

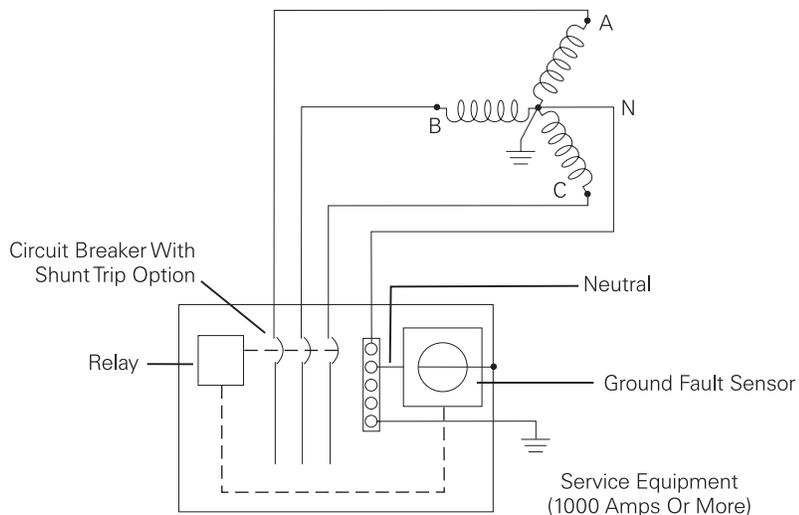
# Ground Fault Protection

In addition to ensuring equipment is properly grounded, ground fault protection for people and equipment is also a concern. *NEC*<sup>®</sup> Article 230.95 states that *ground-fault protection of equipment shall be provided for solidly grounded wye electrical services of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase for each service disconnecting means rated 1000 amperes or more.*

Although ground-fault protectors are not required on service disconnects that are less than 1000 amperes, depending on the installation, they still may be desirable. Ground fault interrupters designed to provide life protection must open a circuit at 5 milliamps ( $\pm 1$  milliamp). Ground fault protection for equipment must open a circuit when ground fault current reaches 30 milliamps. Health care facilities, such as hospitals, require additional ground fault protection. This is outlined in *NEC*<sup>®</sup> Article 517.17.

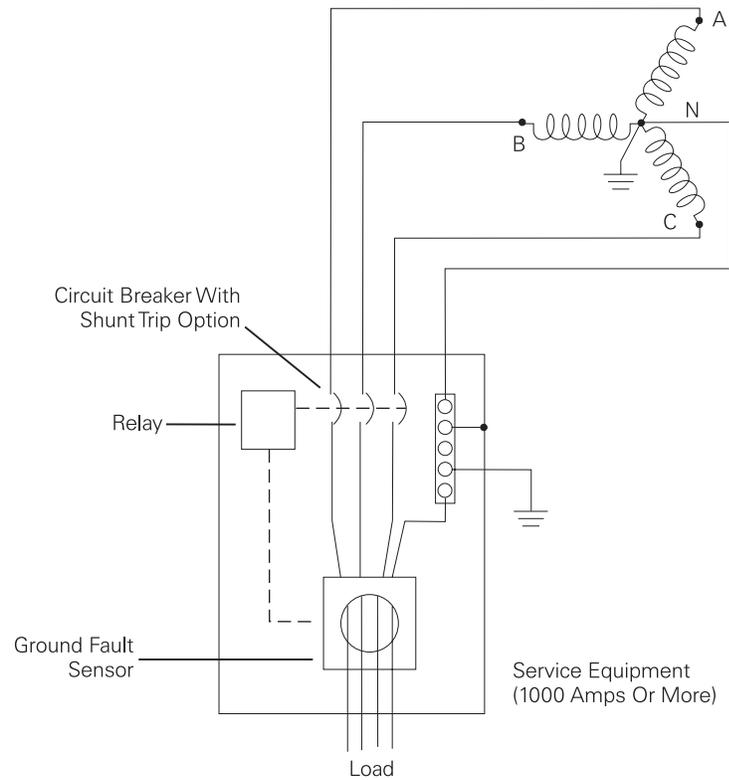
## Direct Method

One way a ground fault protector works is to install a sensor around one conductor, normally the neutral-to-ground strap. This is referred to as the direct method. When an unbalanced current from a line-to-ground fault occurs current will flow from ground to neutral. When the current reaches the setting of the ground-fault sensor the shunt trip opens the circuit breaker, removing the load from the line.



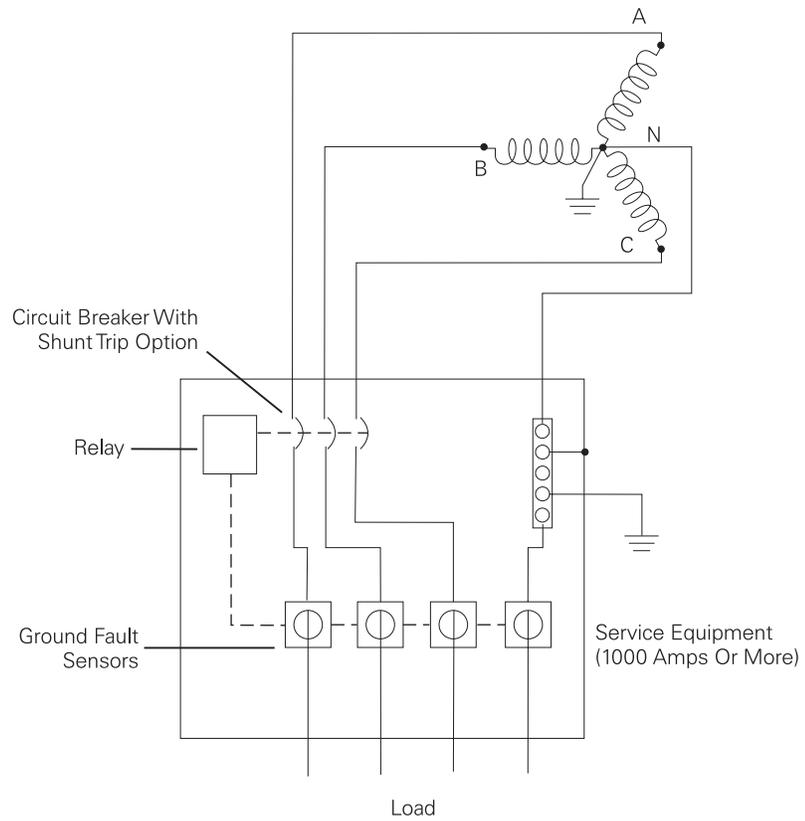
## Zero sequencing Method

Another way a ground fault protector works is with a sensor installed around all the circuit conductors, including the neutral on 4-wire systems. This is referred to as zero sequencing. During normal current flow the sum of all the currents detected by the sensor is zero. However, a ground fault will cause an unbalance of the currents flowing in the individual conductors. When this current reaches the setting of the ground-fault sensor the shunt trip opens the circuit breaker.



