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Introduction

Welcome to another course in the STEP 2000 series, **S**iemens **T**echnical **E**ducation **P**rogram, designed to prepare our distributors to sell Siemens Energy & Automation products more effectively. This course covers **Busway** and related products.

Upon completion of **Busway** you should be able to:

- Identify the major components of several Siemens busway systems and describe their functions
- Identify the role of busway in a distribution system
- Explain the need for circuit protection
- Identify feeder and plug-in busway and explain the use of each
- Identify various organizations involved with busway design standards
- Describe selected sections of the National Electrical Code® (NEC®) as it applies to busway
- Measure and layout a basic busway system
- Identify various ratings of Siemens busway
- Describe how a cost savings is realized when busway is selected over cable and conduit

This knowledge will help you better understand customer applications. In addition, you will be better able to describe products to customers and determine important differences between products. You should complete **Basics of Electricity** before attempting **Busway**. An understanding of many of the concepts covered in **Basics of Electricity** is required for **Busway**.

If you are an employee of a Siemens Energy & Automation authorized distributor, fill out the final exam tear-out card and mail in the card. We will mail you a certificate of completion if you score a passing grade. Good luck with your efforts.

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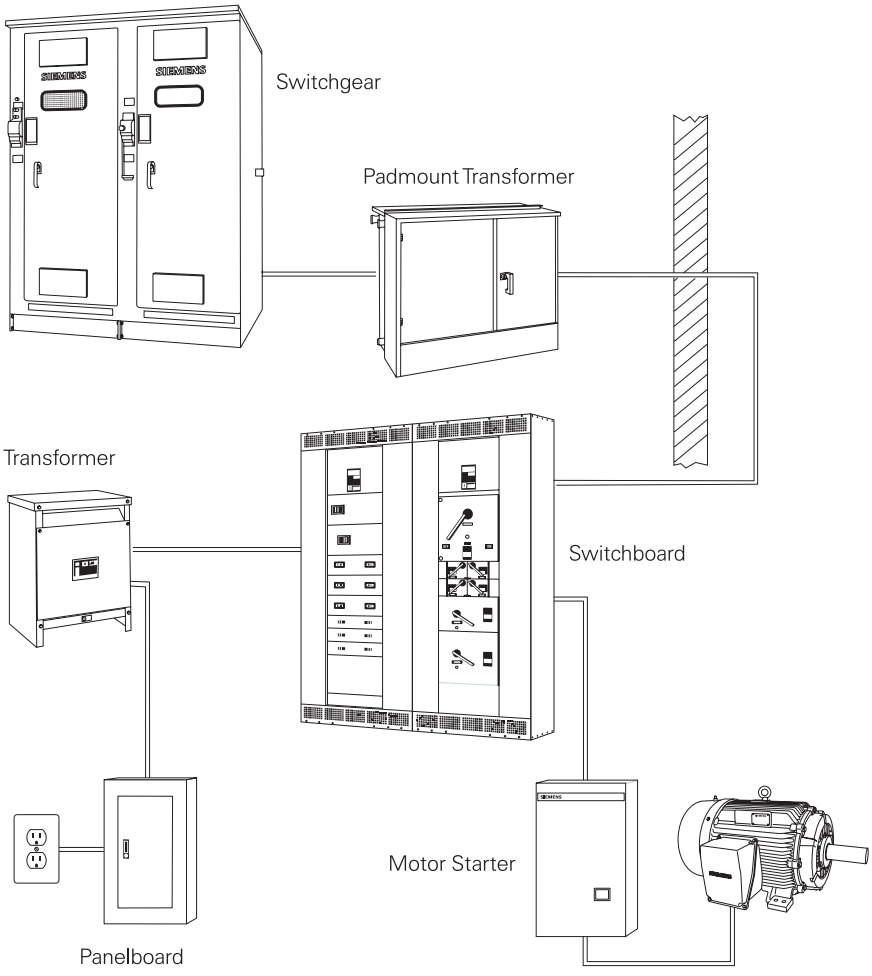
Distribution Systems

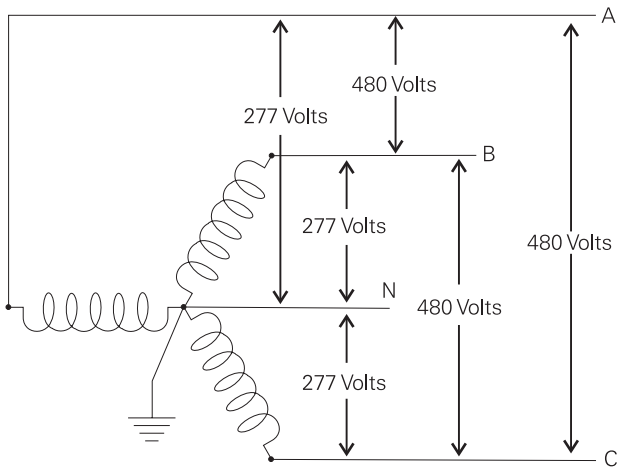
A distribution system is a system that distributes electrical power throughout a building. Distribution systems are used in every residential, commercial, and industrial building.

Distribution systems used in commercial and industrial locations are complex. A distribution system consists of metering devices to measure power consumption, main and branch disconnects, protective devices, switching devices to start and stop power flow, conductors, and transformers. Power may be distributed through various switchboards, transformers, and panelboards. Good distribution systems don't just happen. Careful engineering is required so that the distribution system safely and efficiently supplies adequate electric service to both present and possible future loads.



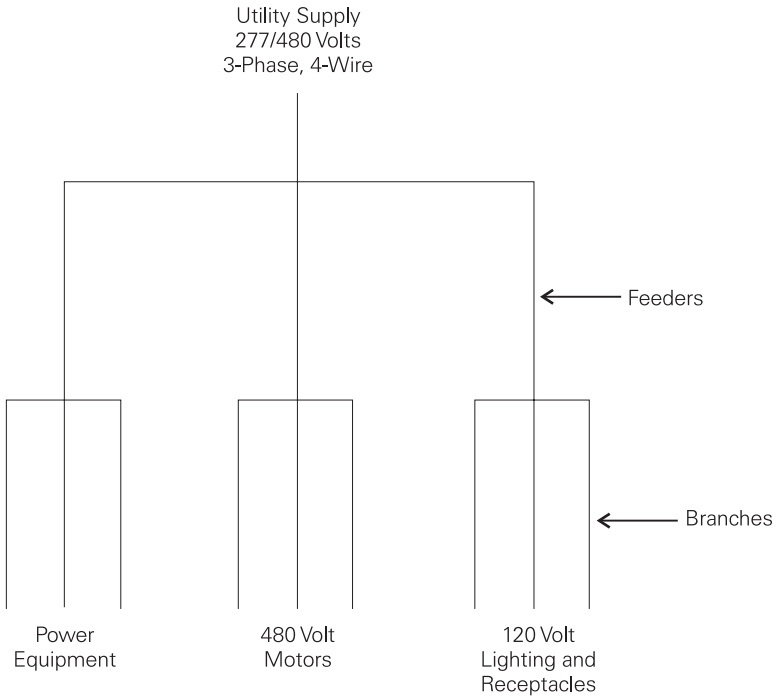
Distribution Example

In this example of a distribution system the incoming power is 277/480 volts, three-phase, four-wire. The utility company supplies power from a transformer. The secondary winding of the transformer produces 277/480 VAC.



Feeders

A feeder is a set of conductors that originate at a main distribution center and supplies one or more secondary, or one or more branch circuit distribution centers. Three feeders are used in this example. The first feeder is used for various types of power equipment. The second feeder supplies a group of 480 VAC motors. The third feeder is used for 120 volt lighting and receptacles.

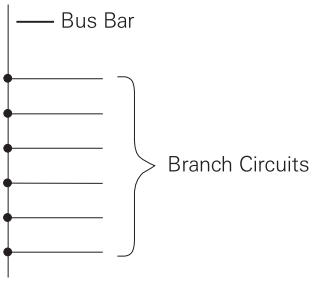


Busway Purpose and Definition

Commercial and industrial distribution systems use several methods to transport electrical energy. These methods may include heavy conductors run in trays or conduit. Once installed, cable and conduit assemblies are difficult to change. Power may also be distributed using bus bars in an enclosure. This is referred to as busway.

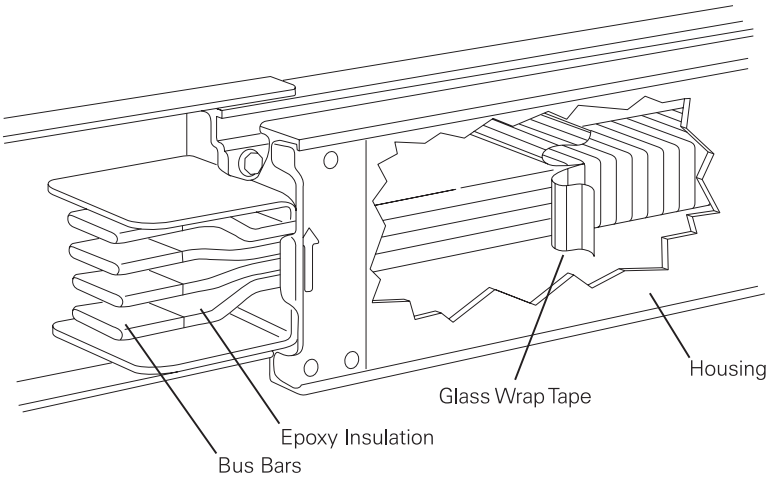
Bus Bars

A bus bar is a conductor that serves as a common connection for two or more circuits. It is represented schematically by a straight line with a number of connections made to it. Standard bus bars in Siemens busway are made of aluminum or copper.



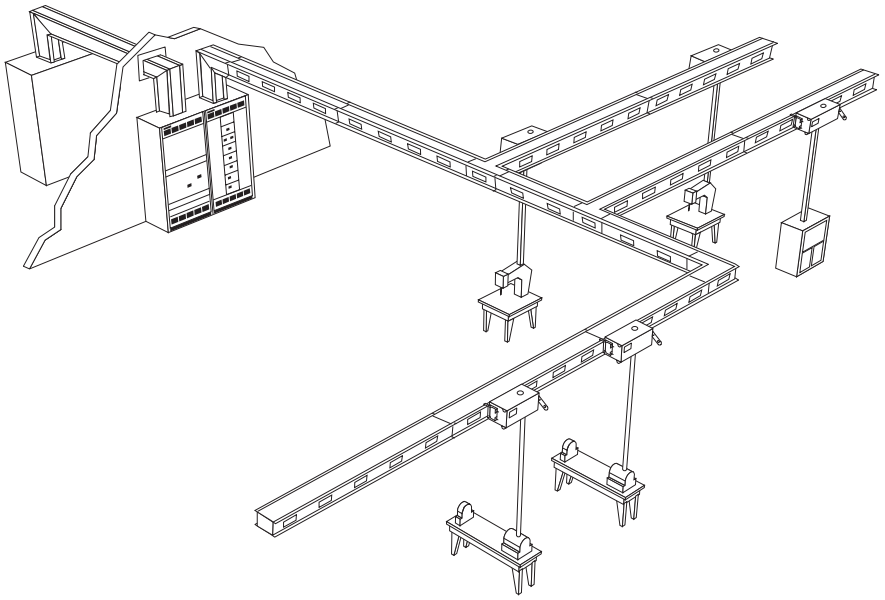
NEMA Definition

Busway is defined by the National Electrical Manufacturers Association (NEMA) as *a prefabricated electrical distribution system consisting of bus bars in a protective enclosure, including straight lengths, fittings, devices, and accessories.* Busway includes bus bars, an insulating and/or support material, and a housing.

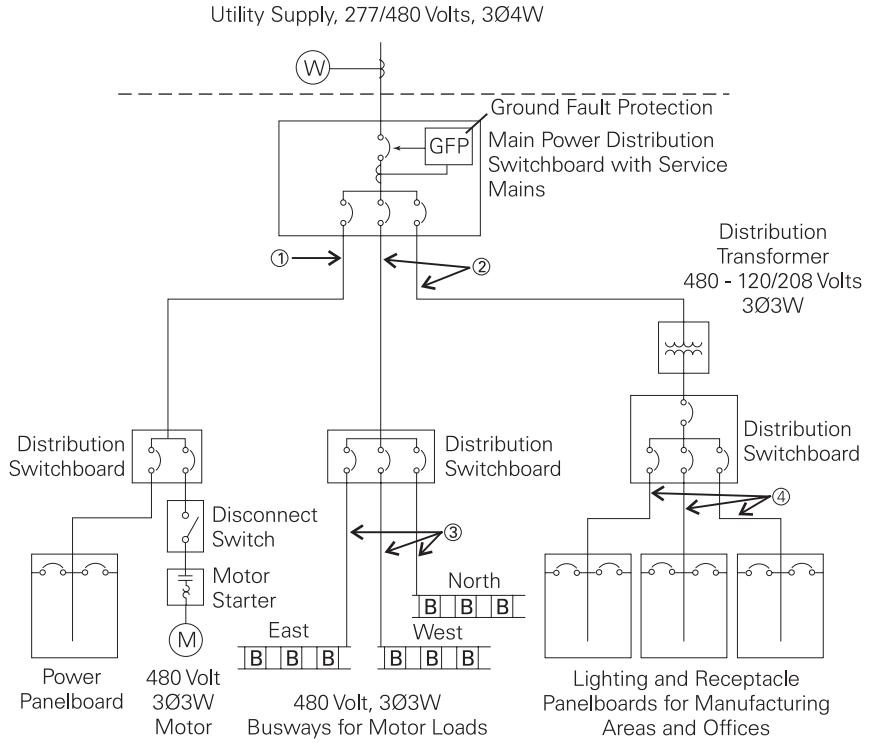


Busway Used in a Distribution System

A major advantage of busway is the ease in which busway sections are connected together. Electrical power can be supplied to any area of a building by connecting standard lengths of busway. It typically takes fewer man-hours to install or change a busway system than cable and conduit assemblies.



