of being removed while the other transformer(s) and equipment remain in place and in operation. Provide painted stripes and warning signs on the floor and walls along the exit (removal) route. See [Section 5.1.5, Equipment Access](#).

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Further details on this month's topic are available on the DRM website

<https://www.orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/DesignRequirementsManual2016.aspx>

DRM Chapter 10, Section 10.2, Chapter 6, Chapter 5.