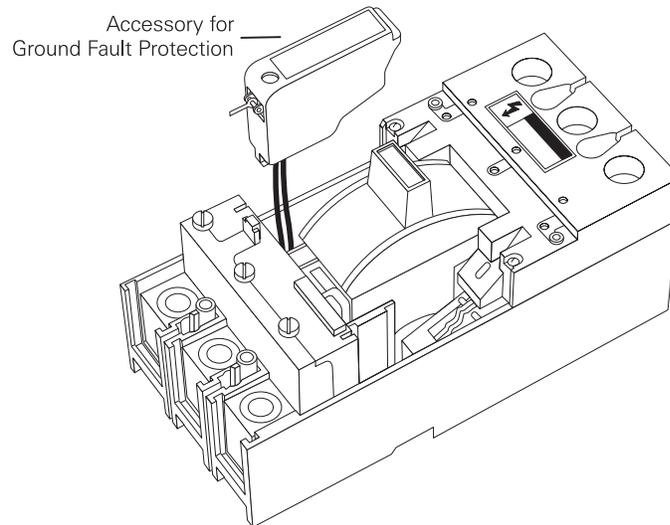
## Residual Method

Separate sensors monitor current on all three phases (and the neutral on a 4-wire system). If the vectorial sum of the currents on the secondary of the sensors does not equal zero the breaker will be tripped.

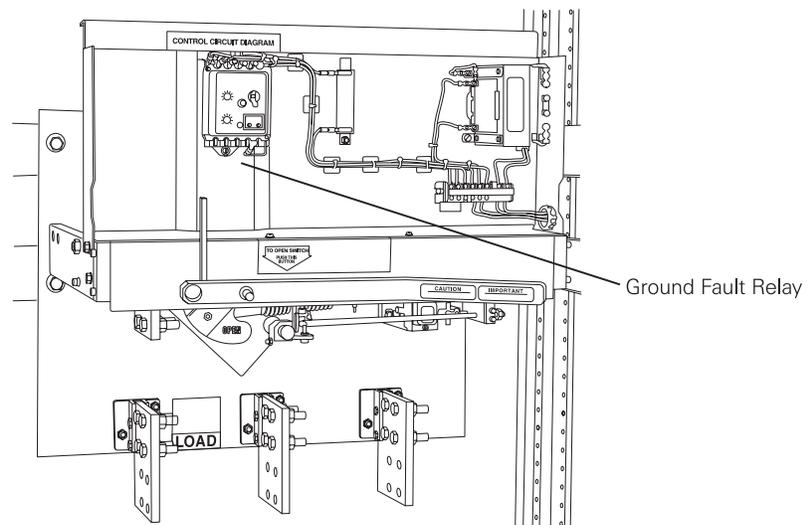


## Ground Fault Protection Devices

Ground fault protection is generally incorporated into a special type of protective device such as a molded case circuit breaker. Ground fault protection is also available in Siemens insulated case circuit breakers.



Ground fault protection can also be supplied on various disconnect switches, such as the bolted pressure switch.



**Note:** All main protective devices, except Vacu-Break<sup>®</sup> fusible switches, can be equipped with ground fault relays to comply with NEC<sup>®</sup> requirements.

# Switchboard Ratings

When selecting switchboards and overcurrent protection devices it is extremely important to know both the maximum continuous amperes and available fault current along with several other rating terms.

## Interrupting Rating

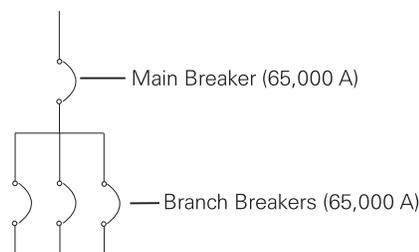
Interrupting rating refers to the current rating a protective device, such as a fuse or circuit breaker, can safely interrupt. Interrupting rating is also referred to as ampere interrupting capacity (AIC). *NEC*<sup>®</sup> article 110.9 states:

*Equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current which is available at the line terminals of the equipment.*

*Equipment intended to interrupt current at other than fault levels shall have an interrupting rating at nominal circuit voltage sufficient for the current that must be interrupted.*

## Full Rating

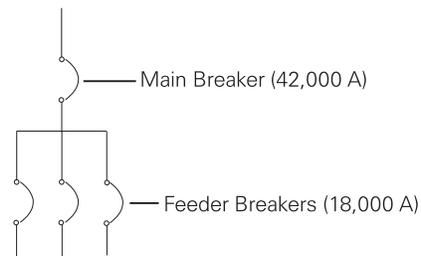
There are two ways to meet this requirement. The full rating method is to select circuit protection devices with individual ratings equal to or greater than the available fault current. This means that, in the case of a building with 65,000 amperes of fault current available at the service entrance, every circuit protection device must be rated at 65,000 amperes interrupting capacity (AIC). Switchboards are available with short circuit withstand ratings up to 200,000 amps. However, a full-rated switchboard over 100,000 AIC can be expensive because of the necessary bus bracing.



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## Series-Rated

A full-rated switchboard is not always required. Series-rated switchboards are UL listed and are adequate for many applications at a lower cost. The series-rated concept is that the main upstream circuit protection device must have an interrupting rating equal to or greater than the available fault current of the system, but subsequent downstream circuit protection devices connected in series can be rated at lower values. This is permitted as long as the series combinations shown have been tested and certified by UL. For example, a building with 42,000 amperes of available fault current might have the breaker at the service entrance rated at 42,000 AIC and additional downstream breakers rated at 18,000 AIC.



Series-rated breaker combinations must be tested in series in order to be UL listed. Siemens series-rated breakers are listed in the UL "Recognized Components Directory" (yellow books) Volume 1. Selected series-rated breakers are listed in the Speedfax catalog. Your Siemens sales engineer can provide more information on Siemens series-rated circuit breakers.

Keep in mind that it is the protection device mounted in the switchboard that interrupts current. Therefore, the interrupt rating applies to the protective devices.

## Withstand Rating

Short circuit withstand rating refers to the level of fault current a piece of equipment can withstand without sustaining damage. The standards for short circuit withstandability are set by Underwriters Laboratories (UL Standard 891). Bus structures and bracing are designed to withstand a specified amount of current for a specified amount of time. The short circuit withstand rating of a switchboard is determined by the combined withstand, interrupting, and current limiting capabilities of the bus, overcurrent protective devices in the switchboard, and any overcurrent protective devices within or ahead of the switchboard that may supply and protect it.

