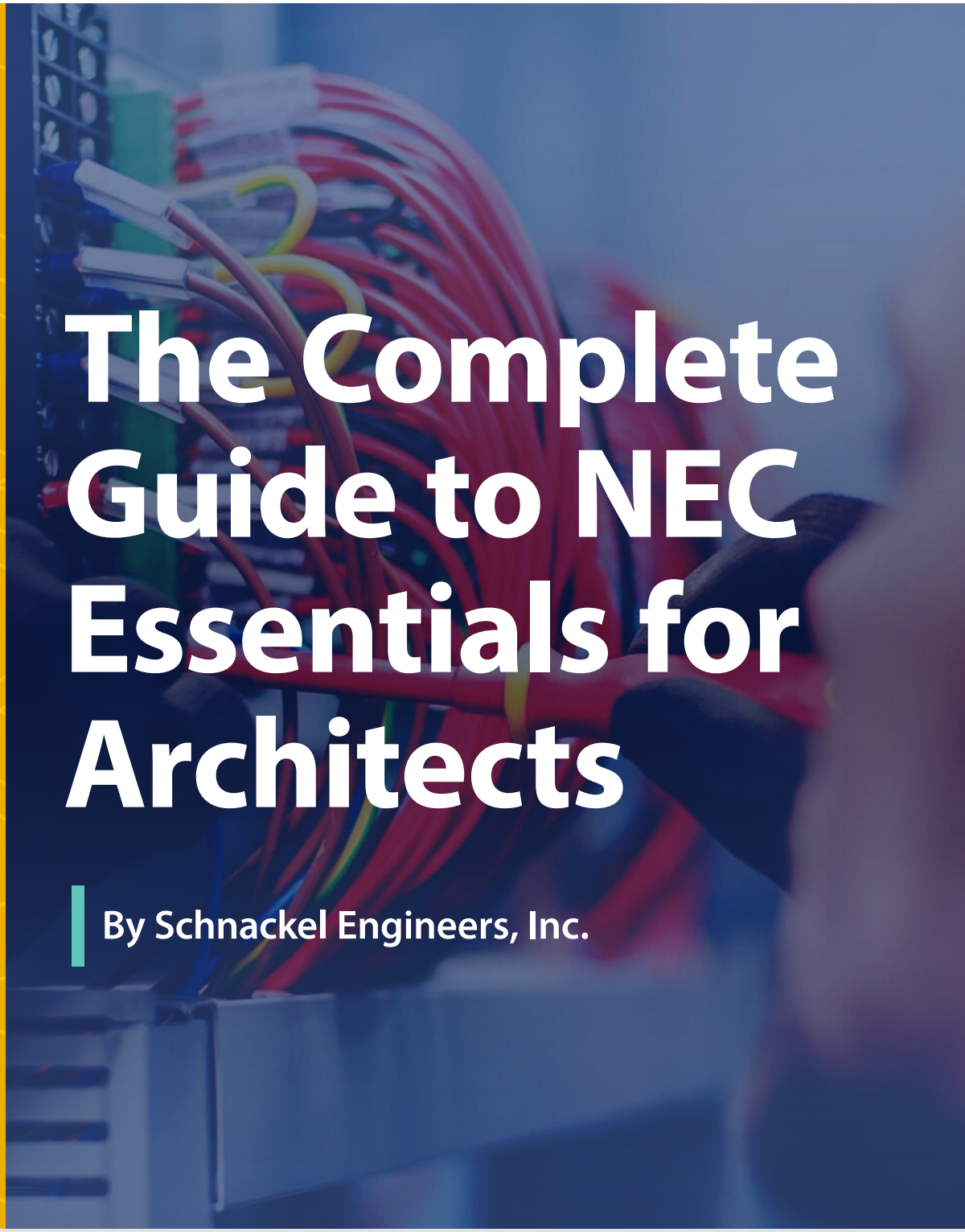
Schnackel engineers®



The Complete Guide to NEC Essentials for Architects

By Schnackel Engineers, Inc.

The Complete Guide to NEC Essentials for Architects.

Table of Contents

Introduction

The purpose of this guide is to provide architects with a summary of the requirements found in the *National Electrical Code* that have a direct impact on space planning and the architectural design of buildings.

