PRODUCT APPLICATION

A technical bulletin for engineers, contractors and students in the air movement and control industry

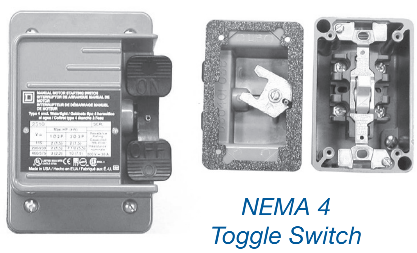
A Guide to Selecting Disconnect Switches for Human Safety, Overload, and Short Circuit Protection of HVAC Equipment

Heating, Ventilating, and Air Conditioning (HVAC) equipment disconnect switches are a required and necessary safety feature for every installed piece of HVAC equipment. Mounted directly on the equipment and/or within sight and reach, disconnect switches provide the best protection against accidental start-up during service or inspection.

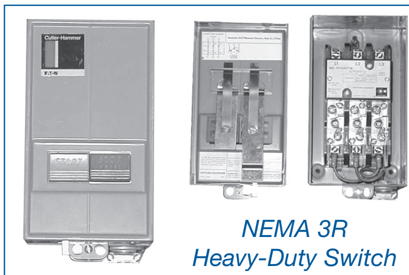
Applicable Standards and Codes

The National Fire Protection Association (NFPA) / National Electric Code (NEC) Standard 70E, NFPA / NEC 70, and NFPA Standard 79 dictate the presence of a disconnect switch stating that any large and permanently wired equipment must have a disconnecting means within sight distance. These North American standards align with the International Electrotechnical Commission (IEC) 60204-1: "Safety of Machinery."

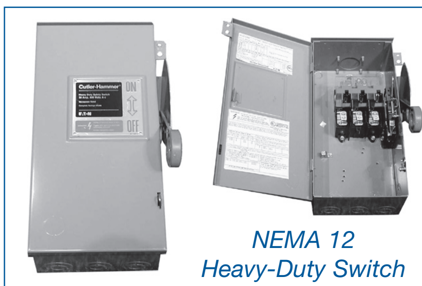
NEMA 1 Disconnect



NEMA 4 Toggle Switch



NEMA 3R Heavy-Duty Switch



NEMA 12 Heavy-Duty Switch

The International Electrotechnical Commission (IEC) 60204-1: Safety of Machinery – Electrical Equipment of Machines states in Part 1, General Requirements: A manually operated disconnect switch must be provided for every main power supply installed. The disconnect switch must indicate its on/off function, and the disconnect switch must include an accessible handle for easy, manual operation. Additionally, when the switch is in the "off" position, IEC standards mandate that it should disconnect all connected conductors. Finally, the switch should also facilitate a padlock which allows operators to "lock out" the power.

NEMA / ANSI 250 is a standard developed by the National Electrical Manufacturers Association (NEMA) that defines the ingress protection of enclosures for electrical equipment intended to be installed and used in specific nonhazardous and hazardous locations and rated at 1000 volts or less.

Other code compliance requirements may be dictated by local codes or facility specifications.

Protecting Against Electrical Overload

Electrical overload is also commonly referred to as overcurrent. It is caused by an excessive flow of current within the windings of the motor, which exceeds the design current that the motor can carry efficiently and safely. Overcurrent is often the result of a low supply voltage, which results in the motor drawing in more current to maintain torque. Electrical overload can also be caused by short-circuited conductors or an excessive voltage supply.

It is important to install effective overcurrent protection which can detect overcurrent and interrupt supply to protect the motor.

With optional fusing, disconnects can also prevent catastrophic equipment and facility damage resulting from a short circuit. A short circuit is the unintentional electrical connection between any two normally current-carrying conductors of an electrical circuit such as line to neutral or line to line.

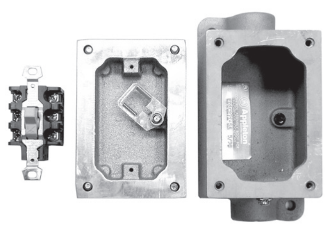
Motor overload protection (in motor starters) is not designed or may not be able to stop short-circuit currents or ground fault currents. A fault is not an overload as stated in the NEC Article 100 definitions. However, an overload is considered an overcurrent. A motor's full load amps (FLA) are used to size the overload protection. This FLA is found on the equipment nameplate. Examples of overload devices include fuses and circuit breakers as well as motor starters with overload relay(s) or a solid-state motor controller/starter if applied properly. Typical overload protection can be fuses or circuit breakers.