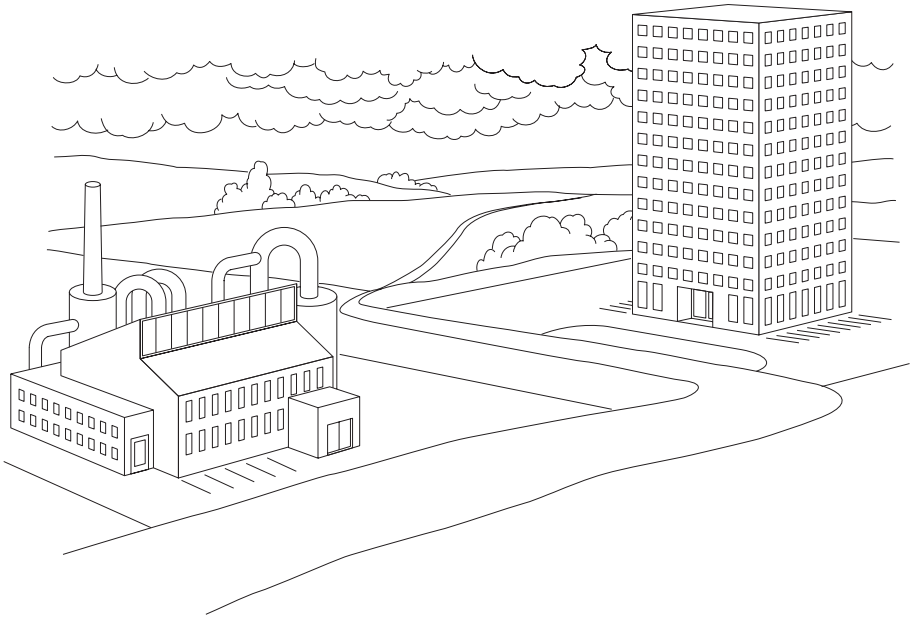
The total distribution system frequently consists of a combination of busway and cable and conduit. In this example power from the utility company is metered and enters the plant through a distribution switchboard. The switchboard serves as the main disconnecting means. The feeder on the left feeds a distribution switchboard, which in turn feeds a panelboard and a 480 volt, three-phase, three-wire (3Ø3W) motor. The middle feeder feeds another switchboard, which divides the power into three, three-phase, three-wire circuits. Each circuit feeds a busway run to 480 volt motors. The feeder on the right supplies 120/208 volt power, through a step-down transformer, to lighting and receptacle panelboards. Branch circuits from the lighting and receptacle panelboards supply power for lighting and outlets throughout the plant. In many cases busway can be used in lieu of the cable/conduit feeders at a lower cost.



Symbols			
	Circuit Breaker		Transformer
	Switch		Current Transformer
M	Motor	B B B	Busway
	Motor Starter	W	Watt Hour Meter

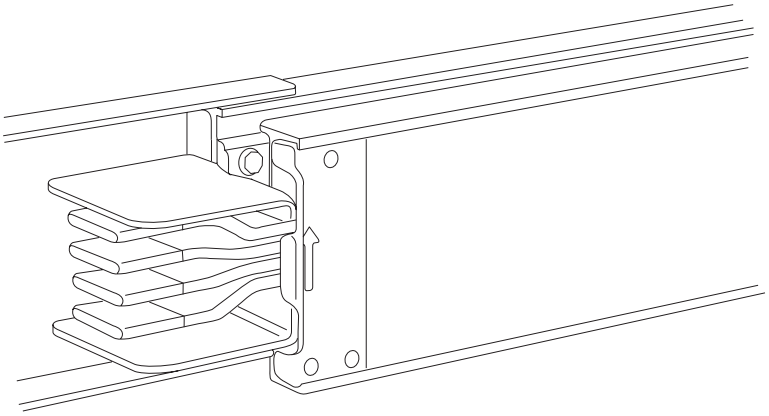
① 277/480 Volt 3Ø4W Feeder
② 480 Volt 3Ø3W Feeders
③ 480 Volt 3Ø3W Circuits
④ 120/208 Volt 3Ø4W Circuits

Busway is used in various applications and can be found in industrial installations as well as high-rise buildings. Busway used in industrial locations can supply power to heavy equipment, lighting, and air conditioning. Busway risers (vertical busway) can be installed economically in a high-rise building where it can be used to distribute lighting and air conditioning loads.



Sentron Busway

Throughout this course Siemens Sentron™ busway will be used to explain and illustrate principles and requirements of busway. Sentron busway will meet the needs of most busway systems with current ratings from 800 amperes to 5000 amperes. Siemens manufactures several types of busway. There are a number of reasons why different types of busway are manufactured. An existing pre-Sentron busway system, for example, may need to be expanded. Other types of Siemens busway, including significant features, and ratings will be discussed later in the course.

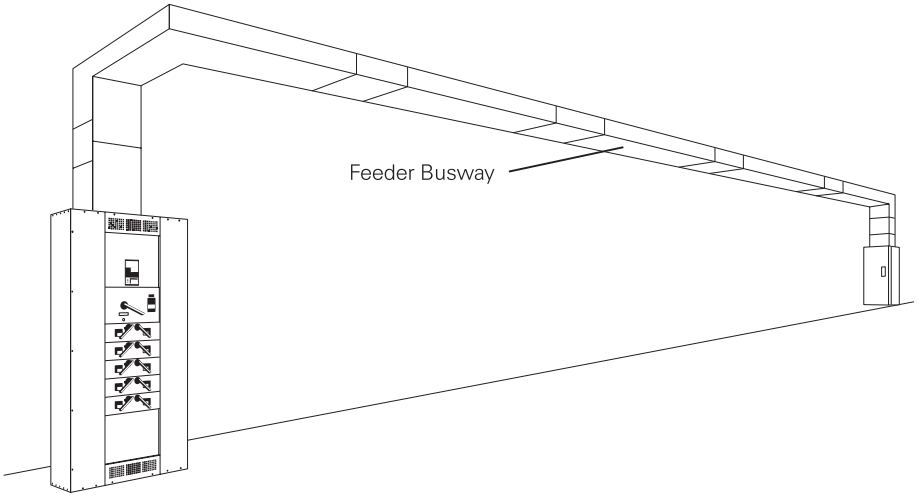


Sentron Busway

Types and Application

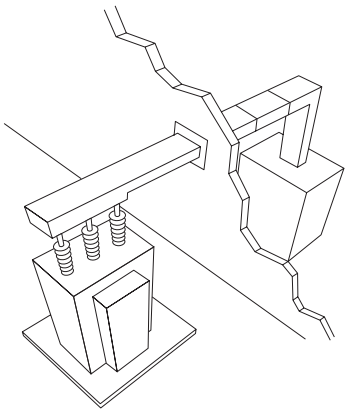
Feeder Busway

There are two types of busway, feeder and plug-in. Feeder busway is used to distribute power to loads that are concentrated in one physical area. Industrial applications frequently involve long runs from the power source to a single load. This load may be a large machine, motor control center, panelboard, or switchboard.



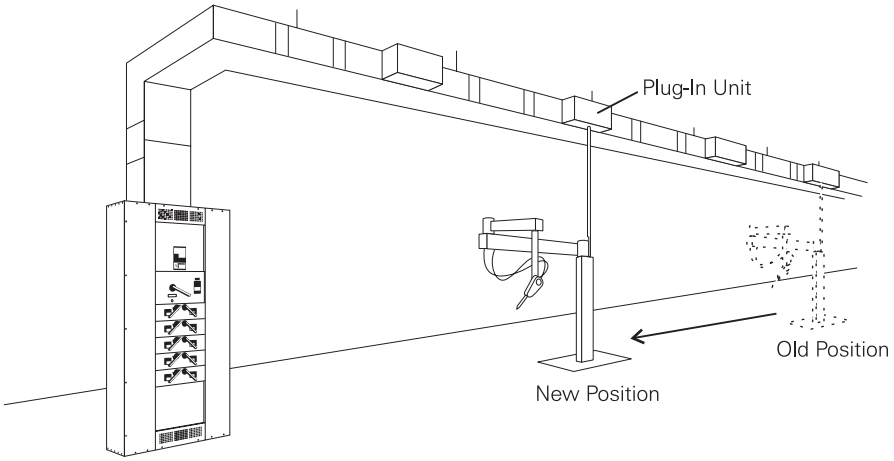
Service Entrance

The service entrance is the point of entrance of supply conductors to a building or other structure. Feeder busway, which can be purchased for indoor or outdoor use, can be used as service entrance conductors to bring power from a utility transformer to a main disconnect inside the building.



Plug-in Busway

Plug-in busway is used in applications where power requirements are distributed over a large area. Using plug-in units, load connections can be added or relocated easily. Plug-in busway is for indoor use only.



Review 1

1. A _____ _____ distributes electrical power throughout a building.

2. A _____ is a set of conductors that originate at a main distribution center and supply one or more secondary, or one or more branch circuit distribution centers.

3. _____ is a type of power distribution device that is made up of heavy bus bars in an enclosure.

4. It typically takes fewer man-hours to install or change a _____ system than cable and conduit assemblies.

5. The two types of busway are _____ and _____ _____ .

6. _____ busway can be purchased for use indoors or outdoors, _____ busway is for indoor use only.

Design Standards and Ratings

Several organizations maintain standards of design, construction, installation, and performance of busway. The following list includes some of these organizations:

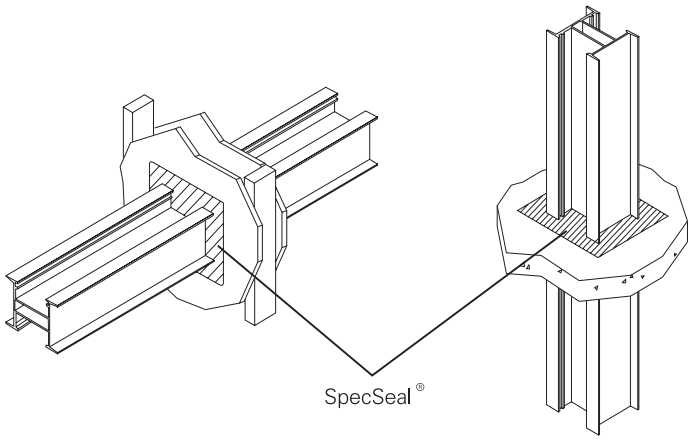
Underwriters Laboratories, Inc. (UL)
The National Electrical Manufacturers Association (NEMA)
International Electrotechnical Commission (IEC)
The National Electrical Code® (*NEC®*)
Organizations responsible for state and local electrical codes

Sentron™ busway meets the worldwide standards of UL 857, IEC 439-1, and IEC 439-2.

Underwriters Laboratories

Busway bearing the Underwriters Laboratories listing mark must pass a series of performance tests based on UL publication UL 857. These tests and standards relate to the strength and integrity of a busway system when subjected to specific operating and environmental conditions.

UL 1479 provides guidelines for a fire rating. Sentron busway has been tested in accordance with UL 1479 and offers a certified two hour fire rating for gypsum wallboard and a three hour fire rating for concrete slab or cement block. These ratings are achieved by using standard Sentron busway installed with SpecSeal® sealant from Specified Technologies, Inc.



Two Hour Fire Rating
Gypsum Wallboard

Three Hour Fire Rating
Concrete Slab

NEMA

NEMA standards for busway are listed in NEMA publication number BU 1.1-2000. NEMA is primarily associated with equipment used in North America. It is important to note that NEMA short-circuit ratings require a 3 cycle short-circuit rating. This means that the busway was tested and rated on the basis of successfully experiencing 3 cycles of peak current (I_P). NEMA recommends the following minimum short-circuit current ratings for busway.