## Ampere Rating

The ampere rating refers to the current a switchboard or protective device will carry continuously without deterioration and without exceeding temperature rise limits.

## Voltage Rating

The voltage rating of a switchboard must be at least equal to the system voltage. The voltage rating of a switchboard can be higher than the system voltage, but never less. For example, a 480 VAC switchboard could be used on a 240 VAC system. A 240 VAC switchboard could not be used on a 480 VAC system.

## Review 5

1. Ground fault protection is required for grounded wye electrical services of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase when service disconnecting devices are rated at \_\_\_\_\_ amps or more.
2. All main protective devices except \_\_\_\_\_ - \_\_\_\_\_ can be equipped with ground fault relays.
3. Ground fault protection is discussed in *NEC*<sup>®</sup> Article \_\_\_\_\_ .
4. \_\_\_\_\_ rating refers to the level of fault current a piece of equipment can withstand without sustaining damage.
5. \_\_\_\_\_ rating refers to the maximum current a protective device such as a fuse or circuit breaker can safely interrupt.
6. A switchboard is said to be \_\_\_\_\_ - \_\_\_\_\_ when the main upstream circuit protection device is equal to or greater than the available fault current, but subsequent downstream circuit protection devices connected in series are rated at a lower AIC.
7. \_\_\_\_\_ \_\_\_\_\_ refers to the current a switchboard or protective device will carry continuously without deterioration and without exceeding temperature rise limits.

# SB1, SB2, and SB3 Switchboards

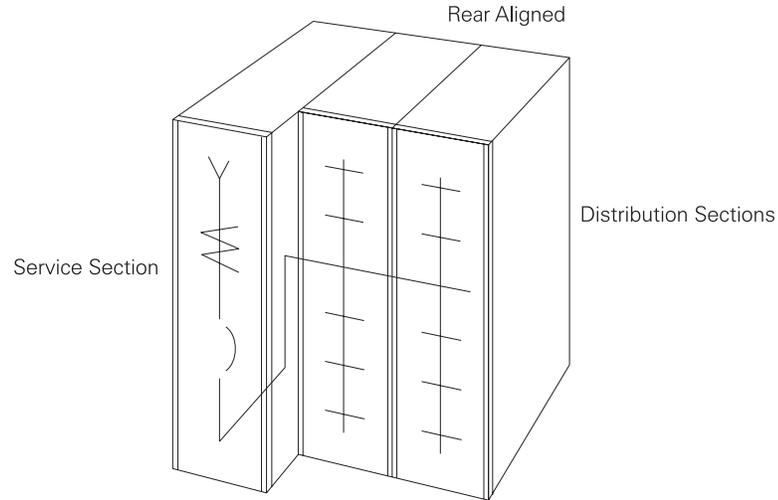
Siemens manufactures a variety of switchboards. The type of switchboard selected is determined by a variety of factors such as space, load, and environment. In addition to meeting present loads, the switchboard should be sized to accommodate reasonable future load additions. The continuous rating and through-bus can be sized on the basis of anticipated future load demand. Trip units or fuses of lower ratings can be installed to meet present load demands and changed in the future as load increases. Siemens switchboards are available in Type 1 (indoor) or Type 3R (outdoor) enclosures.

SB1, SB2, and SB3 Sentron™ switchboards can be found in a variety of industrial plants, hospitals, and commercial buildings.



## SB1 Switchboards

SB1 switchboards are designed to be used in an application where space is a consideration. SB1 switchboards are rear aligned. The service section can be deeper than the distribution sections. By aligning the rear the switchboard can be installed against a wall.



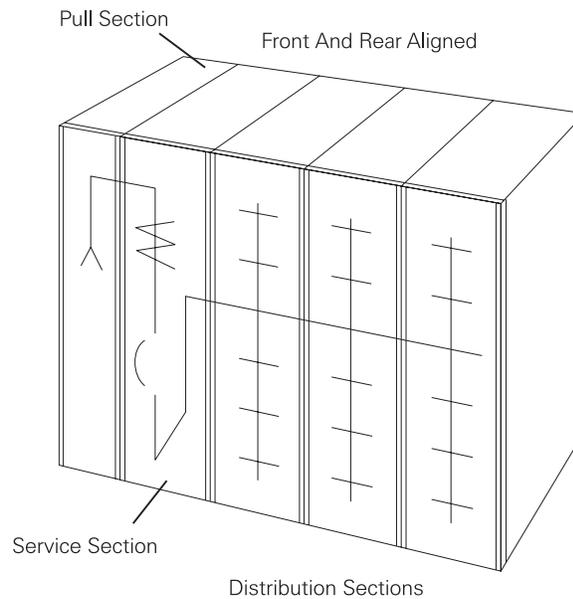
## SB1 Ratings and Devices

The SB1 switchboard contains front-connected main protective devices and through-bus ratings up to 2000 amps at 480 VAC. SB1 switchboards are front accessible with front connected devices. Main devices, used in the service section, are available from 400 - 2000 amps. Branch devices, used in the distribution section, are available from 15 - 1200 amps.

Device	Molded Case Circuit Breaker	Vacu-Break Fusible Switch	Bolted Pressure Switch	HCP Fusible Switch
Main Device Individually Mounted	400-2000 A	800-1200 A	800-2000 A	400-1200 A
Main Device Panel Mounted	400-1200 A	400-600 A		400-1200 A
Branch Device Panel Mounted	15-1200 A	30-600 A		400-1200 A

## SB2 Switchboards

The rear of SB2 switchboards align as standard. Front and rear alignment is available as an option. SB2 switchboards are front accessible and front connected. The following switchboard pictorial illustrates an SB2 that is front and rear aligned. In this example a pull section has been added to allow room to pull cable up from the bottom to connections in the top of the service section. Bottom feed without a pull section is also available. SB2 switchboards may be mounted against a wall.



## SB2 Ratings and Devices

The SB2 contains through-bus ratings up to 4000 amps at 480 VAC. Main devices are available from 400 - 4000 amps. Branch devices are available from 15 - 1600 amps.