When sizing the overload device, if the calculation results in a nonstandard amp rating for a circuit breaker or fuse, the engineer is to use the next smaller size. Standard fuses and circuit breaker sizes can be found in NEC 240.6(A).

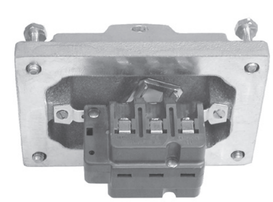
Short Circuit Current Rating (SCCR) is a rating on components and assemblies representing the maximum level of short circuit current that a component or assembly can withstand without causing a fire or shock hazard. An SCCR is the maximum current a device or system can safely withstand for a specified time (such as 0.05 seconds), or until a specified fuse or circuit breaker opens and clears the circuit. A short circuit exceeding this rating can cause catastrophic and violent equipment, component, and enclosure failure. SCCR is usually expressed in kiloamperes (kA).

Not every electrical component has an SCCR value. A typical AC motor or fan would not inherently have an associated SCCR. Some components do however have these. In short, toggle disconnects, EC motors, and VFDs would have an SCCR value associated with them. Note: A fused disconnect has a higher SCCR while a thermal overload disconnect has none. Another rating that applies to protective interrupting devices like circuit breakers and fuses is KAIC, an acronym standing for Kilo-Ampere Interrupting Capacity or thousand-ampere interrupting capacity. KAIC is a common rating in the electrical industry that measures a circuit breaker's ability to withstand a short circuit or overload. KAIC is the maximum current a breaker can interrupt under standard test conditions without sustaining damage.

Closed NEMA Disconnect Switch



Open NEMA 9 Disconnect Switch disassembled



Top portion of a NEMA 9 Disconnect Switch with a toggle switch mounted

Disconnect Selection

Although there are different types of disconnect switches, toggle and heavy-duty disconnect switches are most commonly used. Toggle switches are flipped on and off like a light switch, and heavy-duty switches have a push button or a flip arm knife blade design. They may be visible or enclosed in some type of housing.

Disconnect switches come in a multitude of shapes and sizes, are available in many enclosures and duties, and are classified under several different National Electrical Manufacturers Association (NEMA / ANSI 250) ratings based on the special applications/ambient conditions in which they are installed. Understanding the similarities and differences in disconnect switches and their enclosures will aid in the proper value selection for an application.

NEMA ratings range from NEMA 1 through NEMA 12 and are based on the switch enclosure's ability to protect against moisture, dust, corrosion, or explosion.

Nonhazardous NEMA Enclosures

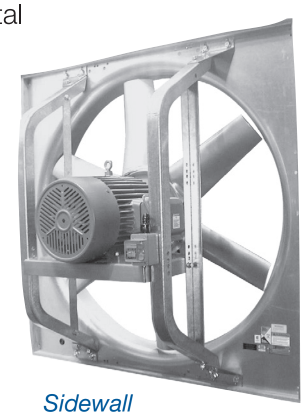
The following NEMA electrical enclosures are recommended for nonhazardous locations:

NEMA 1: Enclosure constructed for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection against falling dust. The NEMA 1 enclosure meets the rod entry and the indoor corrosion protection design tests. The rod entry test is intended to simulate incidental contact with enclosure equipment.

NEMA 3R: Enclosure constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment, and to provide a degree of protection against falling dirt, rain, sleet, snow, and windblown dust. The enclosed equipment will be undamaged by the external formation of ice on the enclosure. The NEMA 3R enclosure meets the rod entry, rain, external icing, outdoor corrosion protection, and gasket design tests.

Roof-mounted upblast fan shown with a NEMA 3R disconnect, exterior mounted and factory wired to the motor with non-metallic liquid tight conduit.

NEMA 4: Enclosure constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosure equipment and to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water; and that will be undamaged by the external formation of ice on the enclosure. The NEMA 4 enclosure meets the external icing, hose-down, outdoor corrosion protection, and gasket design tests.



Sidewall propeller fans commonly use a dust-tight NEMA 4 disconnect.