Continuous Current Rating of Busway (Amperes)	Short-Circuit Ratings (Symmetrical Amperes)	
	Plug-In Busway	Feeder Busway
100	10,000	
225	14,000	
400	22,000	
600	22,000	42,000
800	22,000	42,000
1000	42,000	75,000
1200	42,000	75,000
1350	42,000	75,000
1600	65,000	100,000
2000	65,000	100,000
2500	65,000	150,000
3000	85,000	150,000
4000	85,000	200,000
5000		200,000

IEC

The International Electrotechnical Commission is associated with equipment sold in many countries, including the United States. IEC standards are found in IEC publications 439 and 529.

IEC also recommends short-circuit ratings for busway. Siemens manufacturers Sentron busway with continuous current ratings from 800 amperes to 5000 amperes. The following table shows the short-circuit ratings for Sentron busway. These ratings meet IEC specifications.

Continuous Current Rating of Sentron Busway (Amperes)	6 Cycle (0.1 sec.) Short-Circuit Ratings (Symmetrical Amperes)		60 Cycle (1 sec.) Short-Circuit Ratings (Symmetrical Amperes)	
	Aluminum	Copper	Aluminum	Copper
800	100,000	85,000	47,000	40,000
1000		100,000	50,000	50,000
1200	125,000		60,000	65,000
1350	150,000		75,000	80,000
1600		125,000	90,000	95,000
2000		150,000	110,000	115,000
2500	200,000		130,000	130,000
3000		200,000	160,000	175,000
4000			200,000	200,000
5000				

The following chart lists IEC and UL specifications for enclosure protection of busway.

IEC 529 - Degrees of Protection Provided by Enclosures		Approved for Sentron Busway		
Code	**Description**	**Feeder**	**Plug-In**	**Plug-In Units**
IP2X	Plug-in outlet protects against access to live parts by 12 mm (.472") test probe, even with cover opened. Finger Safe.	Yes	Yes	Yes
IP40	Enclosure protects against entry of 1.0 mm (.039") test probe. Indoor (typical UL designation).	Yes	Yes	Yes
IP54	Enclosure protects against entry of dust and splashing water. Spray Proof.	Yes	Yes	Yes
IP55	Enclosure protects against the entry of dust and jetted water.	Yes	No	No

UL 50 - Enclosures for Electrical Equipment		Approved for Sentron Busway		
Code	**Description**	**Feeder**	**Plug-In**	**Plug-In Units**
NEMA 3R	Outdoor use, protection against rain, sleet and damage due to ice formation.	Yes	No	No

Feeder or Plug-In

Indoor	IP 40
Spray Proof	IP 54 & IP55

Feeder Only

Outdoor	NEMA 3R

National Electrical Code®

The *National Electrical Code®* (sponsored by the National Fire Protection Association), once adopted by the authority having jurisdiction, stipulates installation requirements which are necessary for the safe application of electrical equipment. Article 368 of the *NEC®* specifically applies to busway, although other articles in the *NEC®* are applicable in certain situations. Thorough familiarization of the *NEC®* requirements for busway is recommended.

368.1 Scope
368.2 Definition
368.4 Use
368.5 Support
368.6 Through Walls and Floors
368.7 Dead Ends
368.8 Branches from Busways
368.9 Overcurrent Protection
368.10 Rating of Overcurrent Protection - Feeders
368.11 Reduction in Ampacity Size of Busway
368.12 Feeder of Branch Circuits
368.13 Rating of Overcurrent Protection - Branch Circuits
368.15 Marking

State and Local Codes

State and local authorities have electrical codes which are often more stringent than other organizations. You are encouraged to become familiar with this material in your local area. In addition, busway is frequently used for the main electrical service of a building, in which case the busway is connected to one or more distribution transformers owned by local electric power companies. Electrical power companies throughout the United States prefer different methods of connecting to busway. It is recommended that the local power company be contacted before applying or installing a service entrance busway run.

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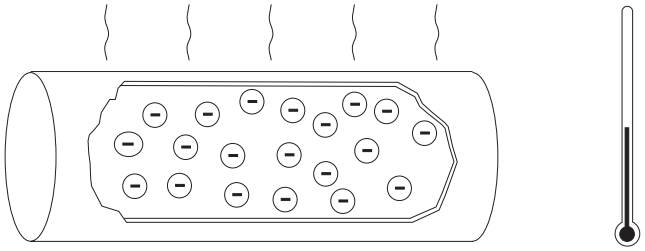
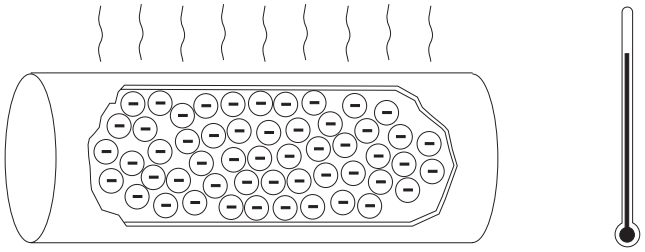
Circuit Protection

Circuit protection must be taken into consideration with any electrical circuit, including busway. Current flow in a conductor always generates a watts loss in the form of heat. As current flow increases, the conductor must be sized appropriately in order to compensate for higher watt losses. Excess heat is damaging to electrical components. For that reason, conductors have a rated continuous current carrying capacity or ampacity. Overcurrent protection devices are used to protect conductors from excessive current flow. Two devices used to protect circuits from overcurrent are fuses and circuit breakers. These protective devices are designed to limit the flow of current in a circuit to a safe level, preventing the circuit conductors from overheating.



Normal Current Flow



Excessive Current Flow

The *National Electrical Code®* defines overcurrent as *any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault* (Article 100-definitions).

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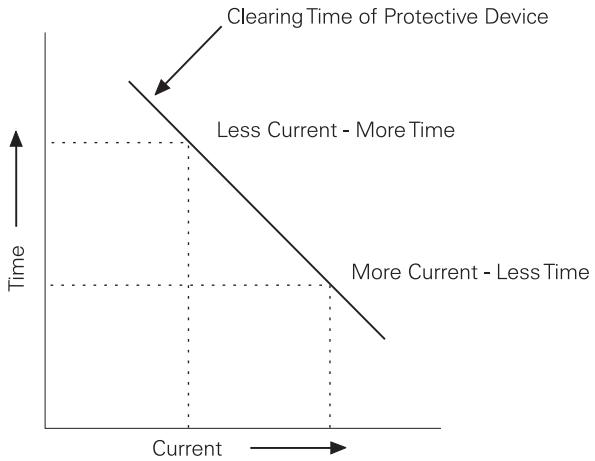
Circuit protection would be unnecessary if overloads and short circuits could be eliminated. Unfortunately, overloads and short circuits do occur. To protect a circuit against these currents, a protective device must determine when a fault condition develops and automatically disconnect the electrical equipment from the voltage source.

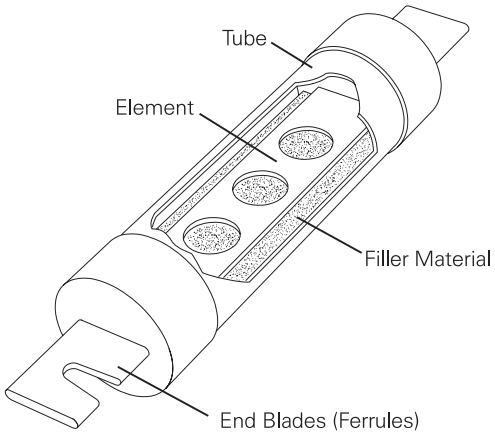
Inverse Time-Current Characteristic

An overcurrent protection device must be able to recognize the difference between overcurrents and short circuits and respond in the proper way. Protection devices use an inverse time-current characteristic. Slight overcurrents can be allowed to continue for some period of time, but as the current magnitude increases, the protection device must open faster. Short circuits must be interrupted instantly.



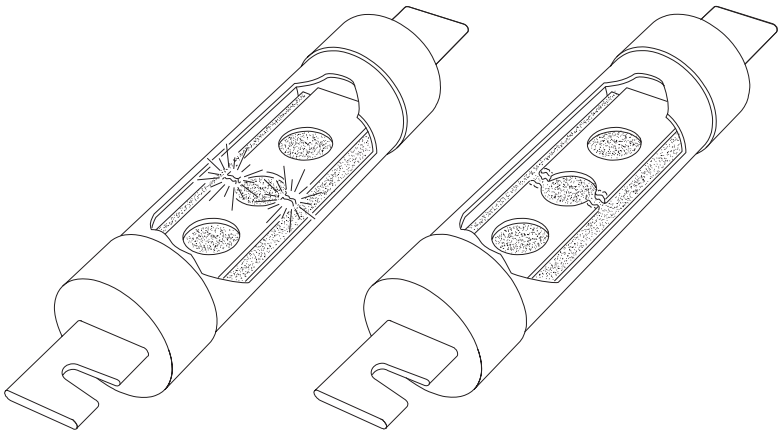
Fuse Construction

A fuse is the simplest device for interrupting a circuit experiencing an overload or a short circuit. A typical fuse, like the one shown below, consists of an element electrically connected to end blades or ferrules. The element provides a current path through the fuse. The element is enclosed in a tube and surrounded by a filler material.



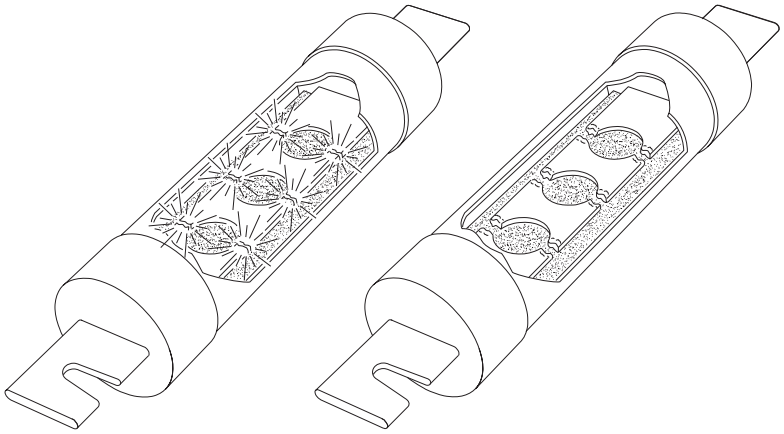
Overcurrent

Current flowing through the element generates heat, which is absorbed by the filler material. When an overcurrent occurs temperature in the element rises. In the event of a harmless transient overload condition the excess heat is absorbed by the filler material. If a sustained overload occurs the heat will eventually melt open an element segment forming a gap; thus stopping the flow of current.



Short-Circuit Current

Short-circuit current can be several thousand amperes and generates extreme heat. When a short circuit occurs several element segments can melt simultaneously, which helps remove the load from the source voltage quickly. Short-circuit current is typically cut off in less than half a cycle, before it can reach its full value.



Nontime-Delay Fuses

Nontime-delay fuses provide excellent short circuit protection. Short-term overloads, such as motor starting current, may cause nuisance openings of nontime-delay fuses. They are best used in circuits not subject to large transient surge currents. Nontime-delay fuses usually hold 500% of their rating for approximately one-fourth second, after which the current carrying element melts. This means that these fuses should not be used in motor circuits which often have inrush (starting) currents greater than 500%.

Time-Delay Fuses

Time-delay fuses provide overload and short circuit protection. Time-delay fuses usually allow five times the rated current for up to ten seconds. This is normally sufficient time to allow a motor to start without nuisance opening of the fuse unless an overload persists.

Ampere Rating

Fuses have a specific ampere rating, which is the continuous current carrying capability of a fuse. The ampere rating of a fuse, in general, should not exceed the current carrying capacity of the circuit. For example, if a conductor is rated for 10 amperes, the largest fuse that would be selected is 10 amperes.

There are some specific circumstances when the ampere rating is permitted to be greater than the current carrying capacity of the circuit. For example, motor and welder circuits can exceed conductor ampacity to allow for inrush currents and duty cycles within limits established by the *NEC*®.

Sentron Fusible Switches

Plug-in fusible switches are available on Siemens busway. Sentron™ fusible switches, for example, are rated from 30 - 600 amperes.

Voltage Rating

The voltage rating of a fuse must be at least equal to the circuit voltage. The voltage rating of a fuse can be higher than the circuit voltage, but never lower. A 600 volt fuse, for example, can be used in a 480 volt circuit. A 250 volt fuse could not be used in a 480 volt circuit.

Ampere Interrupting Capacity (AIC)

Fuses are also rated according to the level of fault current they can interrupt. This is referred to as ampere interrupting capacity (AIC). When applying a fuse, one must be selected which can sustain the largest potential short circuit current which can occur in the selected application. The fuse could rupture, causing extensive damage, if the fault current exceeds the fuse interrupting rating.

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UL Fuse Classification

Fuses are grouped into current limiting and non-current limiting classes based on their operating and construction characteristics. Fuses that incorporate features or dimensions for the rejection of another fuse of the same ampere rating but with a lower interruption rating are considered current limiting fuses. Underwriters Laboratories (UL) establishes and standardizes basic performance and physical specifications to develop its safety test procedures. These standards have resulted in distinct classes of low voltage fuses rated at 600 volts or less. The following chart lists various UL fuse classes.