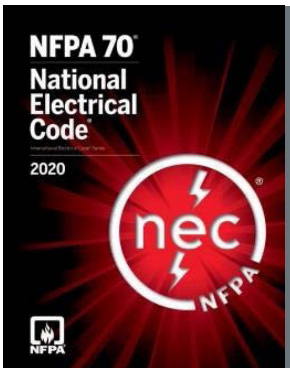
This guide will focus on the specific requirements of the following pieces of low voltage (1,000 volts or less) electrical distribution equipment:

- Panelboards.
- Switchboards.
- Dry-type transformers.
- Enclosed switches (aka "safety switches").

Codes Used Throughout Guide

The information within this guide is based on the *2020 National Electrical Code (NEC)*. Many people do not realize it but the *NEC* is actually part of the National Fire Protection Association series of codes, specifically the *NFPA 70-2020*. The 2020 version is the most recent edition of this code.

It is important to note that previous versions of the *NEC* may have different requirements. Additionally, while the *NEC* is adopted nationally, many local jurisdictions and power utility companies have adopted amendments that may be more stringent than the requirements outlined in this guide and the base code.



CHAPTER 1

Basic Nomenclatures and Characteristics

Because the code requirements vary depending on the type of electrical distribution equipment in question, it is important to be familiar with the different types of electrical equipment in order to apply the requirements appropriately.

This first chapter is intended to familiarize the audience with the basic nomenclatures and general characteristics of low voltage panelboards, switchboards, transformers, and safety switches.

Panelboards

Panelboards are typically the most common piece of electrical distribution equipment found throughout commercial buildings. There are two basic categories of panelboards – lighting and appliance panelboards and power panelboards.

Lighting and Appliance Panelboards

Lighting and appliance panelboards serve as distribution points for branch circuits, such as circuits that serve lighting, receptacles, appliances, small motors, and mechanical equipment.

Although exceptions exist that are dependent upon the specific construction of a panelboard, the overcurrent protective devices (fuses or circuit breakers) found in lighting and appliance panelboards are typically limited to 100 amperes or less. Because of the small loads typically served, lighting and appliance panelboards will typically house a large quantity of single-pole overcurrent protective devices as compared to multipole overcurrent protective devices.

The enclosures for indoor lighting and appliance panelboards are typically 20 inches wide by 5.75 inches deep. The heights vary depending on a number of variables, but are primarily driven by the number of overcurrent protective devices installed within the panelboard. Sometimes panelboards are ganged together into a “double-wide” panelboard, which simply increases the width to 40 inches since two standard panelboards are set side by side.

Another variant is a column width panelboard, which is typically 8 to 9 inches wide and are intended to be installed directly on columns in industrial or storage warehouse installations.

Load centers are residential-grade lighting and appliance panelboards commonly used within dwelling units and sometimes in smaller, low cost commercial buildings. The enclosures for indoor load centers are typically 14.25 inches wide by 3.75 inches deep, allowing them to physically fit within the 2-inch by 4-inch stud walls commonly found in residential construction. Load centers are considered less durable in construction and should not be used for heavy duty commercial use.

Power Panelboards

While a lighting and appliance panelboard typically distributes power to receptacles, lighting, and other small loads that are rated 100 amperes or less, power panelboards typically distribute power to larger loads rated between 110 amperes and 1,200 amperes, inclusive.

The enclosures for power panelboards vary widely in dimensions, depending on the ampere rating of the power panelboard and the ampere rating of the overcurrent protective devices installed within. However, most enclosures will typically fall within 24 inches to 48 inches wide and 8 inches to 16 inches deep.

Because of the larger loads typically served, power panelboards will typically house more multipole overcurrent protective devices, as compared to single-pole overcurrent protective devices. While single-pole overcurrent protective devices are available for power panelboards, they are very expensive for the loads served.

Switchboards

A switchboard typically consists of two or more equipment sections mounted side-by-side and internally electrically interconnected by busbars. Switchboards are typically used when the required rating of the equipment exceeds 1,200 amperes and the equipment's primary purpose is to distribute power to other panelboards or other large equipment loads.

Because a switchboard typically consists of two or more sections of equipment, the physical dimensions of a switchboard can vary widely based on the various components installed within the switchboards and the quantity of sections required to house those components. Switchboards are very custom in nature and are not an off-the-shelf product.

