LA-UR-24-25281

Approved for public release; distribution is unlimited.

Title:	Switches and Disconnects
Author(s):	Stromberg, Eric Roland
Intended for:	Training
Issued:	2024-05-29

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by Triad National Security, LLC for the National Nuclear Security Administration of U.S. Department of Energy under contract 89233218CNA000001. By approving this article, the publisher recognizes that the U.S. Government retains nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

Los Alamos National Laboratory: Switches and Disconnects

By Eric Stromberg:

UTrain course number-58422

Unclassified: David Allen Smith 2024-05

Switches and Disconnects

NEC Article for Switches

Article 404

Part I – Installation

Part II – Construction Specifications

Terminal Objective: Switches and Disconnects

- **Students will be able to demonstrate their knowledge of circuit breakers, including their characteristics, requirements, and uses, as well as LANL-specific electrical safety requirements for disconnects.**

Objectives: Switches and Disconnects

Identify circuit breaker characteristics and uses.

Identify circuit breaker requirements for fluorescent lighting per NEC 240.82(D).

Identify disconnect switch types used and not used at LANL.

Explain why LANL requires field disconnects near HVAC units.

Identify LANL electrical requirements for disconnects.

Switches

Types of Switches

There are a wide variety of switches. From the device in the wall to turn on a room light to devices controlling several thousand amps.

Wiring Devices

- Single pole
- Double pole
- Three-way
- Four-way

Time switches

Knife switches

Dimmers?

Circuit Breakers

Switches

Article 100 definitions:

- Switch, General-Use
  - A switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage.
- Switch, General-Use Snap
  - A form of general-use switch constructed so that it can be installed in device boxes or on box covers, or otherwise used in conjunction with wiring systems recognized by this *Code*.

Switches

Article 100 definitions:

- Switch, Switch, Isolating
  - A switch intended for isolating an electrical circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means.
- Switch, Motor-Circuit
  - A switch rated in Horsepower that is capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at rated voltage.

Switches

Circuit Breakers?

The Article 100 definition of a circuit breaker is as follows:

- A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

The underlining is mine, for emphasis.

404.1 adds to this:

- This Article covers all switching devices, and circuit breakers used as switches operating at 1000 volts and below, unless specifically referenced elsewhere in this Code for higher voltage.

Again, the underlining is mine. When a circuit breaker is used to turn on and off a load, like warehouse lighting, the circuit breaker is simply considered a switch. This has ramifications in electrical safety because a switch is not subject to the requirements of the breaker operation policy.

Switches

Circuit Breakers…*cont*

Circuit breakers can be purchased that have a SWD rating, or a HID rating.

- SWD means "switching duty," or "switch duty."
- HID means "high intensity discharge."

NEC 240.83(D) states that circuit breakers used as switches for 120 volt or 277 volt fluorescent lighting must be marked either SWD or HID. It also states that circuit breakers used as switches for high-intensity discharge lighting shall be marked HID. Circuit breakers for other than these uses can be used for switching and do not have to be marked either SWD or HID.

Switches

Motor Rated

Motor-circuit switches can be purchased that are rated in horsepower. If a motor rated switch is not used, NEC 430.110(A) requires the switch to have not less than 115% of the full-load current rating of the motor.

LANL is not in the practice of using motor rated switches. LANLs requirement is to use disconnects with doors that open.

Disconnects

Frame Sizes

- 30, 60, 100, 200, 400, 600, 800,…

Duty

- Standard, or General
  - Not used at LANL
- Heavy duty
  - Heavy duty disconnects come with a door interlock defeat mechanism. LANL requires Heavy Duty disconnects for all applications. Door interlocks do not allow the door to be opened while the disconnect is in the closed position. The defeat mechanism allows the door to be opened when the disconnect is in the on position.

Disconnects

Heavy Duty

Fused or Non-Fused

Disconnects come in both fused and non-fused. Non-fused disconnects are often called 'safety switches,' but this is not an official designation. There are also fused safety switches.

General, or Standard, Duty

Disconnects

Fuse sizes

Fuses are made so they won't fit in a smaller frame size disconnect.

For example:

15, 20, 25, and 30 amp fuses are made to fit in a 30 amp disconnect

35, 40, 45, 50, and 60 amp fuses are made to fit in a 60 amp disconnect

70, 80, 90, and 100 amp fuses are made to fit in a 100 amp disconnect

125, 150, 175, and 200 amp fuses are made to fit in a 200 amp disconnect

And so on…

Fuse adapters are available such that a smaller fuse can be installed in a larger frame size. For example, a 80 amp fuse fits in a 100 amp disconnect, but with fuse adapters can be installed in a 200 amp disconnect. An 80 amp fuse with two sets of fuse adapters can be installed in a 400 amp disconnect.