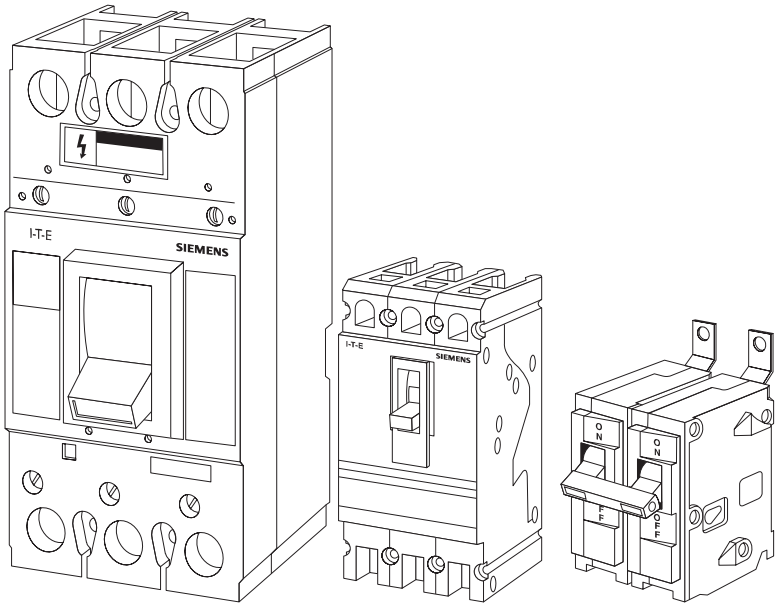
Class	Voltage Rating	Ampere Rating	Interrupting Rating (Amps)	Sub Classes	UL Standard
G*	300	0-60	100,000		UL 198 C
H	250, 600	0-600	10,000	Renewable Non renewable	UL 198 B
J*	600	0-600	200,000		UL 248 B
K	250, 600	0-600	50,000 or 100,000, or 200,000	K1 and K5	UL 198 D
L*	600	601-6000	200,000		UL 248 10
R*	250, 600	0-600	200,000	RK1 and RK5	UL 248 12
T*	300	0-1200	200,000		UL 248 15
T*	600	0-800	200,000		UL 248 15
CC*	600	0-30	200,000		UL 248 4
Plug	125	0-30	10,000	Edison Base and Type S	UL 198 F

*Current Limiting Fuses

Circuit Breakers

Another device used for overcurrent protection is a circuit breaker. The *National Electrical Code®* defines a circuit breaker as *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* (Article 100 - definitions).

Circuit breakers provide a manual means of energizing and deenergizing a circuit. In addition, circuit breakers provide automatic overcurrent protection of a circuit. A circuit breaker allows a circuit to be reactivated quickly after a short circuit or overload is cleared. Unlike fuses which must be replaced when they open, a simple flip of the breaker's handle restores the circuit.



Ampere Rating

Like fuses, every circuit breaker has a specific ampere, voltage, and fault current interruption rating. The ampere rating is the maximum continuous current a circuit breaker can carry without exceeding its rating. As a general rule, the circuit breaker ampere rating should match the conductor ampere rating. For example, if the conductor is rated for 20 amperes, the circuit breaker should be rated for 20 amperes. Siemens I-T-E® breakers are rated on the basis of using 60° C or 75° C conductors. This means that even if a conductor with a higher temperature rating were used, the ampacity of the conductor must be figured on its 60° C or 75° C rating.

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There are some specific circumstances when the ampere rating is permitted to be greater than the current carrying capacity of the circuit. For example, motor and welder circuits can exceed conductor ampacity to allow for inrush currents and duty cycles within limits established by *NEC*®.

Generally the ampere rating of a circuit breaker is selected at 125% of the continuous load current. This usually corresponds to the conductor ampacity which is also selected at 125% of continuous load current. For example, a 125 ampere circuit breaker would be selected for a load of 100 amperes.

Sentron MCCB Plug-In Units

Plug-in devices with molded case circuit breakers (MCCB) are available on Sentron busway with circuit breaker ratings from 125 - 800 amperes.

Voltage Rating

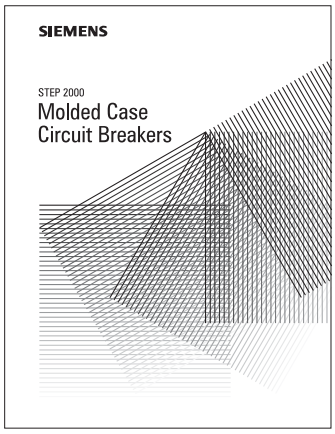
The voltage rating of the circuit breaker must be at least equal to the circuit voltage. The voltage rating of a circuit breaker can be higher than the circuit voltage, but never lower. For example, a 480 VAC circuit breaker could be used on a 240 VAC circuit. A 240 VAC circuit breaker could not be used on a 480 VAC circuit. The voltage rating is a function of the circuit breakers ability to suppress the internal arc that occurs when the circuit breaker's contacts open.

Fault Current Interrupting Rating

Circuit breakers are also rated according to the level of fault current they can interrupt. When applying a circuit breaker, one must be selected which can sustain the largest potential short circuit current which can occur in the selected application. Siemens circuit breakers have interrupting ratings from 10,000 to 200,000 amperes. To find the interrupting rating of a specific circuit breaker refer to the Speedfax® catalog.

Additional Information

For additional information on circuit breakers refer to the STEP 2000 course, **Molded Case Circuit Breakers**.



Review 2

1. In accordance with UL 1479, Sentron busway offers a _____ hour fire rating for gypsum wallboard, and a _____ hour fire rating for concrete slab when used with SpecSeal® sealant.

2. Sentron busway, with a continuous current rating of 800 amperes and aluminum bus bars, has a 60 cycle short-circuit rating of _____ amperes.

3. The highest level of enclosure protection of Sentron feeder busway is IP _____ and the highest level of enclosure protection of Sentron plug-in busway is IP _____ .

4. Article _____ in the *National Electrical Code®* specifically applies to busway.

5. A Class R has an ampere interrupting capacity of _____ _____ amperes.

6. Siemens circuit breakers have a fault current interrupting capacity of _____ to _____ amperes.

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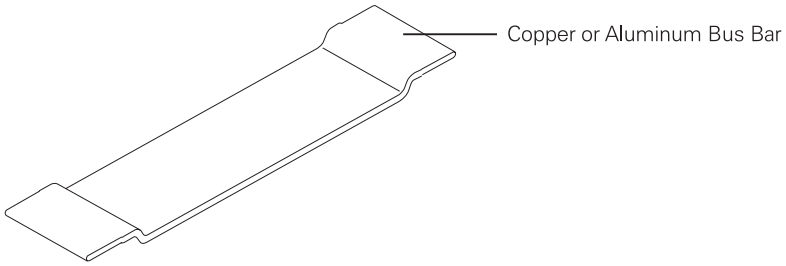
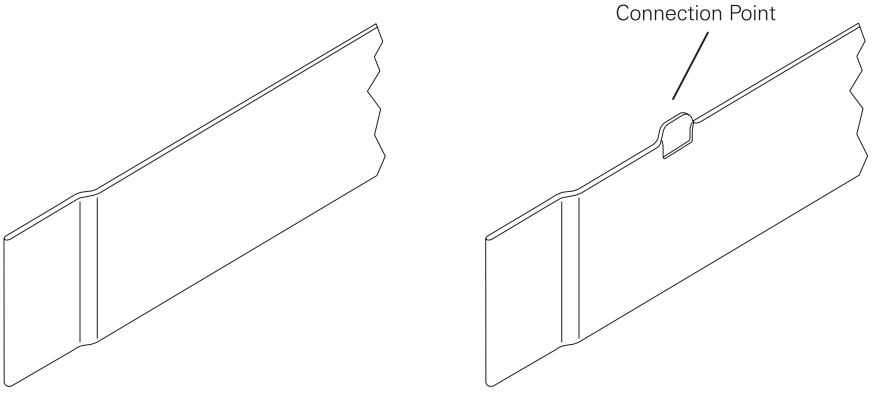
Busway Construction

Bus Bars

A better understanding of what busway is can be gained by examining its construction. A typical Siemens Sentron™ busway section has three or four formed aluminum or copper bars that function as electrical conductors. Aluminum busway can be supplied in ampacities up to 4000 amperes. Copper busway can be supplied in ampacities up to 5000 amperes.



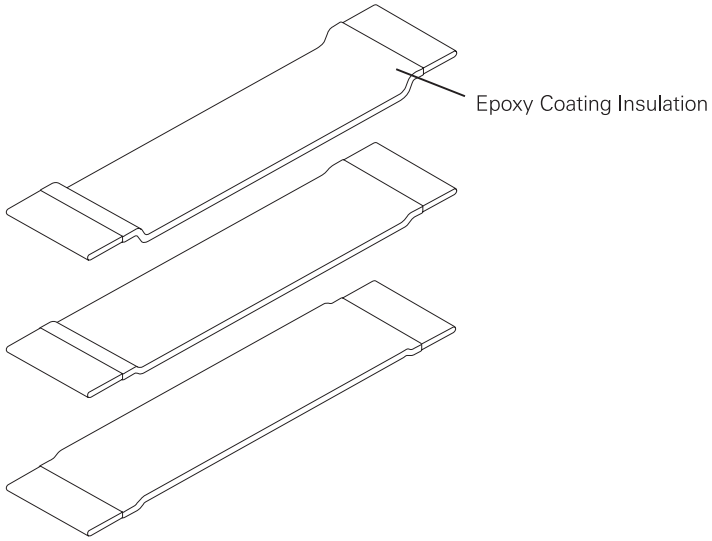
Bus bars manufactured for use in feeder busway differ from those manufactured for use in plug-in busway. Plug-in busway will have a tab or some other form of connecting a plug-in device such as a disconnect.



Sentron Feeder Busway

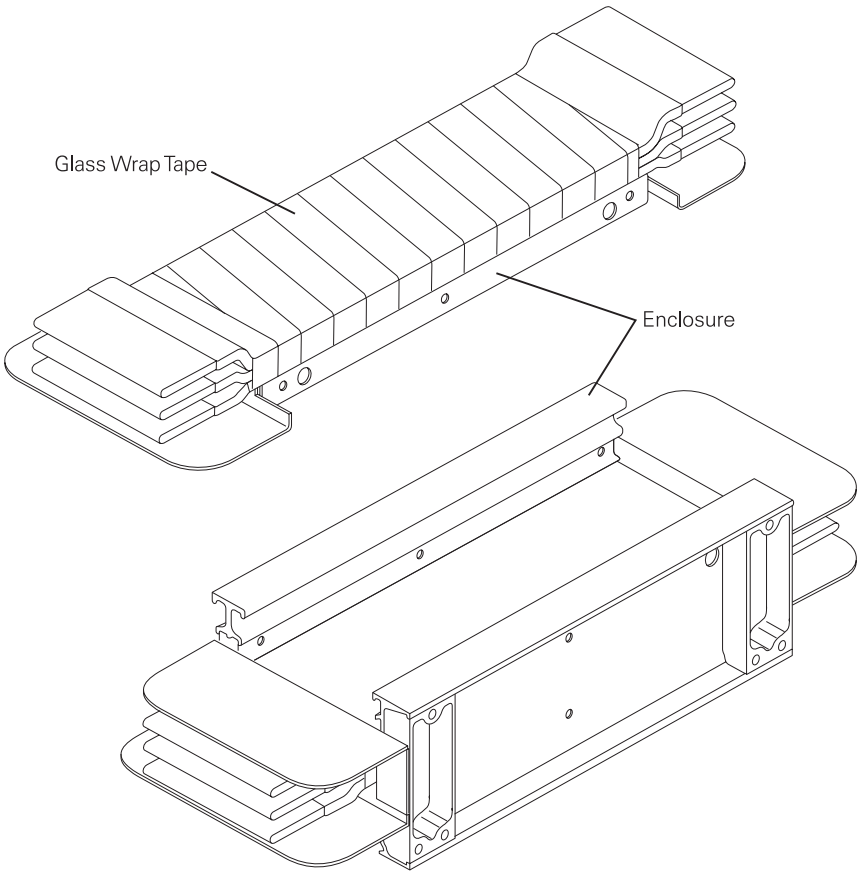
Sentron Plug-In Busway

Each bus bar is referred to as a phase. Bus bars of Sentron busway are separated electrically with epoxy insulation.



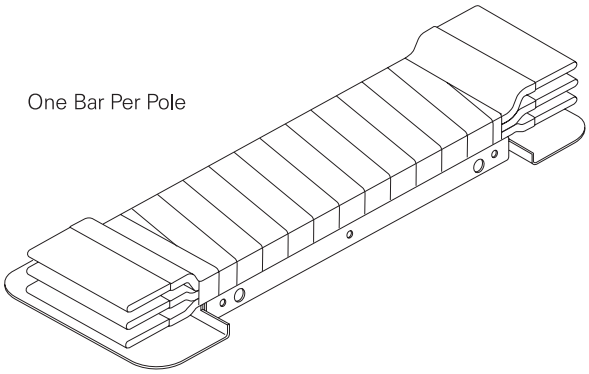
Enclosure

Glass wrap tape is wrapped around the Sentron bus bars to provide additionally protection and hold the bars together. The bus bars are then installed in an enclosure. The enclosure provides protection and support.