The width of each section will vary between 24 inches and 48 inches wide and switchboard sections are typically 90 inches to 91.5 inches high. The ampere rating of the horizontal busbars that electrically interconnect the sections of the switchboard often drives the depth of each section, however they typically vary between 24 inches and 36 inches for most installations, except for very large service capacities.

The following table provides reliable initial estimates of the depths of indoor switchboards based on standard horizontal busbar ratings:

Horizontal Busbar Rating	Depth
1,600 amperes	24 inches
2,000 amperes	24 inches
2,500 amperes	24 inches
3,000 amperes	36 inches
4,000 amperes	48 inches
5,000 amperes	60 inches

Transformers

Transformers are easily identifiable – they are the metal boxes that hum, vibrate, and emit heat. Transformers are used to increase or decrease the voltage of a circuit and are nearly always found in facilities where the incoming power is something other than a standard 120/240 volt or 120/208 volt system.

Transformers are rated using a kilovolt-ampere (kVA) power rating. The physical dimensions of a transformer will vary based on whether the transformer is single phase or three phase and the kVA rating of the transformer.

Safety Switches

The term “disconnect switch” is often used to designate an enclosed switch used for disconnecting a load. The official name is a safety switch.

Safety switches are used to provide a local disconnecting means, and possibly overcurrent protection, for various components of an electrical installation.

The physical dimensions of a safety switch will vary based on a number of factors including the voltage classification of the switch, the duty rating of the switch, the ampere rating of the safety switch, and whether the switch is fusible.

CHAPTER 2

General Installation Requirements

In this second chapter, we will outline some very general requirements found in NFPA 70-2020 (NEC) for the installation of the following pieces of low voltage (1,000 volts or less) electrical distribution equipment:

- Panelboards.
- Switchboards.
- Dry-type transformers.
- Enclosed switches (aka "safety switches").

Accessibility

Generally, all equipment is required to be accessible. There are limited exceptions to these requirements, which are not addressed within this guide.

Location in or on Premises

With some limited exceptions, all overcurrent protective devices (fuses and circuit breakers) are required to be installed in "readily accessible" locations. As such, this requirement inherently requires the panelboards, switchboards, and safety switches the overcurrent protective devices are installed within to also be installed in "readily accessible" locations.

"Readily Accessible"

"Readily accessible" is defined as, "Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to take actions such as to use tools (other than keys), to climb over or under, to remove obstacles, or to resort to portable ladders, and so forth." In short, panelboards, switchboards, and safety switches are required to be installed in locations where they can be accessed easily and freely.

Not "Readily Accessible"

Maximum Mounting Heights

Circuit breakers and switches containing fuses are required to be installed such that the center of the grip of the operating handle, when in its highest position, does not exceed 79 inches above the working platform.

Note that this requirement does not prohibit the top of a panelboard, switchboard, or safety switch enclosure from being above 79 inches above the working platform. The requirement applies to the overcurrent protective devices installed within the panelboard, switchboard, or safety switch and those overcurrent protective devices are typically installed several inches below the top of the enclosure.

Minimum Mounting Heights

Minimum mounting heights are not dictated. As such, panelboards are permitted to be stacked vertically, provided the center of the grip of the operating handle, when in its highest position, does not exceed 79 inches above the working platform.

However, the practice of stacking panelboards is generally frowned upon due to the upper panelboard obstructing the path from conduits exiting from the top of the lower panelboard.

Accessibility to Occupants

Overcurrent protective devices are required to be installed in locations where each occupant has ready access to the overcurrent devices serving their respective occupancy.

This requirement is most often met by providing each tenant of a multi-occupancy building with panelboards that are dedicated to their tenant space.

Prohibited Locations

Overcurrent protective devices are prohibited from being installed in the following locations:

- In the vicinity of easily ignitable material, such as clothes closets.
- In bathrooms of dwelling units, dormitory units, and guest rooms or guest suites.
- Over steps of a stairway.

Because overcurrent protective devices are prohibited from being installed within these locations, the panelboards, switchboards, and safety switches housing the overcurrent protection devices are also inherently prohibited from being installed in these locations.

Examples of Prohibited Locations

In addition to the prohibited locations noted above, the electrical service disconnecting means, which serves as the main power disconnect for the building, is prohibited from being installed in bathrooms of any occupancy.