Device	Molded Case Circuit Breaker	Vacu-Break Fusible Switch	Bolted Pressure Switch	HCP Fusible Switch	Insulated Case Circuit Breaker
Main Device Individually Mounted	400-3200 A	400-1200 A	800-4000 A	400-1200 A	800-4000 A Fixed
Main Device Panel Mounted	400-1200 A	400-600 A		400-1200 A	
Branch Device Individually Mounted		800-1200 A	800-1600 A	400-1200 A	
Branch Device Panel Mounted	15-1200 A	30-600 A		400-1200 A	

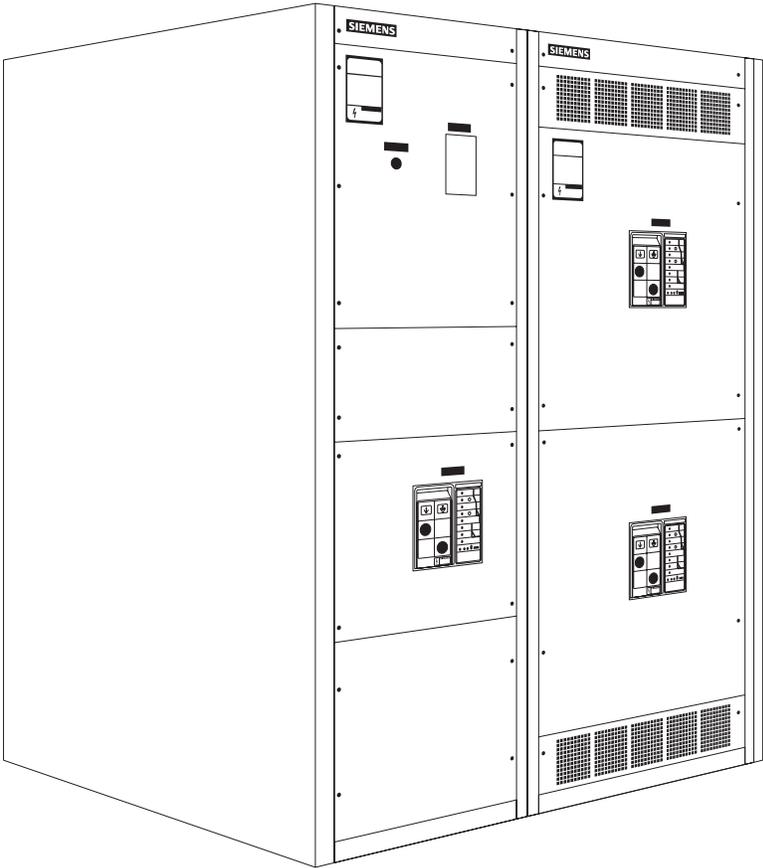
## SB3 Switchboards

SB3 switchboards are front and rear aligned. SB3 switchboards are designed for special configurations, such as incoming and outgoing busway connections, and automatic transfer schemes. Through-bus ratings are available up to 6000 amps. Branch devices are available from 15 - 2000 amps (custom configurations with higher ratings are available).

Device	Molded Case Circuit Breaker	Vacu-Break Fusible Switch	Bolted Pressure Switch	HCP Fusible Switch	Insulated Case Circuit Breaker	LV Power Circuit Breaker
Main Device Individually Mounted	400-3200 A	400-1200 A	800-4000 A	400-1200 A	800-5000 A Fixed or Drawout	800-4000 A Drawout
Main Device Panel Mounted	400-1200 A	400-600 A		400-1200 A		
Branch Device Individually Mounted	400-3200 A	800-1200 A	800-4000 A	400-1200 A	800-5000 A Fixed or Drawout	
Branch Device Panel Mounted	15-1200 A	30-600 A		400-1200 A		

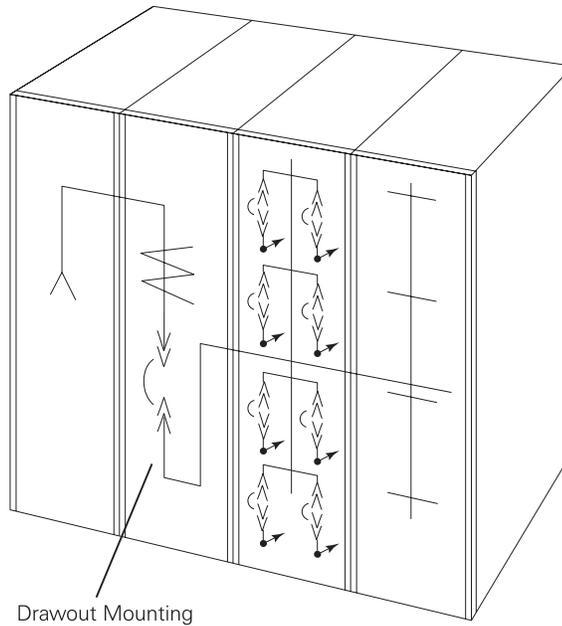
# RCIII Switchboards

The branch and feeder devices in the Siemens type RCIII switchboards are individually mounted. This mounting method requires access to outgoing cable terminations from the rear. Type RCIII switchboards are rear connected and require rear access. Bus bar extensions from the feeder devices are run back to the rear of the switchboard for easy access. RCIII switchboards are front and rear aligned. The following drawing illustrates a type RCIII switchboard with Siemens insulated case circuit breakers (ICCB) in the service and distribution sections.



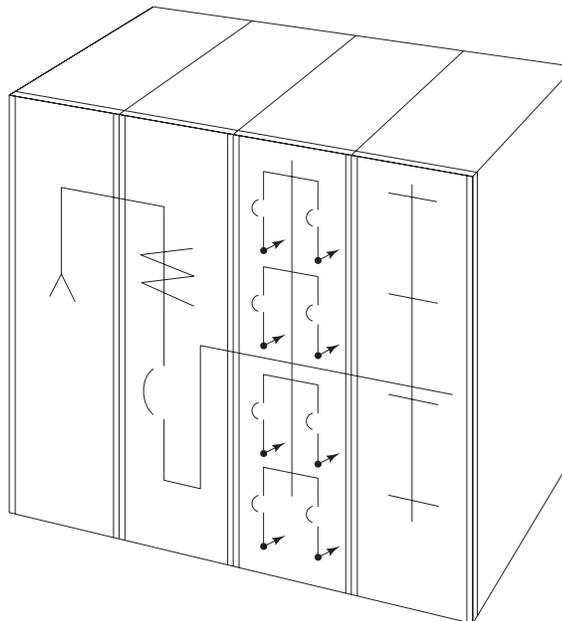
## Drawout or Fixed Mounting

Depending on the protective device, it may be either drawout or fixed mounted. Insulated case circuit breakers (ICCB), for example, may be drawout or fixed mounted. Vacu-break<sup>®</sup> fusible switches are fixed mounted.