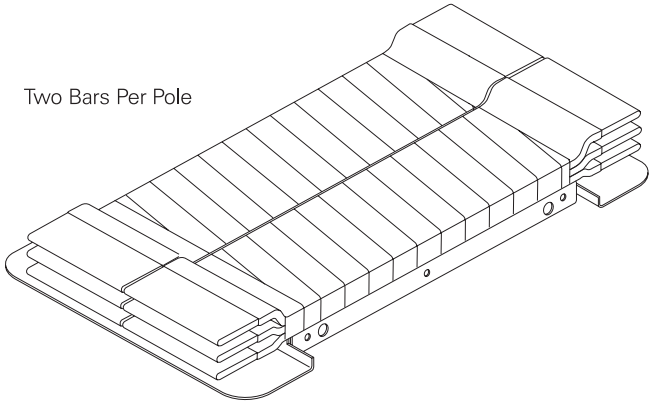
Bars per Pole

Sentron busway uses one bar per pole on busway rated up to 2000 amperes aluminum and 2500 amperes copper.



Ampere Rating	
Aluminum	Copper
800	800
1000	1000
1200	1200
1350	1350
1600	1600
2000	2000
	2500

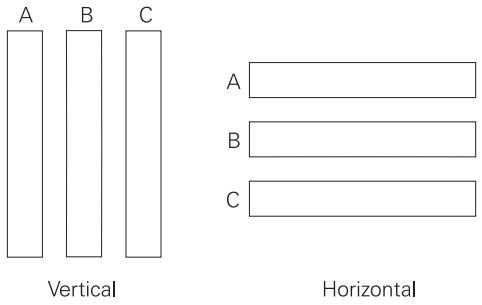
Sentron busway uses two bars per pole on busway rated from 2500 to 4000 amperes aluminum and 3000 to 5000 amperes copper.



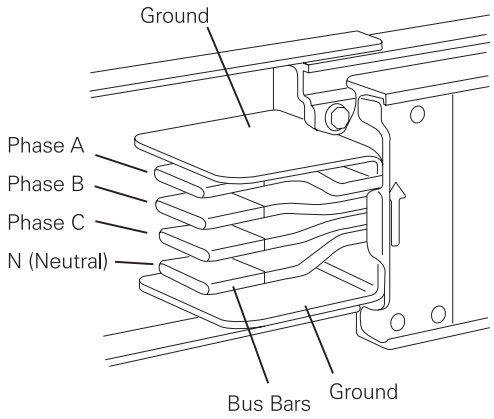
Ampere Rating	
Aluminum	Copper
2500	3000
3000	4000
4000	5000

NEMA Phase Arrangement

Bus bars are required to have phases in sequence so that an installer can have the same fixed phase arrangement in each termination point. This is established by NEMA (National Electrical Manufacturers Association). The following diagram illustrates accepted NEMA phase arrangements.



The following illustration shows the proper phase arrangement of bus bars in Sentron busway.

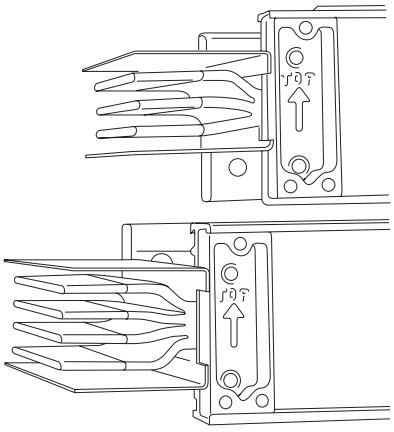


Number of Bus Bars

The number of bars depends on the number of phases on the power supply and whether or not a neutral or ground is used.

3 Phase, 3 Wire

3 Phase, 4 Wire (Neutral)

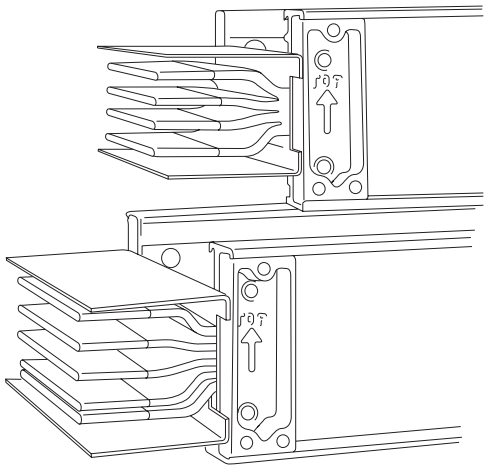


200% Neutral

Siemens Sentron busway is available with a 200% neutral within the bus bar housing. Certain loads on the distribution system can cause non-sinusodial current referred to as harmonics. These harmonics cause circulating currents which increase the heat in the system and shorten component life. The 200% neutral capacity minimizes overheating, thus prolonging the life of power distribution equipment.

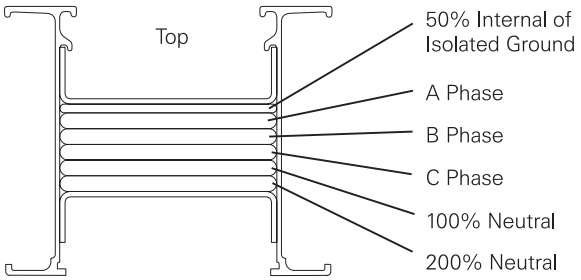
3 Phase, 4 Wire, 100% Neutral

3 Phase, 4 Wire, 200% Neutral



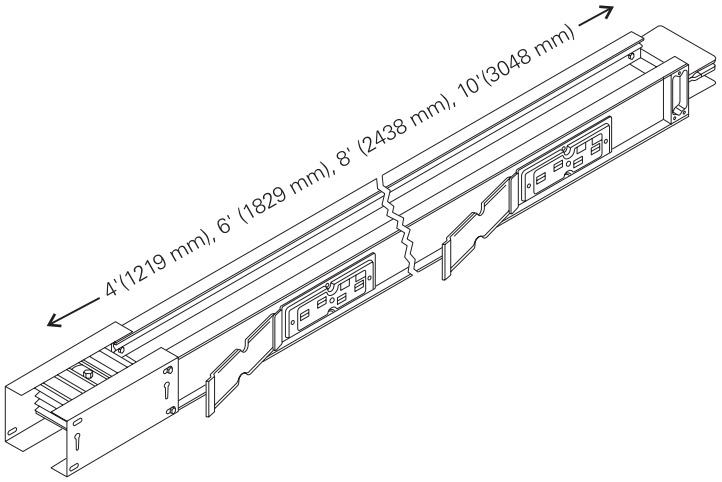
Ground

The *National Electrical Code*® requires the metal enclosure of any busway run to be grounded back at the service entrance equipment. Sentron busway has several options to meet this requirement. The busway housing is an integral ground. Under more severe industrial applications a heavier ground may be required. The following cross section drawing of Sentron busway shows a bus bar a 50% internal ground has been added. This means that the ground is rated at 50% of the ampacity of the phase bus bars.

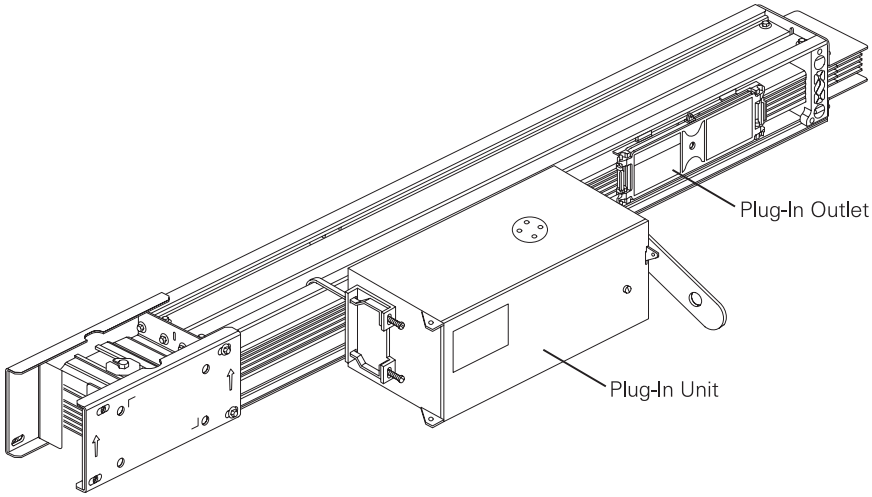


Busway Lengths

The standard length of a plug-in busway section is 10' (3048 mm). Sentron busway is also available in 4' (1219 mm), 6' (1829 mm), and 8' (2438 mm) lengths.

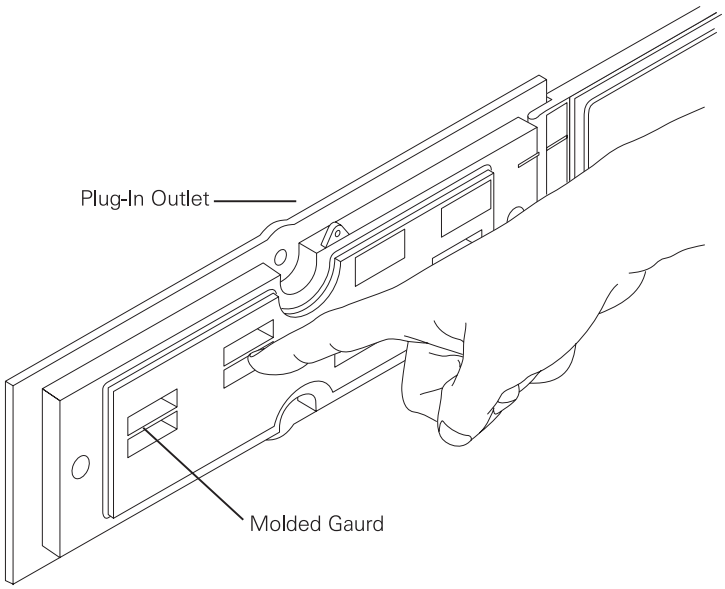


Plug-in outlets on Sentron plug-in busway are located on 2′ (610 mm) centers on both sides of the busway.



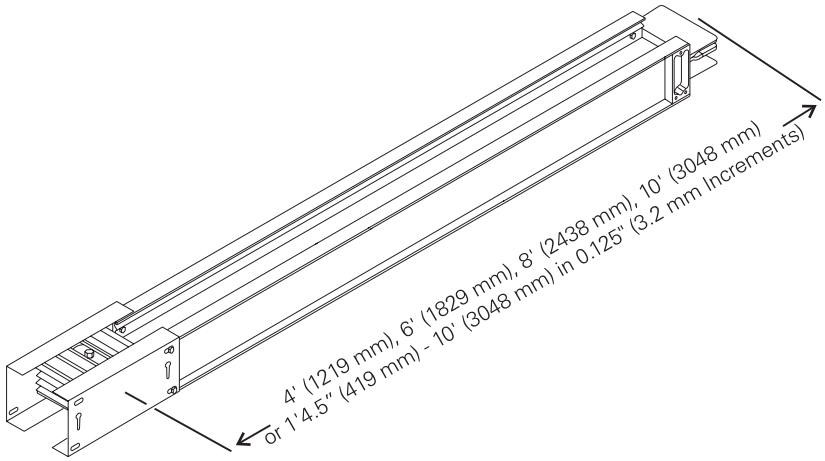
Sentron Plug-In Outlets

The Sentron plug-in outlet features a molded guard which prevents incidental finger contact with live conductors. This meets IEC, IP 2X requirements for preventing a 0.472″ (12 mm) probe from entering. This is referred to as finger safe.



Feeder Busway Lengths

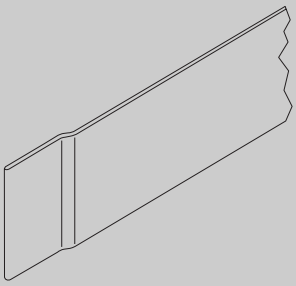
In addition to the 4′ (1219 mm), 6′ (1829 mm), 8′ (2438 mm), and standard 10′ (3048 mm) lengths, Sentron feeder busway sections are available in 0.125″ (3.2 mm) increments from 1′ 4.5″ (419 mm) to 10′ (3048 mm). Feeder busway does not have any plug-in outlets.

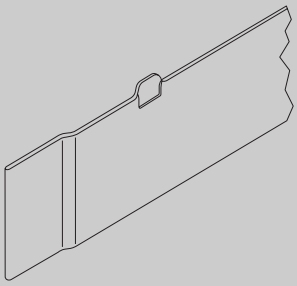


Review 3

1. In the Sentron busway, aluminum bus bars are available with ampacities up to _____ amperes and copper bus bars are available with ampacities up to _____ amperes.