Panelboard Mounting

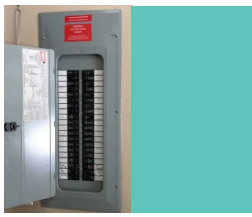
Panelboards are supported by and secured to walls.

Surface Mounted Panelboard

Lighting and Appliance Panelboards

Indoor lighting and appliance panelboards can be surface- or flush- (recessed) mounted. Outdoor lighting and appliance panelboards are always surface-mounted.

The following table outlines minimum wall depths required to flush-mount indoor lighting and appliance panelboards:



Flush Mounted Panelboard

Lighting and Appliance Panelboard Type	Minimumn Wall Depth
Load Center	4 inches
Rated 400 Amperes or Less	6 inches
Rated 600 Amperes	8 inches

Power Panelboards

Although there are no code restrictions on flush-mounting power panelboards, power panelboards are nearly always surface-mounted because the depth of the enclosures typically exceed the depth of the wall behind the power panelboard.

If flush-mounting a power panelboard is desired, close coordination within the design team is required to ensure the depth of the wall is sufficient for the equipment.

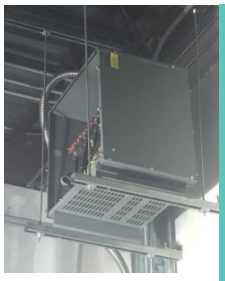
Switchboard Mounting

Switchboards are supported by and secured to the floor. As such, switchboards are always surface-mounted, typically on a concrete housekeeping pad.
The housekeeping pad is not a code requirement, but is typically incorporated into the design to provide a degree of protection from water and debris from infiltrating the bottom of the switchboard.

Transformer Mounting

Transformers are mounted using one of three methods, depending on the physical size and weight of the transformer – suspended on a trapeze from the structure above, wall-mounted, or floor- or platform-mounted. Regardless of where transformers are mounted, vibration isolators are typically incorporated into the design to mitigate the transformer's vibration from being transmitted to building elements.

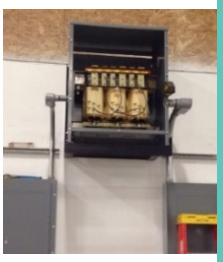
Suspending on Trapeze



Transformers of all sizes and ratings are capable of being suspended on a trapeze from the structure, provided adequate physical space is provided and the structure can accommodate the weight of the transformer.

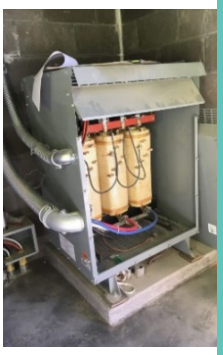
Transformers rated 50 kVA or less are permitted to be installed above accessible ceilings. Transformers rated greater than 50 kVA are not permitted above accessible ceilings. Transformers are never permitted in ceiling spaces that are not accessible.

Wall Mounting



Transformers rated 75 kVA or less are typically capable of being wall-mounted using the manufacturer's wall-mounting brackets, provided the transformer does not weigh more than 700 pounds. In a wall-mounting application, it is important that adequate wall backing be provided to adequately anchor the wall brackets.

Floor - or Platform Mounting



Transformers of all sizes and ratings are capable of being mounted to the floor or to a platform, such as a platform above a toilet room.

When mounting a transformer to a floor, a concrete housekeeping pad is typically incorporated into the design. The housekeeping pad is not a code requirement, but is intended to provide a degree of protection from debris from accumulating under the transformer. The concrete pad also acts as an inertia base to further mitigate vibrations from being transmitted to the structural floor. This is especially important with a transformer is floor-mounted on a floor above grade level.

Safety Switch Mounting

Because safety switches are equipped with a manually-operable handle on the right-hand side of the enclosure, safety switches are always surface-mounted to permit operation.

CHAPTER 3

Clearances

This third chapter seeks to outline "clearance" requirements found in *NFPA 70-2020 (NEC)* for the installation of the following pieces of low voltage (1,000 volts or less) electrical distribution equipment:

- Panelboards.
- Switchboards.
- Dry-type transformers.
- Enclosed switches (aka "safety switches").

Equipment "Clearances"

The term "clearance" is commonly used throughout design and construction circles to refer to space around electrical equipment. However, it is important to understand that "clearance" is comprised of three separate and distinct components – working space, dedicated equipment space, and manufacturer-required clearance.