NEMA 4X: The NEMA 4X enclosure has the same protection as the NEMA 4 but it also includes protection against corrosion. The NEMA 4X enclosure meets the external icing, hose down, outdoor corrosion protection, 4X corrosion protection, and gasket design tests. 4X corrosion protection is the indoor corrosion protection test (24-hour salt spray test). The 24-hour test ensures the switch to withstand 200 hours.

NEMA 12: The NEMA 12 is a heavy-duty enclosure constructed (without knockouts) for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dust; against circulation dust, lint, fibers, and airborne particulate; and against dripping, and light splashing of liquids. The NEMA 12 enclosure meets the circulating dust, indoor corrosion protection, and gasket design tests.

Centrifugal fans commonly use NEMA 12 disconnects switches that are often shipped loose.

Hazardous NEMA Enclosures

The following NEMA electrical enclosures are designed for use in hazardous environments. Most hazardous environments require an explosion-resistant enclosure. Explosion-resistant enclosures are designed to contain an explosion, not prevent one. They are constructed of cast iron or aluminum and provide limited access rendering them unsuitable as control system enclosures.

NEMA 7: Explosion resistant. Not weatherproof. Intended for indoor use in locations classified as Class I, Groups A, B, C, or D, as defined in the National Electrical Code (NEC). This enclosure can withstand the pressures resulting from an internal explosion of specified gases and contains such that an explosive gas-air mixture existing in the atmosphere surrounding the enclosure will not be ignited. Enclosure heat-generating devices shall not cause external surfaces to reach temperatures capable of igniting explosive gas-air mixtures in the surrounding atmosphere. The NEMA 7 meets explosion, hydrostatic, and temperature design tests.

NEMA 9: Class II, Group E, F, or G hazardous locations. Not weatherproof. Intended for indoor use and has an enclosure that can prevent the entrance of dust. Enclosed heat-generating devices shall not cause external surfaces to reach temperatures capable of igniting or discoloring dust on the enclosure or igniting dust air mixtures in the surrounding atmosphere. The NEMA 9 meets dust penetration and temperature design tests, and aging of gaskets.

Hazardous enclosure class, division, and group specifications are designated by the NEC. The Class number specifies acceptable working conditions of the disconnect switch in a specific mounting location. Below are specific explanations of Class and Division groupings.

Class I, Division I rating states that it is acceptable to operate in locations where flammable gases or vapors are (or may be) present under normal conditions and may ignite, explode or cause the failure of electrical equipment. These Class I, Division I locations are termed “normally hazardous.”

Class I, Division 2 disconnects are termed “not normally hazardous” because, unlike Division I disconnects, they are normally contained within closed containers or a closed system, or are adjacent to Class I, Division I areas.

Class II, Division I covers locations where combustible dust in sufficient levels is (or could be) present in the air under normal operating conditions to produce explosive or ignitable mixtures or interfere with the normal operation of electrical equipment.

Class II, Division 2 covers locations, where combustible dust is not normally present in the air in enough quantities to produce explosive or ignitable mixtures, and dust accumulations, are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus.

For a more specific explanation of explosion-resistant disconnect switches please refer to the National Electric Code in Greenheck Product Application article FA/107-24.

Mounting Locations for Fan-Mounted Disconnects

The mounting locations of the disconnect switches depend on the fan type and the disconnect enclosure. Mounting locations, wiring terminology, etc. vary by manufacturer. For purposes of explanation, we will describe Greenheck’s approach.

For NEMA 1, 7, and 9 switches, the disconnect box will be interior mounted on the fan listed in the following locations:

- Centrifugal roof fans—on the support pan (see photo on page 4)
- Hooded propeller roof fans—on the fan base next to the access door
- Sidewall propeller fan with wall housing—on inside of wall housing
- Sidewall propeller fans without housing—on fan panel (also when a wall collar is used).

Roof-mounted upblast fan with a mounted and wired NEMA 1 disconnect switch.

For NEMA 3R, 4, 4X, and 12 switches, the disconnect box will be mounted on the exterior in the following locations:

- Centrifugal roof fans—on the windband
- Hooded propeller roof fans—on fan base
- Sidewall propeller fan—on wall housing. Requires special considerations: wall housing will not pass through the wall opening.
- Sidewall propeller fans—on wall collar. Requires special consideration: wall collar will not pass through the wall opening
- Sidewall propeller fans—on wall fan panel if no housing or collar is present.