2. Identify the type of busway each of the bus bars represent in the following illustration.





a. _____ b. _____

3. Plug-in busway is available in _____ , _____ , _____ , and 10 foot lengths.

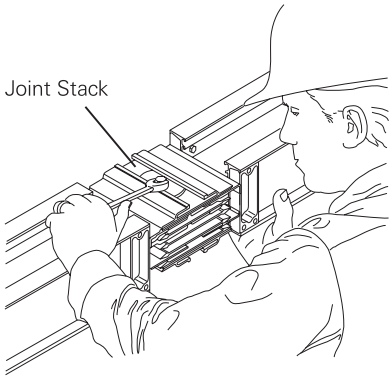
4. Plug-in outlets are located on _____ foot centers.

5. Sentron feeder busway sections are available in _____ inch increments from _____ to _____ feet.

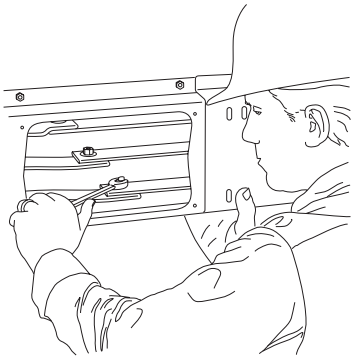
Busway System Components

There are a number of components that make up a busway system. The various system components illustrated in this section, unless otherwise noted, will be the Siemens Sentron™ series. For more information on any component consult the *Sentron Busway System Selection and Application Guide*. It should also be noted that certain components available on one type busway system may not be available on another type busway system.

Although components used in various busway systems perform the same or similar functions, they can't be interchanged from one busway system to another. There are a number of reasons for this. Systems are tested and rated as a complete unit. Ratings and system integrity could not be guaranteed when components are interchanged between systems. Additionally, components from one system may not physically fit or connect to components of another system. Sections of Siemens Sentron busway, for example are clamped together with a joint stack. Siemens BD™ busway is bolted together.



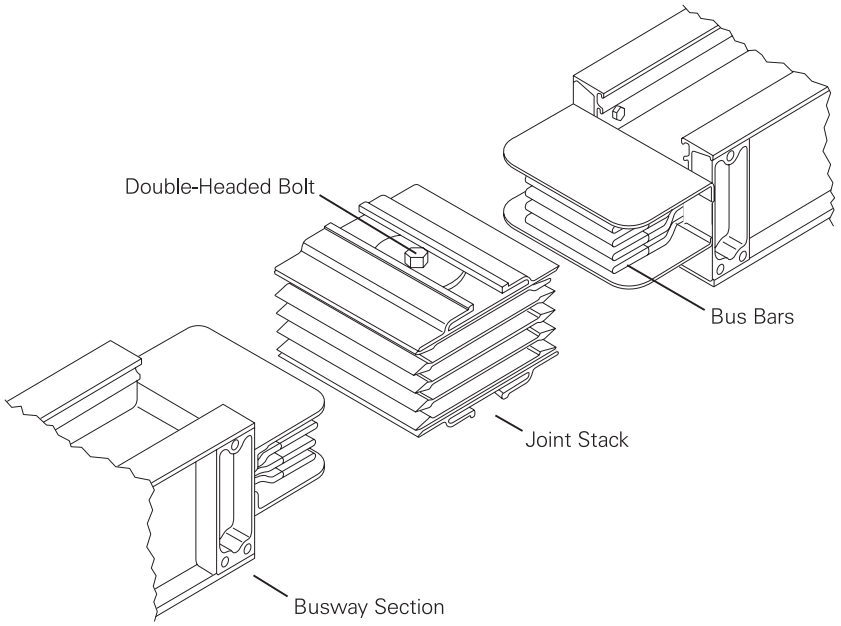
Sentron Busway



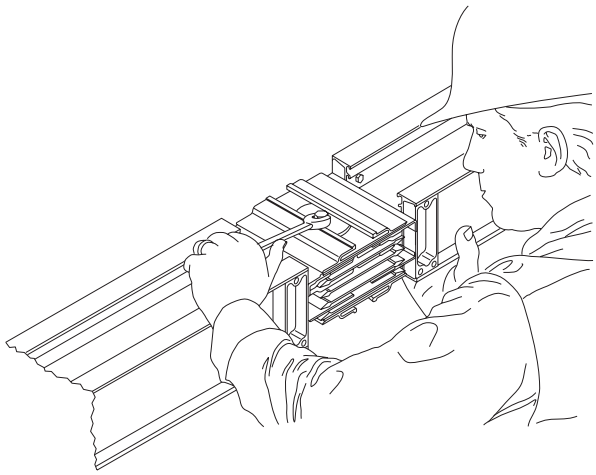
BD Busway

Joint Stack

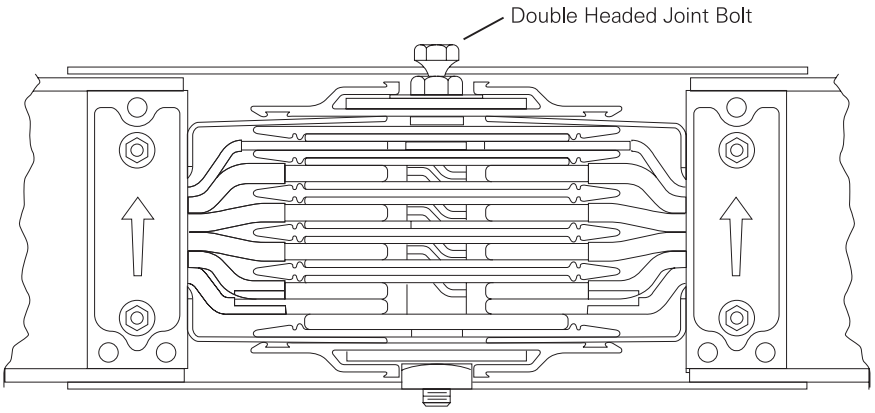
The Siemens Sentron busway system, uses a single-bolt joint stack to connect busway sections. The bus bars from two busway sections are slid into a joint stack.



The assembly is clamped solidly together with the single bolt located on the joint stack. Sentron busway sections and components are supplied with required joint stacks.

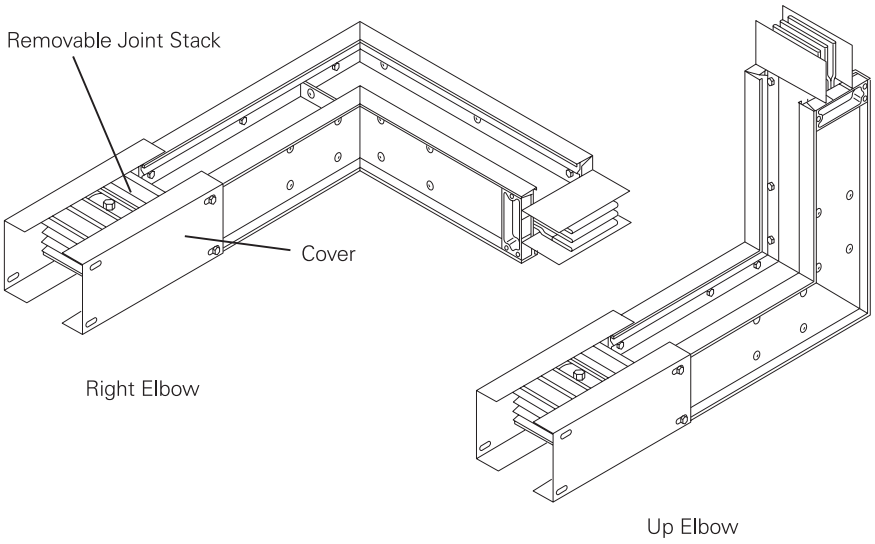


The single-joint bolt is a double-headed break-off bolt. The outer head is 5/8" and the bottom head is 3/4". The double-headed bolt is tightened until the 5/8" outer head twists off (approximately 55 ft. lbs.). This eliminates the need for torque wrenches during initial installation. The bottom 3/4" head is permanent and is used for future joint maintenance. Each joint is adjustable by ± 5/8".



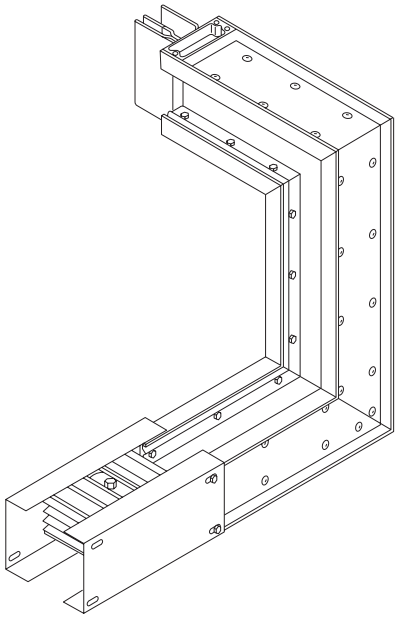
Elbows

Elbows, offsets, and tees allow for turns and height changes in the busway system to made in any direction. An elbow can turn the busway system right or left, up or down. Elbows are supplied with a joint stack and covers.



Combination Elbows

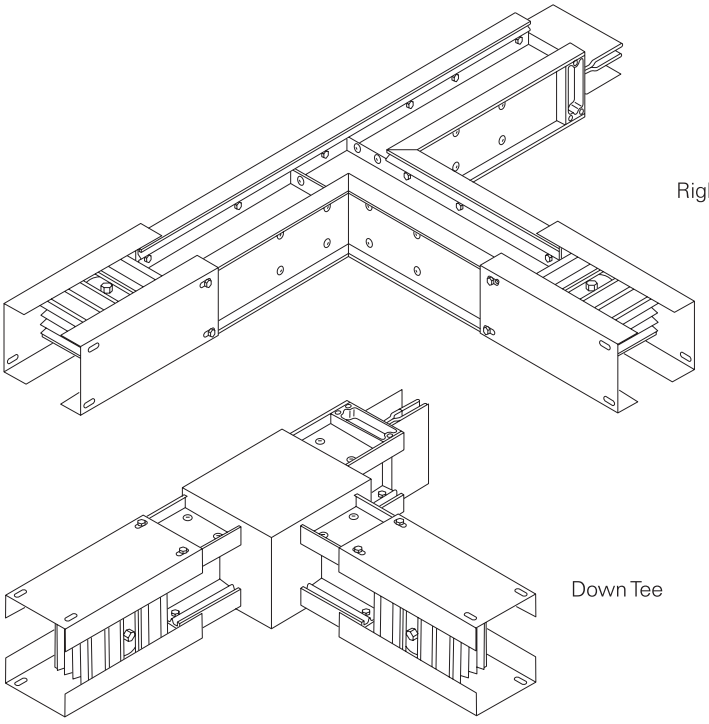
Combination elbows can turn the busway system up or down, and right or left.



Up, Left Combination Elbow

Tees

Tees are used to start a new section of busway in a different direction. Tees can start a new section to the right, to the left, up, or down. Tees are supplied with two joint stacks.

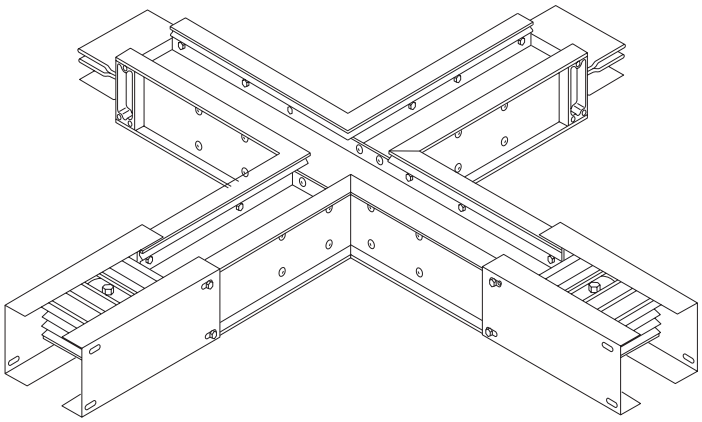


Right Tee

Down Tee

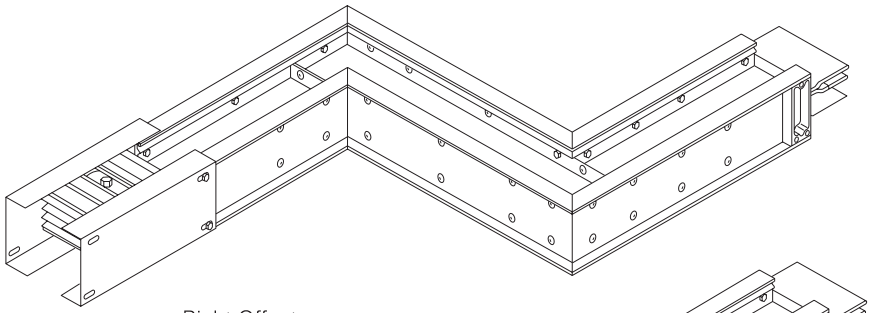
Crosses

A cross allows a busway run to expand in four directions.