Working Space

Working space is the component of the "clearance" that is directly in front of the accessible sides of electrical equipment. All electrical equipment requires some degree of working space to allow access and safe operation and maintenance of the equipment.

Very specific minimum working space dimensions are required when the equipment requires examination, adjustment, servicing, or maintenance while energized, such as panelboards, switchboards, and safety switches. This working space can be represented as a rectangular prism where the bottom sits on the floor and the back side sits against the front of the electrical equipment.

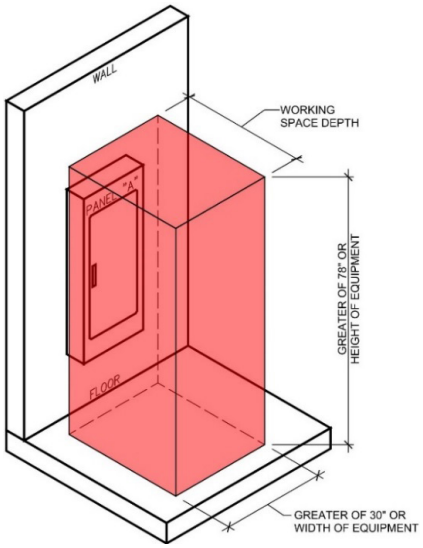
The required width of the working space is the greater of 30 inches or the width of the equipment. The working space width can be centered on the electrical equipment or offset such that the left or right edges are aligned with the sides of the equipment.

The required height of the working space is the greater of 78 inches or the height of the equipment. Regardless of the installed height of the top of the electrical equipment, this requirement inherently requires equipment to be installed in spaces that provide a minimum of 78 inches of headroom.

The required depth of the working space is dependent on the installation conditions and the operating voltage of the equipment. The following table outlines the minimum depths of voltage systems commonly found in buildings.

Voltage	Working Space Depth
120/208 volts	36 inches
120/240 volts	36 inches
277/480 volts	48 inches *
347/600 volts	48 inches *
*This depth may be reduced to 36 inches or 42 inches under certain circumstances. However, Schnackel Engineers does not recommend doing so because future flexibility of the electrical installation may be compromised.	

The following figure provides a graphical representation of working space requirements.



Working Space Diagram

WORKING SPACE FOR TRANSFORMERS

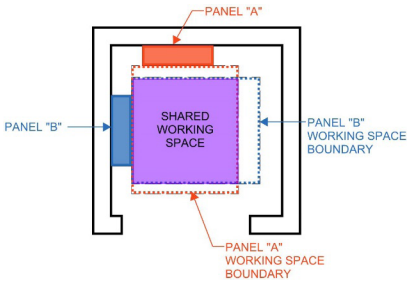
Because the specific working space dimensions are triggered when the equipment requires examination, adjustment, servicing, or maintenance while energized, whether transformers require specific working space dimensions is a great debate throughout the industry.

An informal interpretation obtained from the National Fire Protection Association (NFPA), the authors of the *National Electrical Code (NEC),* states that whether a transformer is likely to require examination, adjustment, servicing, or maintenance while energized is based on whether an employer will permit an employee or contractor to work on the transformer while it is energized. The informal interpretation further states that the permission to waive working space requirements for transformers must be obtained from the Authority Having Jurisdiction (AHJ) and many AHJs will not base a safe installation on an employer's electrical safety program.

Because of NFPA's informal interpretation, providing transformers with the specific working space dimensions is recommended to ensure a compliant installation. If an installation cannot provide the required working space, AHJ approval to waive the working space requirements must be obtained.

SHARING WORKING SPACE

When electrical distribution equipment is located on two adjacent walls or directly across from one another, the working spaces are permitted to overlap or be shared.



Shared Equipment Space

Dedicated Equipment Space

Dedicated equipment space is the component of the "clearance" that is directly above and below electrical equipment. The requirements for dedicated equipment space applies to only switchboards, switchgear, panelboards, and motor control centers. As such, transformers and safety switches are not subject to dedicated equipment space requirements.