Drawout Mounting

Drawout Mounted Devices



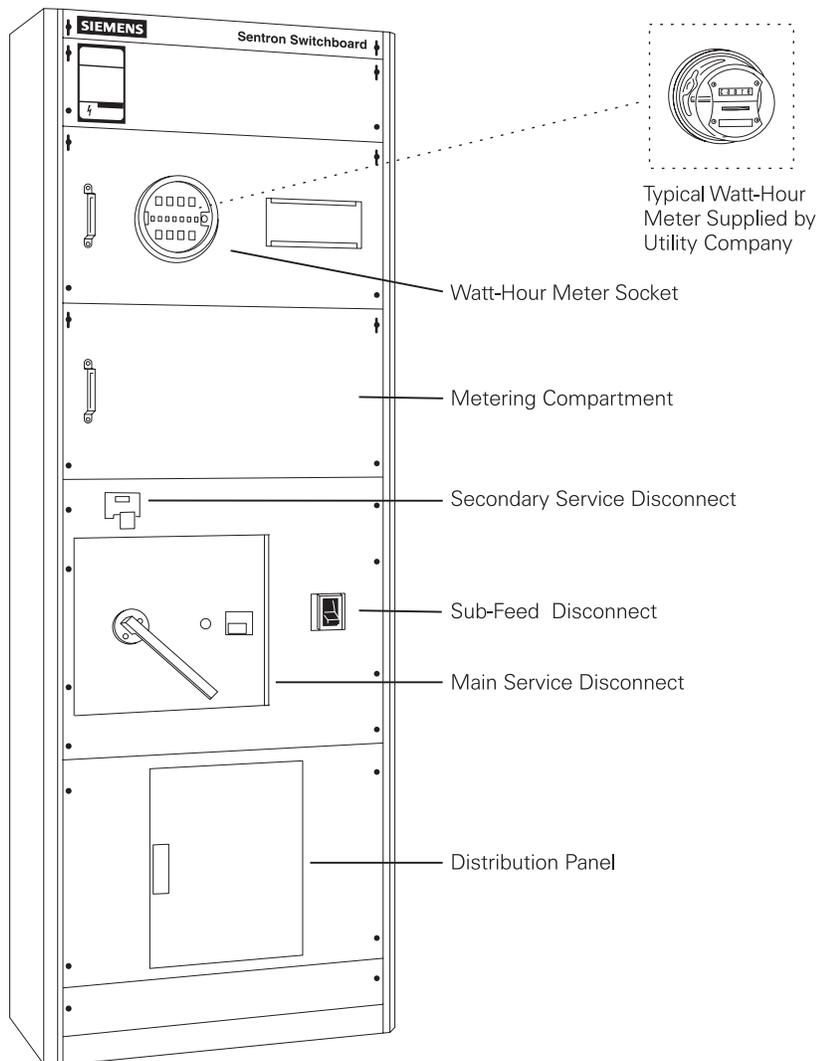
Fixed Mounted Devices

## Ratings

Device	Molded Case Circuit Breaker	Vacu-Break Fusible Switch	Bolted Pressure Switch	Insulated Case Circuit Breaker	LV Power Circuit Breaker
Main Device Individually Mounted	400-3200 A	400-1200 A	800-4000 A	100-5000 A Fixed or Drawout	800-5000 A Drawout
Branch Device Individually (Rear) and Panel Mounted	15-3200 A	30-1200 A	800-4000 A	100-4000 A Fixed or Drawout	800-4000 A Drawout

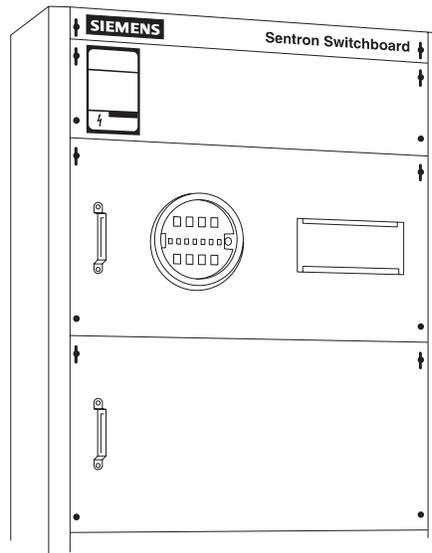
# Super Blue Pennant Switchboards

The Super Blue Pennant™ switchboard is designed as a service entrance switchboard. The main service disconnect and distribution devices are contained in a single unit. The metering provisions meet EUSERC (an electrical standardization coalition) specifications. Super Blue Pennant switchboards are rated for 400, 600, or 800 amps with a circuit breaker main and 400 or 600 amps with a fusible Vacu-Break® switch main.



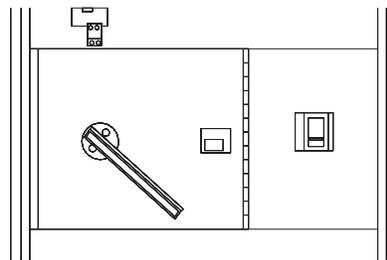
## Metering Compartment

The metering compartment has provisions for mounting a utility meter on the door. Super Blue Pennant uses hot sequence metering. Incoming power is connected to the main lugs.



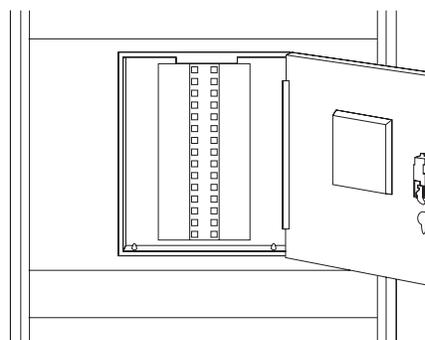
## Service Disconnect

The service disconnect can be a fusible Vacu-Break switch through 200,000 AIC, or a circuit breaker with a maximum rating of 65,000 AIC at 240 volts and 35,000 AIC at 480 volts.



## Distribution Panel

Distribution kits are optional and field adaptable with ratings of 400 - 800 amps. Up to 40 branch circuit provisions are available with an 18 branch circuit minimum.