The NEC states that a 601 amp fuse is a standard size. A 601 amp fuse is a 600 amp fuse that is manufactured in a 800 amp frame size.

Disconnects

Non-Load Break or Load Break

Disconnects are rated for load break operation or for non-load break operation. Operating a non-load break disconnect under load will likely damage the contacts by the arcing caused by breaking the circuit.

Disconnects

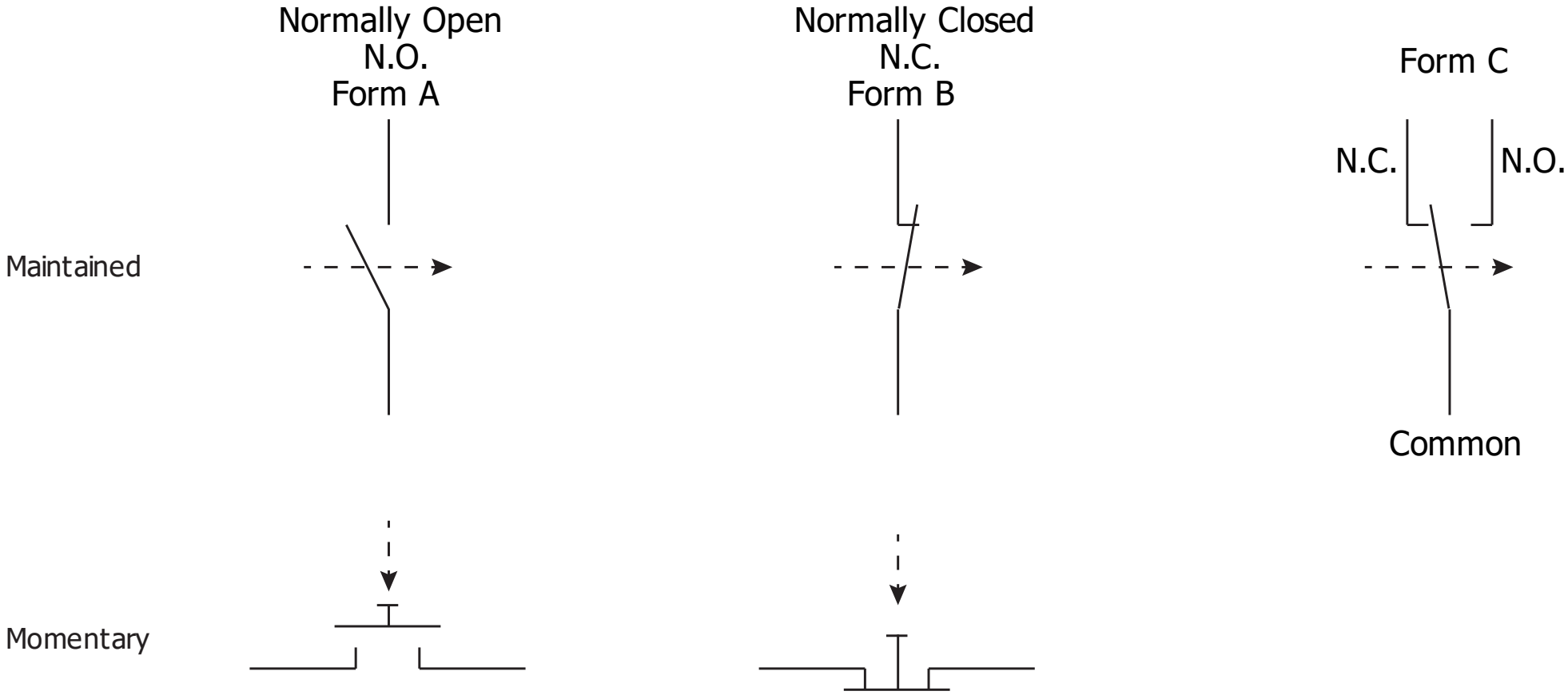
Rotary Disconnects

Rotary disconnects are very common in Europe for field disconnects next to equipment. They typically come with either an IP65 or IP66 rating. They have locking provisions but nowhere to check for zero-voltage.