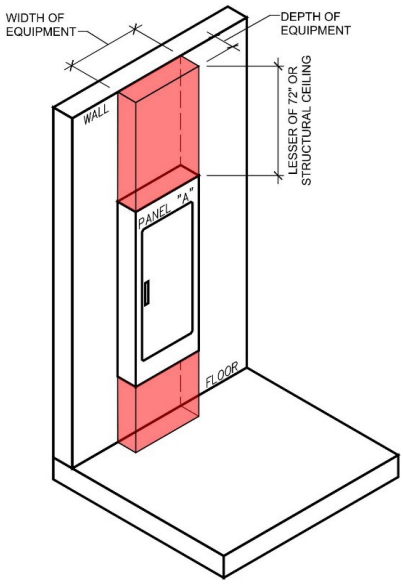
The dedicated equipment space is required to be dedicated to the electrical installation. Foreign systems, except for suspended ceilings with removable panels, are strictly prohibited from being located within the dedicated working space. However, foreign systems are permitted in the area above the dedicated working space when those foreign systems are provided with protection to prevent leaks, condensation, or breaks in the foreign system to prevent damage to the electrical equipment below.

The required width of the dedicated equipment space is the equal to the width of the equipment.

The required height of the dedicated working space starts at the floor and extends to 6 feet above the top of the equipment or to the structural ceiling, whichever is lower. A suspended ceiling is not considered a structural ceiling.

The required depth of the dedicated equipment space is the equal to the depth of the equipment.

The following figure provides a graphical representation of dedicated equipment space requirements.



Dedicated Equipment Space Diagram

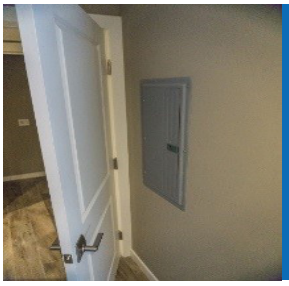
Manufacturer-Required Clearance

Manufacturer-required clearances are not typically required for panelboards, switchboards, or safety switches.

However, some manufacturer's require clearance around transformers. This clearance is typically 6 inches and is required around all sides of a transformer for ventilation.

Panelboards Behind Door Swings

A common question that relates to "clearance" is whether a panelboard is permitted to be installed on a wall behind a door.



This scenario is not directly addressed by the *NEC*. However, the letter of the code does not prohibit this installation and many AHJs prefer this installation because it ensures that nothing will be stored in front of the panelboard and working space will always be maintained.

Nevertheless, some AHJs have adopted local amendments that prohibit this installation.

CHAPTER 4

Entrances, Egress, and Fire Ratings

This final chapter aims to outline common technical requirements found in *NFPA 70-2020 (NEC)* for entrances to, egress from, and fire ratings of spaces containing the following pieces of low voltage (1,000 volts or less) electrical distribution equipment:

- Panelboards.
- Switchboards.
- Dry-type transformers.
- Enclosed switches (aka "safety switches").

Access to Working Space

Entrance(s) are required to provide access to and egress from the electrical distribution equipment's working space. These requirements are in place to ensure workers can escape safely and quickly should the equipment catastrophically fail, such as an arc-flash incident.

Quantity of Entrance(s)

The quantity of entrances required is dependent upon the ampere rating and width of the equipment, but more than two entrances is never required.

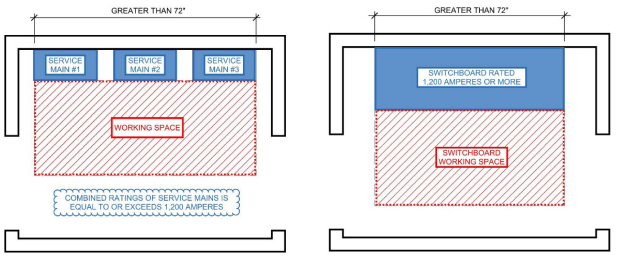
Two entrances are required under either of the following scenarios:

1. The equipment is service equipment consisting of more than one main disconnect and the sum of the disconnect ratings is 1,200 amperes or more and the installation is over 6 feet wide.

2. The equipment is rated 1,200 amperes or more and the equipment is greater than 6 feet wide.

The following images provide a graphical representation of these two scenarios.

All other installations only require one entrance.



Scenario 1 Scenario 2

Exceptions to Two Entrances

Under Scenarios 1 or 2, a single entrance is permitted under either of the following conditions:

1. A continuous and unobstructed path of egress travel is provided. Experience shows that Authorities Having Jurisdiction (AHJs) interpret this exception inconsistently. As such, this exception is typically difficult to obtain and AHJ's acceptance.