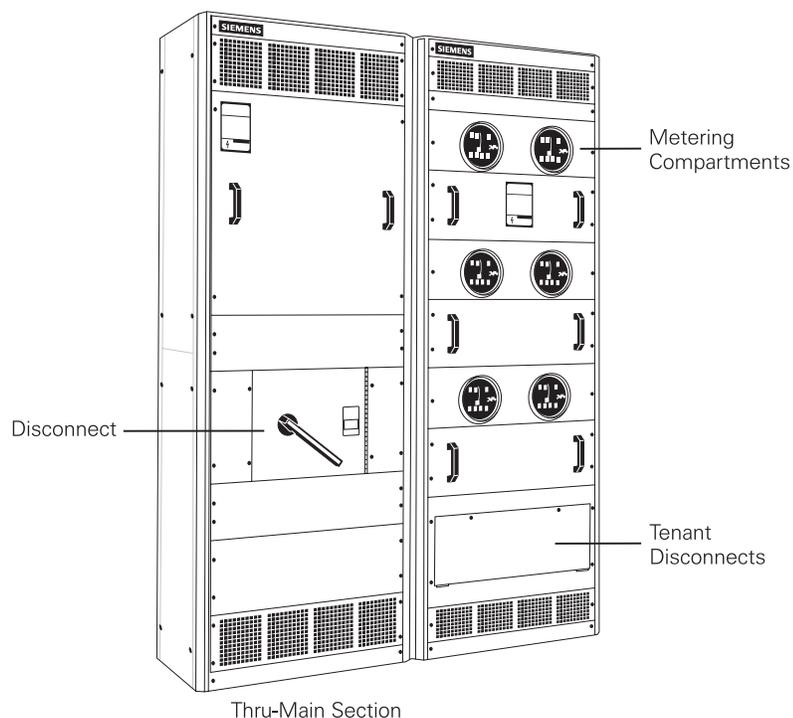


# Commercial Metering Switchboards

Commercial metering switchboards are designed for commercial applications where multi-metering is required. These applications include shopping centers, office buildings, and other commercial buildings with multiple tenants.

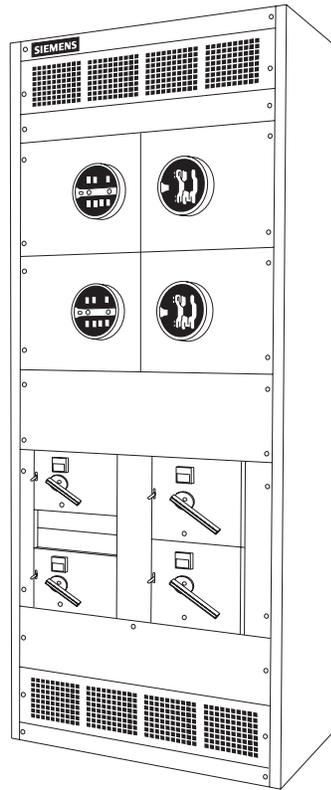
## Type SMM Switchboards

Type SMM switchboards are designed to meet west coast utility and EUSERC specifications. The switchboard main service is rated up to 4000 amps at 480 volts. Service mains can be circuit breakers (up to 2000 amps), insulated case circuit breakers (up to 3000 amps), bolted pressure switches (up to 4000 amps), or Vacu-Break<sup>®</sup>, and HCP fusible switches (up to 1200 amps). Tenant mains, rated at 100 and 200 amps, are interchangeable. Tenant mains can be circuit breakers, fusible switches, or T-fuse pullouts. The bus is braced for 65,000 amps. Higher bracing is available as an option. Metering sockets are rated for 200 amps continuous duty. The SMM switchboards incorporate a ring type meter cover design. The meter ring must be removed to disengage the meter from the socket. The meter cover does not have to be removed. Test blocks are standard equipment. The Type SMM switchboard shown below has a thru-main section.



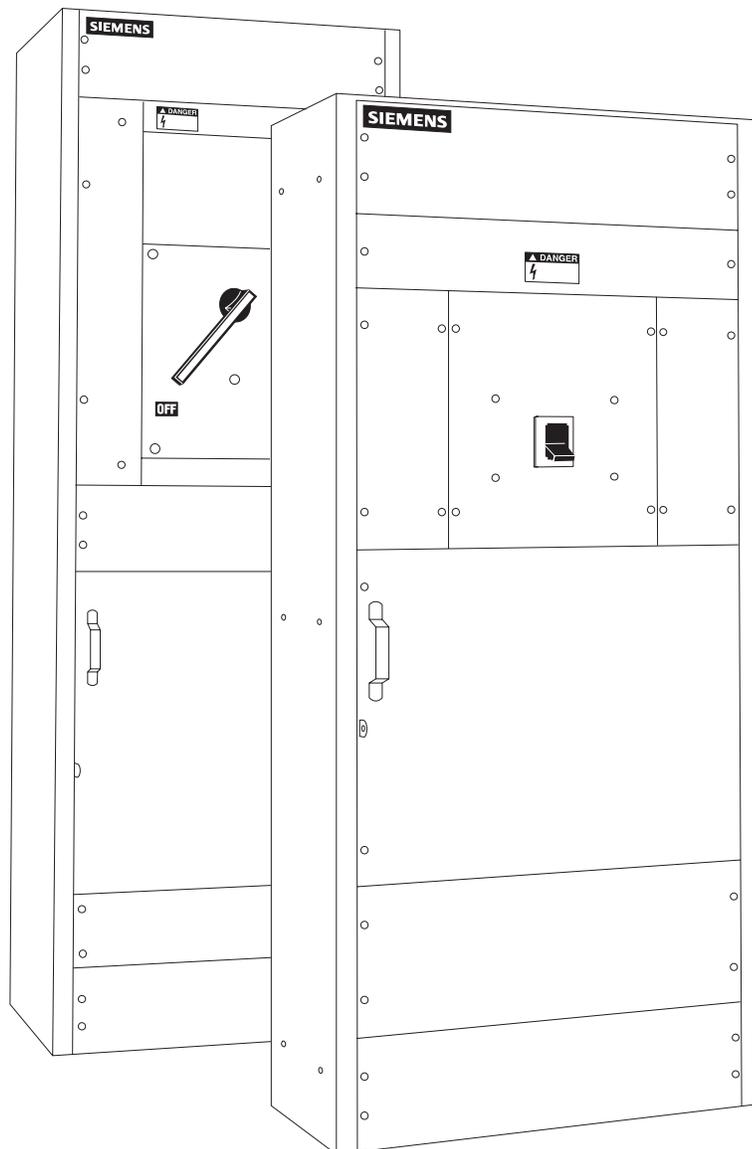
## Type MMS Switchboards

The MMS switchboard is similar to the SMM, however, it is not designed to meet west coast specifications. The main service is rated up to 4000 amps. Service mains can be circuit breakers (up to 2000 A), insulated case circuit breakers (up to 4000 A), bolted pressure switches (up to 4000 A), or Vacu-Break fusible switches (up to 1200 A). Tenant mains, rated at 100 and 200 amps, are interchangeable. Tenant mains can be circuit breakers, fusible switches, or T-fuse pullouts. All meter sockets are rated at 200 amps. Wiring is for 100 amps or 200 amps, depending on the tenant main device. Depending on the tenant main device, MMS switchboards are available with 2, 3, 4, or 6 sockets. The bus is braced for 50,000 amps. Higher bracing is available as an option. Type MMS switchboards incorporate a ringless type meter cover design. The meter cover has to be removed before the meter can be disengaged from the meter socket. Manual bypass is standard equipment.