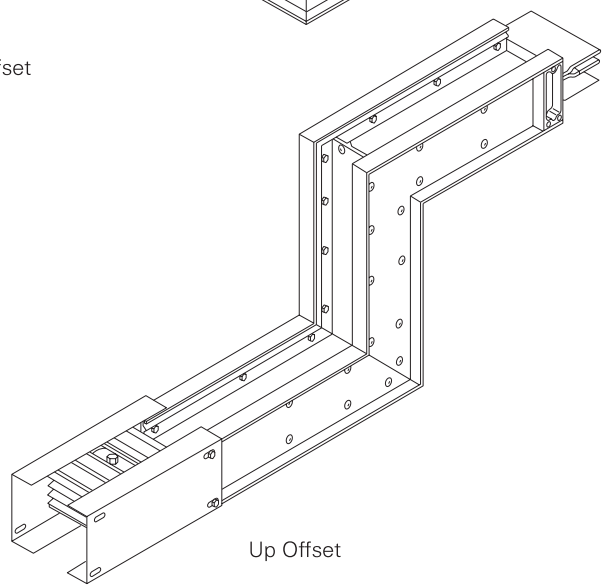


Offsets

Offsets allow the busway system to continue in the same direction. Offsets can move the busway system to the right, to the left, up, or down. Offsets are supplied with a joint stack.



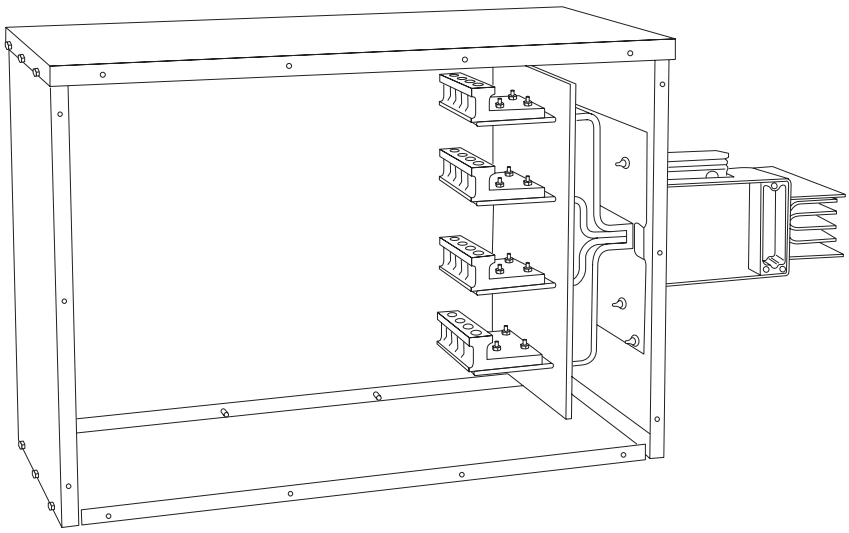
Right Offset



Up Offset

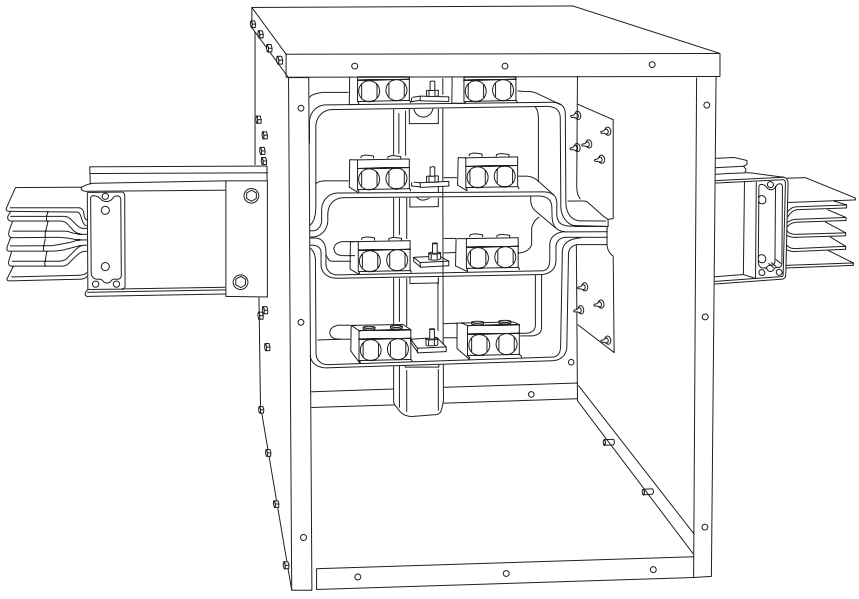
Cable Tap Boxes

Tap boxes are used to connect electrical cable to the busway distribution system. End cable tap boxes can be installed at either end of the busway system. They can be used on feeder or plug-in busway.



End Cable Tap Box

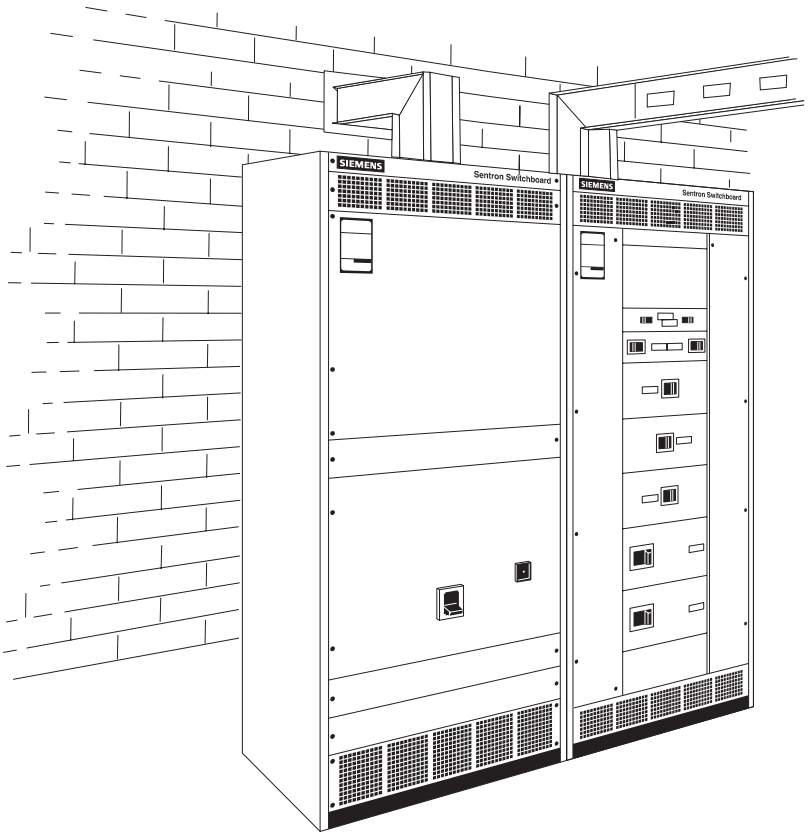
Center, or plug-in, cable tap boxes can be installed along the length of a busway system. Plug-in cable tap boxes can only be used on plug-in busway.



Center Cable Tap Box

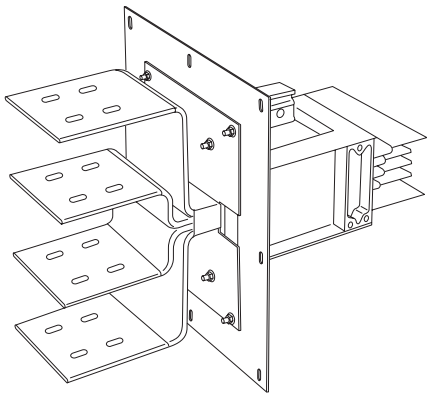
Stubs

Sentron busway standard stubs can be used to connect busway to other Siemens equipment, such as switchgear and switchboards. Sentron busway stubs can be shipped installed in Siemens switchboards and switchgear. This eliminates the field labor required to connect the busway to the switchboard, saving the installer time and money.



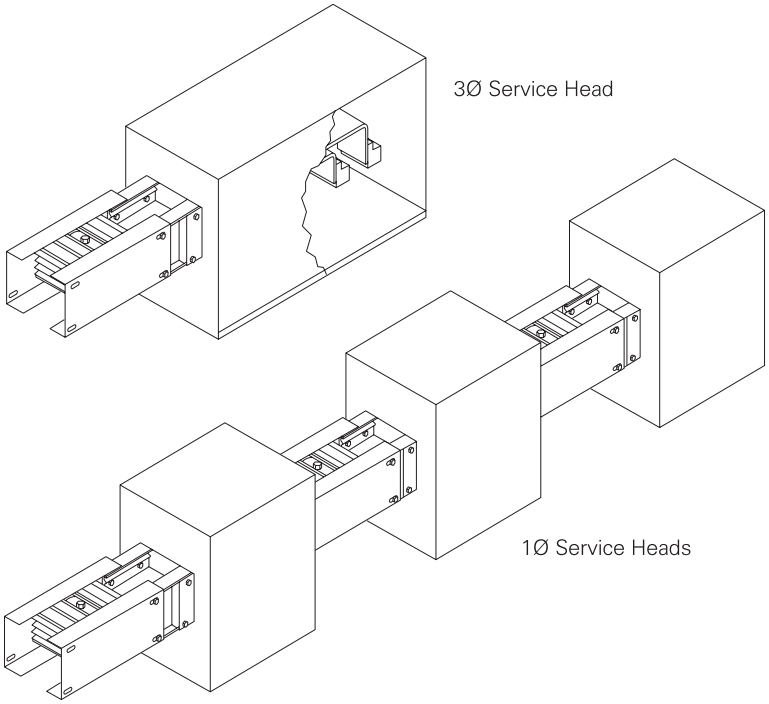
Flanged Ends

Flanged ends are also used to connect busway equipment such as switchgear and switchboards. These can be used with existing equipment. Siemens will furnish the outline drawings of this flanged end to the coordinating switchboard or equipment installer.



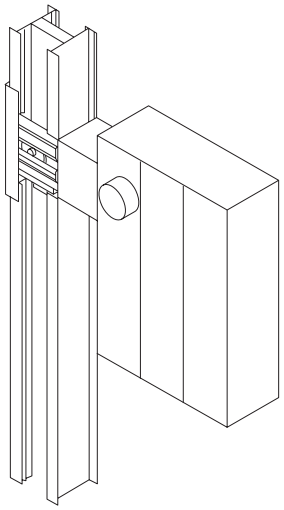
Service Heads

Service heads are used to connect the busway to the electric service. There are two types in the Sentron series. A single service head that has all three phases, or three separate heads, one for each phase.



Riser Adaptors

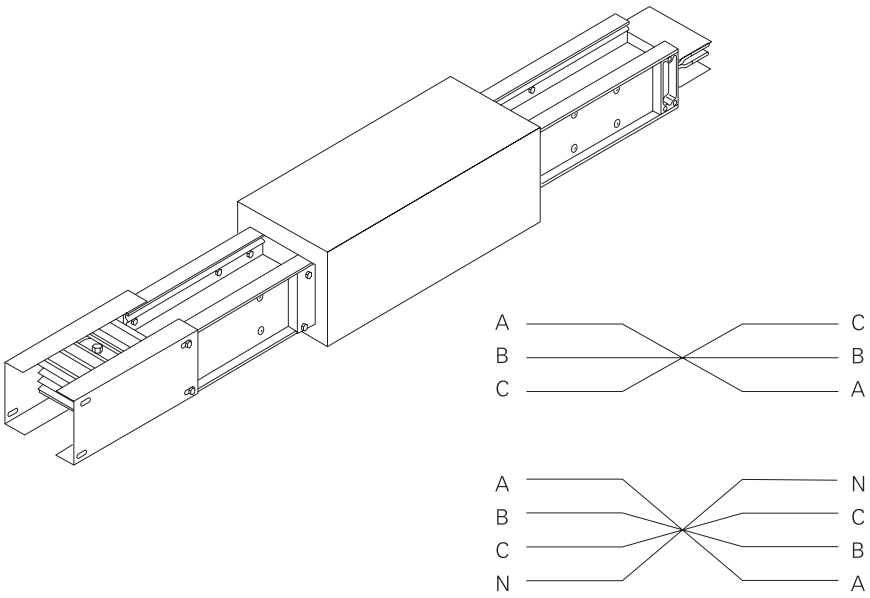
In busway, a riser is a length of vertical busway. Panelboards and meter centers can be mounted directly to risers with a side-mounted adapter. When Sentron plug-in busway is used as a riser, plug-in receptacles are located only on one side.



Side Mounted Adaptor

Phase Rotation

Some applications may require a phase rotation of the power supply to be reversed. The direction of rotation of a 3Ø AC motor, for example, is determined by the phase sequence of the power supply.



Phase Rotation Examples

Reducers

A busway reducer is used to reduce the allowable ampere rating. Money can often be saved by using a lower rated group of sections near the end of a busway run. A branch circuit, for example, does not need as high an ampere rating as the main feeder circuit.