Wiring Terminology

When ordering disconnects, it is helpful to understand the different wiring terminology, i.e., loose, mounted, and wired, or mounted, wired, and connected. If requested as loose the disconnect will be shipped with the fan. The box will not be mounted, and the wiring will not be connected.

Mounted and wired means that the disconnect box will be mounted on the unit and the wiring will be connected and run from the motor to the disconnect box. The wires at the disconnect box will NOT be connected to the load side of the switch. The switch is shipped in a bag attached to the fan. This allows external wiring to be run to and connected in the disconnect box without having to remove the switch. This is the standard Greenheck method of wiring used on its fans.

Mounted, wired, and connected applies only when an extended wiring pigtail is specified. This means the disconnect box will be mounted on the unit, the wiring will be run from the motor to the disconnect box, and the wire will be connected to the load side of the switch. The extended wiring pigtail is also connected to the supply side of the switch. At Greenheck, the fan is then factory-tested with power connected to the extended wiring pigtail.

Characteristics of Disconnects

In addition to determining a mounting style, switch type, and NEMA enclosure, it's necessary to distinguish the disconnect by various characteristics:

Phase: Disconnects are categorized like motors, either single or three-phase, and are factory-selected to match the fan motor or HVAC equipment.

Voltage: The high voltage ratings for single-phase applications are 208, 220, 230, 240, and 277, and the low voltage ratings are 110, 115, 120, and 127. The three-phase high voltages are 380, 400, 460, and 575 and low voltages are 190, 200, 208, 220, 230, and 240.

Overload: Thermal and fused overloads are available as safety features with disconnects.

Horsepower: There are maximum and minimum horsepower designations for each disconnect. The horsepower must fall between these values. The proper disconnect can be selected and provided by the equipment manufacturer depending on the equipment's motor horsepower.

Speed: Multispeed motors for the most part are a thing of the past, except in rare applications. The introduction of variable speed drives (VFDs) and electronically commutated (EC) motors have replaced multispeed motors. However, in their application, disconnect switches are selected to match the number of speeds the fan motor can operate at.

Disconnect Auxiliary Contacts

Auxiliary contacts can be added to heavy-duty disconnect switches and typically are provided in a pair: (1) Normally Open and (1) Normally Closed.

Auxiliary switches can be used to break control power with the line power. Certain applications benefit (such as the isolation function for many VFDs) from removing the control power (or run signal) with the removal of three-phase power and/or for alarming (notifying) that power has been disconnected from a piece of equipment.

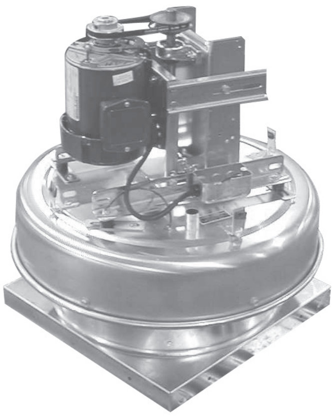
Disconnects and One-Point Wiring

One-point wiring is a convenient optional method of adding value with a time- and money-saving service. By factory-wiring the damper actuator, fan motor, and damper end switch to a single point, we can make the installation of propeller fans faster and easier for the contractor. The option of a NEMA 1 and NEMA 3R disconnect are available with one-point wiring. If you are looking to use a different disconnect, contact the equipment manufacturer.

The following guideline should be followed when using disconnects with single-point wiring. The guideline states that the equipment voltage can be whatever is specified, but the application of a fan with an actuated damper, damper actuator voltage, and the end switch voltage must be 120 volts. This applies to single-speed, either single-phase or three-phase motors.

Disconnect Offerings

HVAC manufacturers offer a wide range of NEMA-rated disconnect switches accommodating all commercial and institutional HVAC applications. Premium manufacturers allow mounting and wiring options to order disconnects exactly how they are specified.



Roof-mounted downblast fan with a mounted NEMA 1 disconnect switch.

References

- *NEMA Standards Publication, NEMA / ANSI 250, Enclosures for Electrical Equipment,*
- *International Electrotechnical Commission (IEC) 60204-1: Safety of Machinery – Electrical Equipment of Machines*
- *National Fire Protection Association (NFPA) / National Electrical Code (NEC) Standard 70E*
- *NFPA Standard 79*
- *NFPA / NEC 70*

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