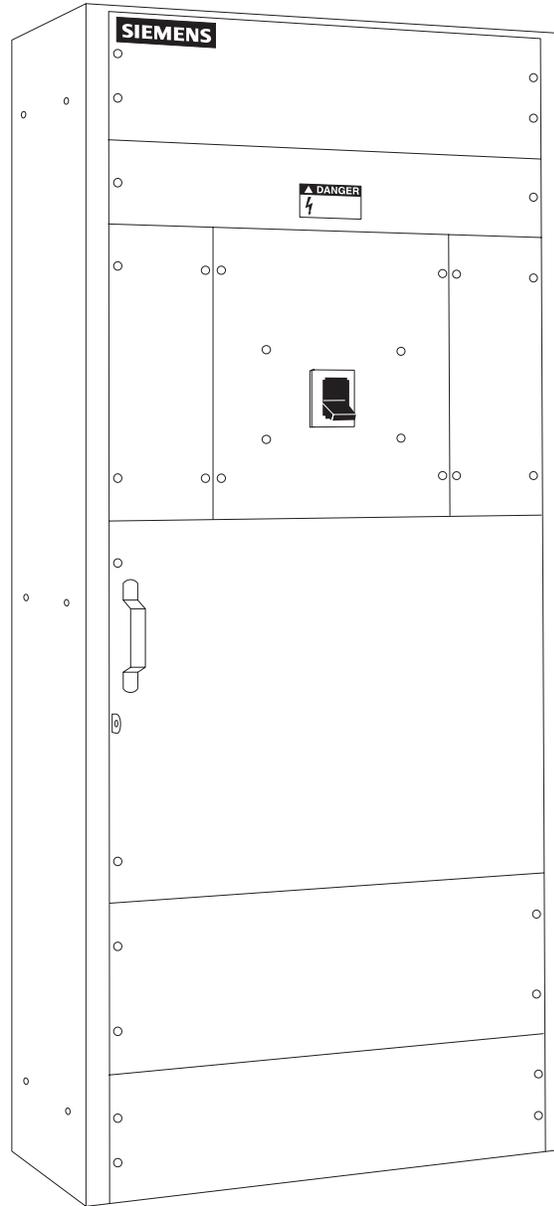
# Specialty Service Entrance Switchboards

Specialty service entrance switchboards can be used in various applications. A specialty service entrance switchboard may, for example, be placed ahead of a main switchboard. The specialty switchboard serves as the disconnect for the main switchboard. Specialty service entrance switchboards are available with a single molded case circuit breaker, Vacu-Break<sup>®</sup> fusible switch, or bolted pressure switch (not shown).



## BCT Service Cubicle

BCT service cubicles use molded case circuit breakers. They are available in current ratings from 400 - 1200 amps. BCT specialty service entrance switchboards use cold sequence metering as standard and are top fed. For hot sequence metering the unit and circuit breaker can be inverted.

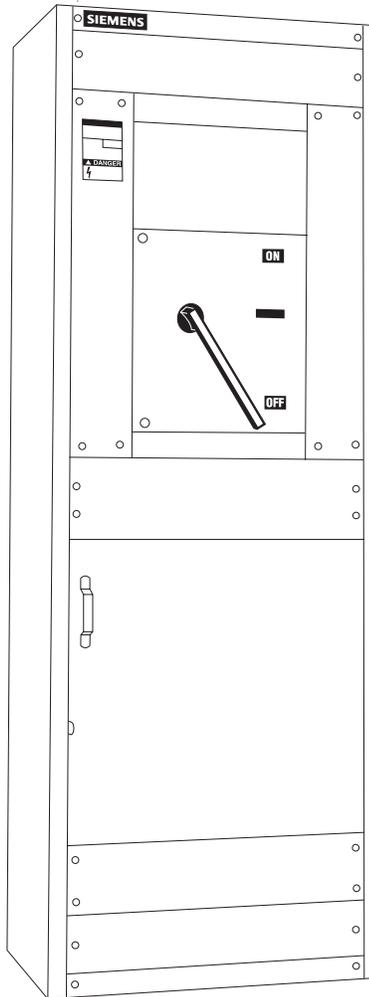


## SCT Service Cubicle

SCT service cubicles use Vacu-Break<sup>®</sup> fusible switches. They are available with the following current ratings:

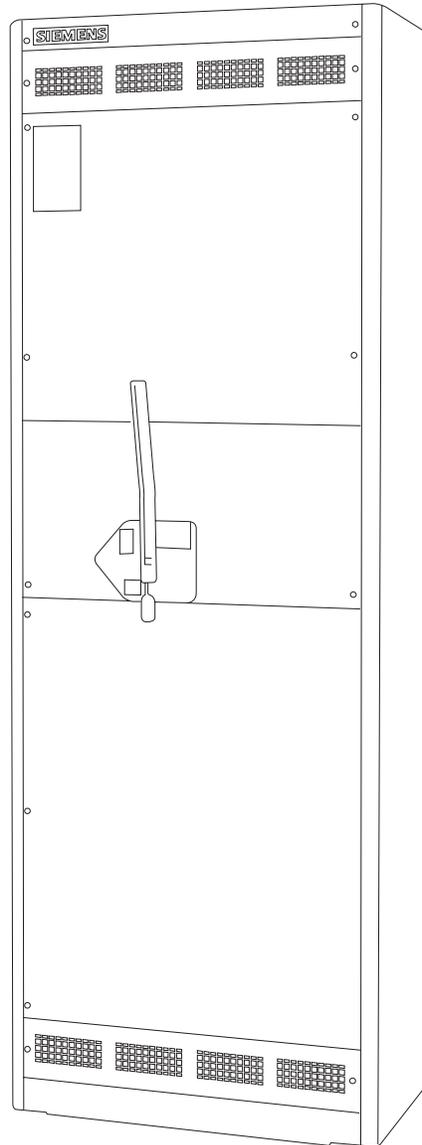
120/240, 480Y/277 volts	400, 600, and 800 amps
208Y/120, 240, 480, 600 volts	600 and 800 amps
208Y/120, 240 volts	800 and 1200 amps

SCT service cubicles use cold sequence metering. Hot sequence metering is available.



## Enclosed Bolted Pressure Switch

Enclosed bolted pressure switch specialty switchboards can be used when metering is not required and are available with top or bottom feed. The following drawing illustrates a top feed enclosed bolted pressure switch. Current ratings are available from 800 - 4000 amps.