IP Rating Chart

First Number	Definition	Second Number	Definition
Protection against solid objects		*Protection against liquids*	
0	No protection	0	No protection
1	Protected against solid objects over 50mm (e.g. accidental touch by hands)	1	Protected against vertically falling drops of water
2	Protected against solid objects over 12mm (e.g. fingers)	2	Protected against direct sprays up to 15° from the vertical
3	Protected against solid objects over 2.5mm (e.g. tools and wires)	3	Protected against direct sprays up to 60° from vertical
4	Protected against solid objects over 1mm (e.g. tools, wires and small wires)	4	Protected against sprays from all directions - limited ingress permitted
5	Protected against dust - limited ingress (no harmful deposit)	5	Protected against low pressure jets if water from all directions - limited ingress permitted
6	Totally protected against dust	6	Protected against strong jets of water (e.g. for use on shipdecks - limited ingress permitted)
		7	Protected against the effects of temporary immersion between 15cm and 1m. Duration of test 30 min.
		8	Protected against long periods of immersion under pressure

Contact Arrangements



"Normal" means de-energized, relaxed, or "shelf position." Meaning, the position the component would be in if you bought it at a supply house, off of the shelf. This is a very important designation, and often misunderstood. For example, there are many circuits that have a 'normally open' set of contacts that are being held in the closed position. These contacts might be closed 24/7 and only open in emergency situations, like a fire alarm or an eye-wash station. The contacts themselves, however, are 'normally open.'

Disconnects

Where required

The National Electrical Code requires disconnects for equipment like motors and HVAC units. The disconnect must be within sight of the equipment.

430 Part IX contains the requirements for motor disconnects

440 Part II contains the requirements for HVAC disconnects

LANL requires disconnects to be near the equipment and for the raceway from the disconnect to the equipment to be fully visible. This is for Lockout/Tagout reasons. The field disconnect is the best place for both mechanical and electrical lockout/tagout. Because Electrical LOTO requires a zero-voltage check, the field disconnect must have a door that opens so that the worker can check the voltage on the load terminals. It is common for HVAC equipment to have what is called a 'unit disconnect.' This is a component part of the equipment and satisfies the NEC requirement. LANL, however, still requires a field disconnect near the equipment so that zero-voltage checks can be performed.

Disconnects

Working Clearance

Are the working clearances of 110.26(A) required for disconnects? This has been the subject of some discussion among inspectors in municipalities all over the country.

110.26(A) distances are for when equipment is energized and there are energized surfaces to which the worker is exposed.

Modern disconnects have a barrier over the line terminals. If the disconnect is turned off before the door is opened, there are no exposed parts that are energized.

The best course of action is to plan for there to be working space for all disconnects on new projects. This allows the door to be opened while energized and for energized troubleshooting.

Existing disconnects at LANL, without the proper working space, are marked with a label stating "no energized work allowed due to insufficient working space." Even with this, zero-voltage checks are allowed due to the extremely small chance that any of the parts will be energized.

Notes:

- The designation “Load Center” is sometimes used by companies. In reality, “Load Centers” are Panelboards as they are also built to UL67. Some companies use the designation “Load Center” to refer to a light duty panelboard that has stab-in circuit breakers, a 10kA rating, maximum 225 amps, and is usually used for residential applications.
- “Arc Resistant” gear is gear which is built to withstand the effects of faults resulting in arc flashes or arc blasts. This is accomplished with the use of venting which directs the pressure outside the equipment. Arc resistant gear is only effective when all the doors are closed, so it will not protect a worker who is performing a zero-voltage check with the doors open. At this point, LANL does not require Arc Resistant gear, but the cost of it is coming down and it is becoming more widely used.

Notes:

- NEC 110.9 requires devices the interrupt fault current to be rated for the amount of fault current available. This rating is known as AIC, or Amps Interrupting Capability.
- NEC 110.10 requires equipment that is subject to fault current (but does not interrupt it) to be able to withstand the effects of the fault current. This rating is known as SCCR, or Short Circuit Current Rating.
- For SPDs, LANL prefers Metal Oxide Varistors over Silicon Avalanche Diodes. MOVs are more robust and last longer than SADs.

Items to be aware of on project reviews:

- Disconnects must be Heavy Duty. Heavy Duty disconnects have a door interlock defeat that allows the door to be opened while the switch is on. This is necessary for Thermal Imaging.
- For disconnects that have an incident energy of over 40cal/cm^2, or in locations where there is not enough working space, install a Grace Technologies test port on both the line and load side of the disconnect. This device has been carefully vetted by the LANL Electrical Safety Committee and substitutions are not allowed.
- Working Space requirements
  - 110.26
  - 110.26(A)
- Ensure there is a field disconnect near the motor or HVAC equipment being supplied. The raceway must be visible from the disconnect to the equipment, and the disconnect must have a door that opens.
  - Motor rated switches should not be used for field disconnects.

Items to be aware of on project reviews:

- NEC 404.8(A) requires the center of a grip or operating handle of a switch to be no more than 6 foot 7 inches above the standing surface, in its highest position. Sometimes, with equipment on housekeeping pads, the upper switches can be above this limit. This would be difficult to see on a drawing, but it is good to keep in mind. If a platform must be built in order to satisfy the 6 foot 7 inch requirement, the platform must extend to the working space required.

Switches and Disconnects

End of Session