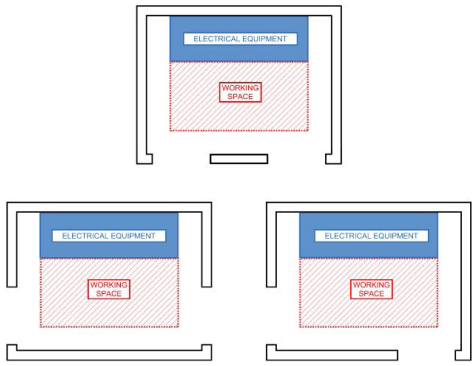
2. The depth of the working space is doubled from that which would otherwise be required. The following table outlines the doubled working space depths of voltage systems commonly found in buildings.

Voltage	Working Space Depth
120/208 volts	72 inches
120/240 volts	72 inches
277/480 volts	96 inches *
347/600 volts	96 inches *
*This depth may be reduced to 72 inches or 84 inches under certain circumstances. However, Schnackel Engineers does not recommend doing so because future flexibility of the electrical installation may be compromised.	

Locations of Entrance(s)

When only one entrance is required, the location is not dictated.

When two entrances are required, those entrances are required to be located at opposite ends of the working space. The image below shows three acceptable entrance configurations when two entrances are required.



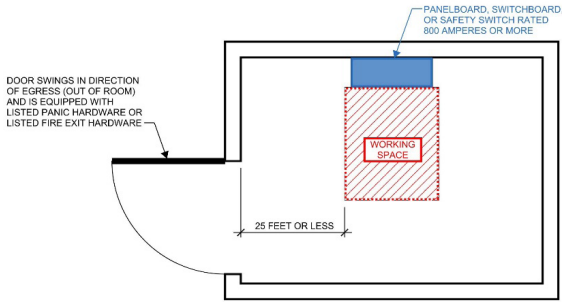
Sizes of Entrance(s)

When two entrances are required, those entrances are required to be a minimum of 24 inches wide and 78 inches high.

However, it is critical to ensure entrances, whether it is a single entrance or two entrances, are sized to permit the equipment to be moved in and out of the room. As such, the width of the entrances should never be less than the smallest equipment dimension to ensure the equipment can be easily placed and/or removed.

Personnel Door Requirements

When personnel doors are installed into areas with equipment that is rated 800 amperes or more, the personnel doors are required to swing in the direction of egress (out of the room) and are required to be equipped with listed panic or fire exit hardware when those personnel door(s) are installed within 25 feet of the nearest point of the working space boundary.



Personnel Door Requirements Into Area with Equipment Rated 800 Amps or More

When personnel doors are installed into areas where the equipment is rated less than 800 amperes, the personnel doors are permitted to swing either into or out of the room and are not required to be fitted with any special egress hardware.

Fire Ratings

Questions regarding NEC requirements for fire ratings of rooms housing electrical equipment are common.

Equipment that is part of an emergency distribution system is required to be installed in spaces with a 2-hour fire resistance rating in the following cases unless the equipment space is fully protected by an automatic fire protection system:

- Assembly occupancies with an occupant load of 1,000 or more persons.
- Buildings over 75 feet in height.
- Educational occupancies with an occupant load greater than 300 persons.

Transformers rated over 112.5 kVA in all occupancies are required to be installed in a room with a minimum fire rating of 1 hour. However, transformers with a Class 155 or higher insulation system are exempt from this requirement.

Nearly all low voltage dry-type transformers currently manufactured are provided with Class 220 insulation systems, meaning they are exempt from being required to be installed in a fire-rated room.

Conclusion

The National Electrical Code (NEC) contains numerous requirements that can affect a building's space planning. Because these requirements are in an electrical code and not within the building codes that drive many Architects' space planning decisions, these requirements are easily overlooked. Requirements such as electrical equipment accessibility, equipment "clearances," quantities and locations of entrances to and egresses from spaces with electrical equipment, door swing and panic hardware requirements, and fire ratings of equipment spaces can all have a profound impact on space planning.

By working with an engineering partner who is savvy in the NEC requirements, the initial space planning stages of any project can preemptively address the requirements of the NEC, ensuring the project design moves forward without the headaches and time lost in reworking spaces to address these requirements after the design has progressed past the initial stage.