# Information Needed To Order Switchboards

When ordering a switchboard several questions need to be answered.

1. What are the power system specifications (voltage, phases, number of wires)?
2. What is the AIC rating (ampere interrupting capacity)?
3. Will full or series rated be required?
4. What is the NEMA Type enclosure desired?
5. How many circuits are required?
6. What types of overcurrent protective devices (MCCB, ICCB, Vacu-Break<sup>®</sup> fusible switch, bolted pressure switch) are required?
7. Does the switchboard need to be suitable for service entrance?
8. What amperage is the switchboard rated at?
9. Will the switchboard be top or bottom fed?
10. Will the switchboard be hot or cold metering?
11. What will the alignment be?
12. What type of bus material is required (temperature/density)?
13. What special modifications are needed (serial communications, pull sections, corner sections)?

## Review 6

1. SB1 switchboards are \_\_\_\_\_ aligned.
2. The maximum main bus rating of an SB1 switchboard is \_\_\_\_\_ amps.
3. The maximum main bus rating of an SB2 switchboard is \_\_\_\_\_ amps.
4. The maximum main bus rating of an SB3 switchboard is \_\_\_\_\_ amps.
5. Super Blue Pennant switchboards are rated up to \_\_\_\_\_ amps with a circuit breaker and \_\_\_\_\_ amps with a Vacu-Break<sup>®</sup> fusible switch.
6. Up to \_\_\_\_\_ branch circuit provisions are available in the distribution panel of the Super Blue Pennant switchboard.
7. The type of commercial metering switchboard used on the west coast is Type \_\_\_\_\_ .
8. The type of specialty service entrance switchboard that uses a molded case circuit breaker as a main disconnect is a Type \_\_\_\_\_ service cubicle.
9. The type of specialty service entrance switchboard that uses a Vacu-Break fusible switch as a main disconnect is a Type \_\_\_\_\_ service cubicle.

# Review Answers

- Review 1** 1) 120; 2) 277; 3) 100; 4) NEMA, UL; 5) 408.
- Review 2** 1) ampacity; 2) Time; 3) 200,000; 4) 90; 5) bus; 6) Splice; 7) through-bus.
- Review 3** 1) service, distribution; 2) pull box; 3) pull section; 4) 4300; 5) Hot sequence; 6) Cold sequence; 7) f; 8) distribution; 9) Rear aligned.
- Review 4** 1) 277; 2) 120, 208, 120; 3) service entrance; 4) six; 5) disconnect link.
- Review 5** 1) 1000; 2) Vacu-Break fusible switches; 3) 230.95; 4) Withstand; 5) Interrupting; 6) series-rated; 7) Ampere rating.
- Review 6** 1) rear; 2) 2000; 3) 4000; 4) 6000; 5) 800, 600; 6) 40; 7) SMM; 8) BCT; 9) SCT.

# Final Exam

The final exam is intended to be a learning tool. The book may be used during the exam. A tear-out answer sheet is provided. After grading the test, mail the answer sheet in for grading. A grade of 70% or better is passing. Upon successful completion of the test a certificate will be issued.

1. The requirements for switchboards are covered in *NEC*<sup>®</sup> Article \_\_\_\_\_ .
  - a. 210
  - b. 318
  - c. 408
  - d. 770
  
2. Two causes of overcurrent are \_\_\_\_\_ .
  - a. overloads and heat
  - b. overloads and short circuits
  - c. short circuits and heat
  - d. ground fault and heat
  
3. The AIC rating of a Class R fuse is \_\_\_\_\_ amps.
  - a. 10,000
  - b. 50,000
  - c. 100,000
  - d. 200,000
  
4. The standard height of a Siemens switchboard is \_\_\_\_\_ inches.
  - a. 32
  - b. 38
  - c. 72
  - d. 90
  
5. The correct NEMA phase sequence for a vertical bus, as viewed from the front, left to right is \_\_\_\_\_ .
  - a. A-B-C
  - b. A-C-B
  - c. C-A-B
  - d. C-B-A

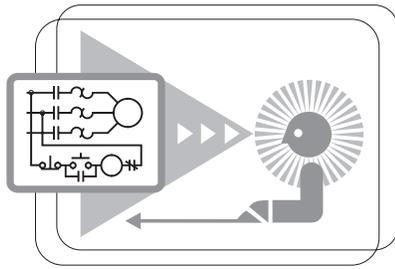
6. Two adjoining switchboard sections are connected together with \_\_\_\_\_ .
- a. vertical bus bars
  - b. compression lugs
  - c. splice plates
  - d. cross bus
7. A \_\_\_\_\_ is used when cables fed from the bottom of a switchboard need to be routed to the top of the switchboard.
- a. service section
  - b. pull section
  - c. pull box
  - d. distribution section
8. \_\_\_\_\_ is when power is still applied to the utility meter when the service main is switched off.
- a. Hot sequence
  - b. Cold sequence
  - c. Top feed
  - d. Bottom feed
9. A switchboard with a service section that is deeper than the distribution section would be \_\_\_\_\_ aligned.
- a. front
  - b. rear
  - c. front and rear
  - d. front or rear
10. On a three-phase, four-wire, wye-connected transformer with a secondary voltage of 480 volts phase-to-phase, the phase-to-neutral voltage is \_\_\_\_\_ volts.
- a. 138
  - b. 240
  - c. 277
  - d. 480
11. On a three-phase, four-wire, B phase high leg, delta-connected transformer the high leg is \_\_\_\_\_ .
- a. A - N
  - b. B - N
  - c. C - N
  - d. A - B



17. The rating which refers to the level of short circuit fault current a piece of equipment can withstand without sustaining damage is the \_\_\_\_\_ rating.
- a. interrupting
  - b. full
  - c. ampacity
  - d. withstand
18. The SB2 contains through-bus ratings up to \_\_\_\_\_ amps.
- a. 1200
  - b. 2000
  - c. 4000
  - d. 6000
19. The maximum rating for an insulated case circuit breaker used as a main device for an RCIII switchboard is \_\_\_\_\_ amps.
- a. 1200
  - b. 2000
  - c. 3000
  - d. 5000
20. Super Blue Pennant switchboards are rated up to \_\_\_\_\_ amps with a fusible Vacu-Break switch main.
- a. 600
  - b. 800
  - c. 1200
  - d. 2000

# Notes

# quickSTEP Online Courses



quickSTEP online courses are available at <http://www.sea.siemens.com/step>.

The quickSTEP training site is divided into three sections: Courses, Downloads, and a Glossary. Online courses include reviews, a final exam, the ability to print a certificate of completion, and the opportunity to register in the Sales & Distributor training database to maintain a record of your accomplishments.

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