Article 368.11 of the *NEC®* states that *overcurrent protection shall be required where busways are reduced in ampacity.*

There is an exception to this article.

Exception: For industrial establishments only, omission of overcurrent protection shall be permitted at points where busways are reduced in ampacity, provided that the length of the busway having the smaller ampacity does not exceed 15 m (50 ft) and has an ampacity at least equal to one-third the rating or setting of the overcurrent device next back on the line, and provided further that such busway is free from contact with combustible material.

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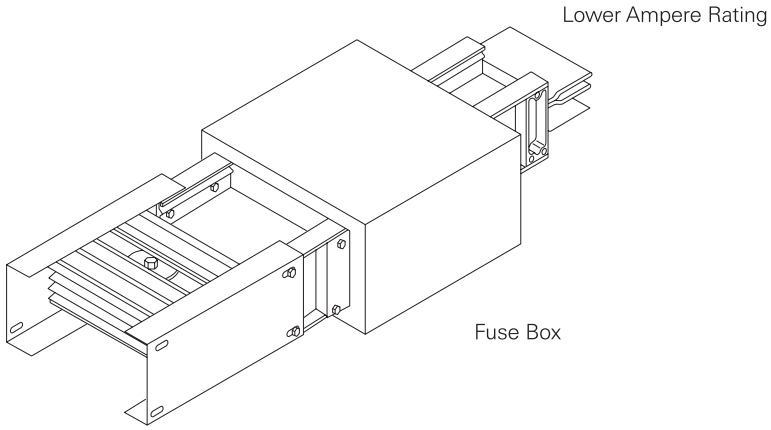
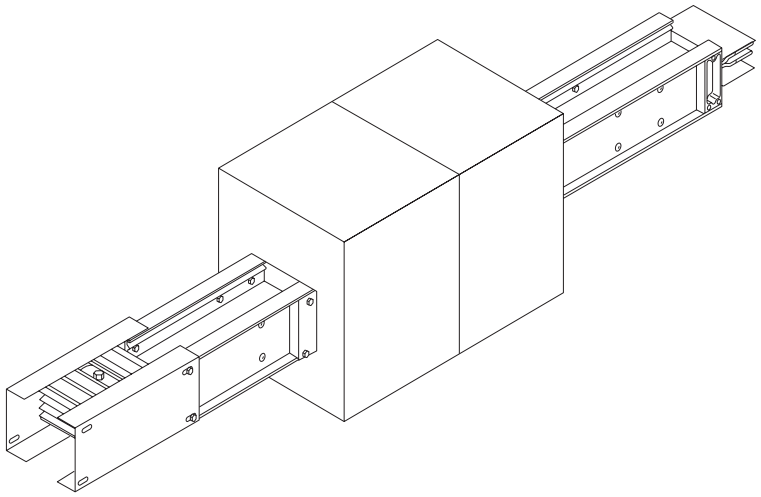
Sentron busway offers fused reducers to meet the requirement of *NEC*® Article 368.11, and non-fused reducers when the exception is allowed. Illustrated below is a fused reducer.



Expansion Fittings

Expansion fittings are used when a busway system crosses an expansion joint in a building, or on long straight runs where both ends are held in a permanent fixed position. The Sentron expansion fitting contains a sliding expansion enclosure. Flexible connectors in the expansion enclosure allow a ±2" movement.



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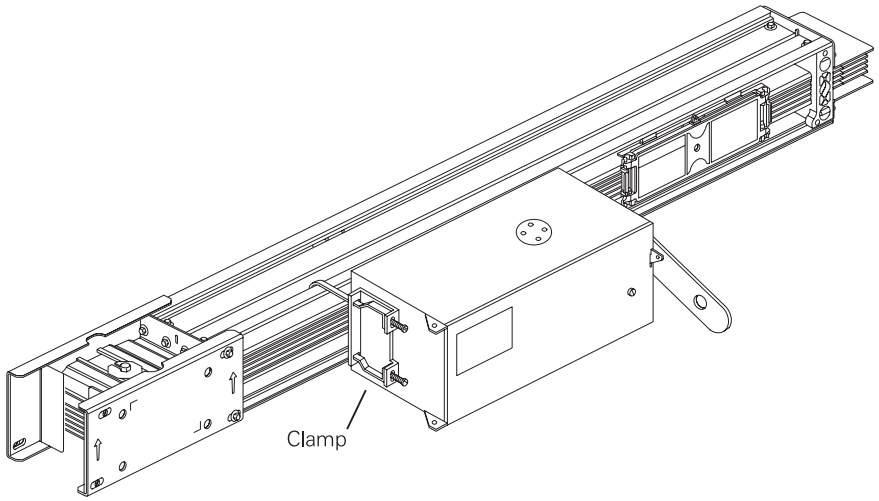
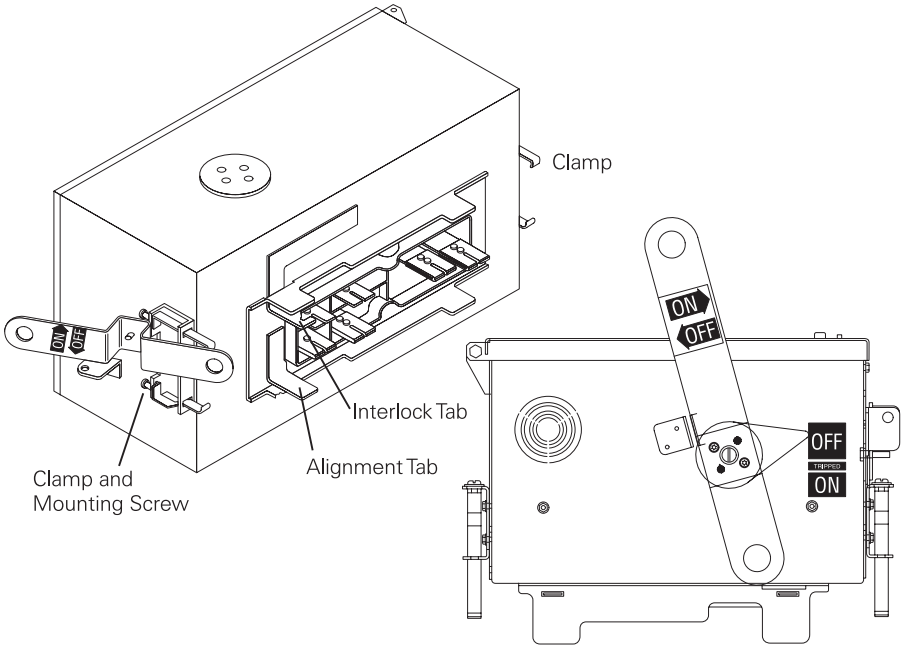
Bus Plugs

Sentron II busway bus plugs are available with Siemens Sentron molded case circuit breakers or Siemens fusible switch.

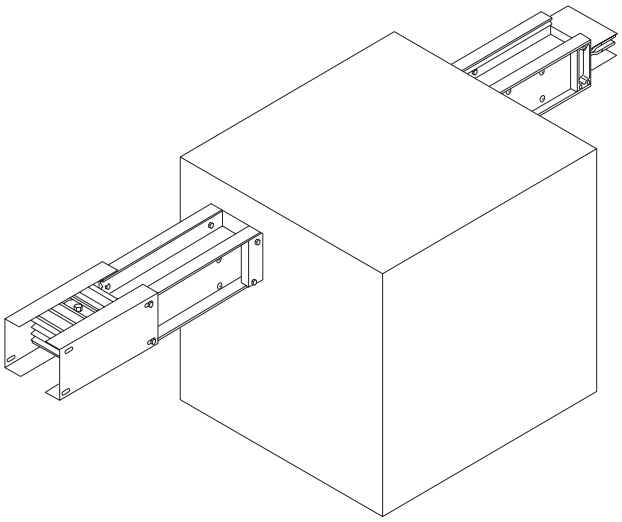


Sentron II bus plugs feature a visible position indicator and relocateable operating handle. Alignment and interlock tabs prevent the plug from being installed 180° out of position and ensures that the plug is in the off position during installation and removal. Clamp assemblies are used to draw the bus plug firmly against the busway housing. Sentron Bus Plugs are designed with standard wire bending space and extended wire bending space (gutter). Plug-in units can be mounted horizontally or vertically (riser).



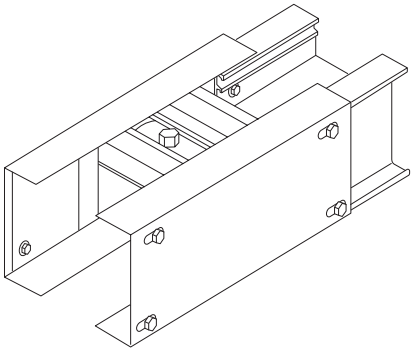
In-line Disconnect Cubicle

Cubicles provide a means of mounting switches or circuit breakers where power enters or leaves a busway system. In-line disconnect cubicles are used where bolted connections are preferred, or at ampere ratings exceeding the standard plug-in unit ratings.



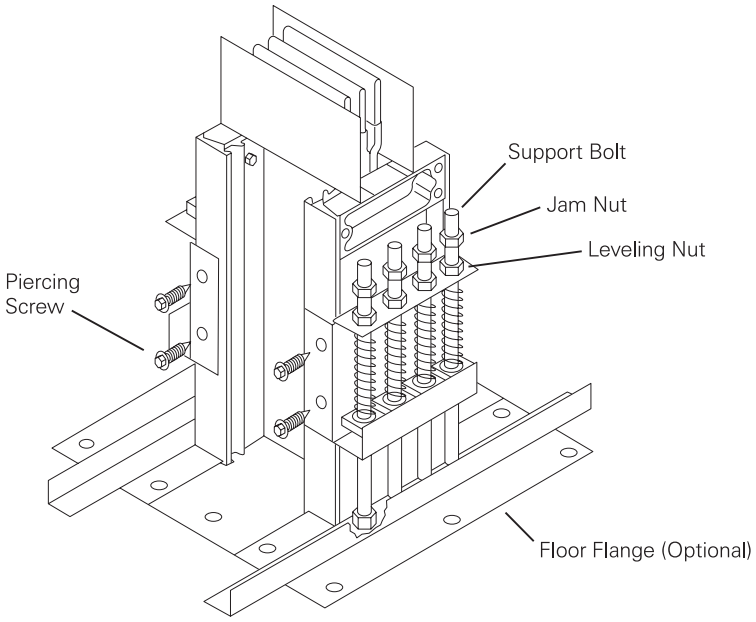
End Closer

End closers are used to safely terminate a run of busway and protect the bus bar ends.

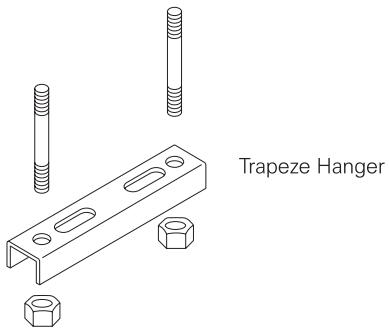


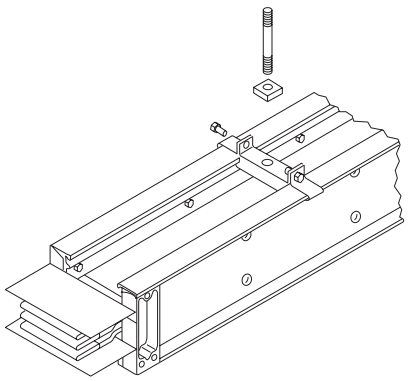
Hangers

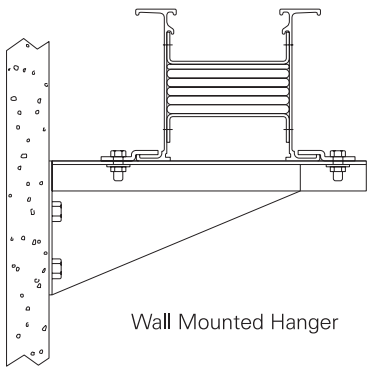
Various hangers are used to support busway. When a vertical run of busway passes through a floor, a floor support is required. Spring hangers provide secure mounting of Sentron busway in riser applications. These hangers counter the weight of the busway on each floor and compensate for minimal building movement and thermal expansion.

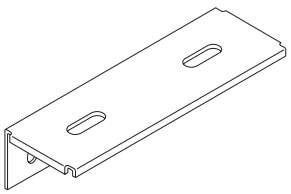


Several types of hangers are available to suspend the busway from the ceiling, structural steel support, or mounted to a wall.



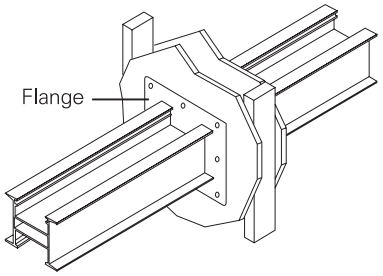




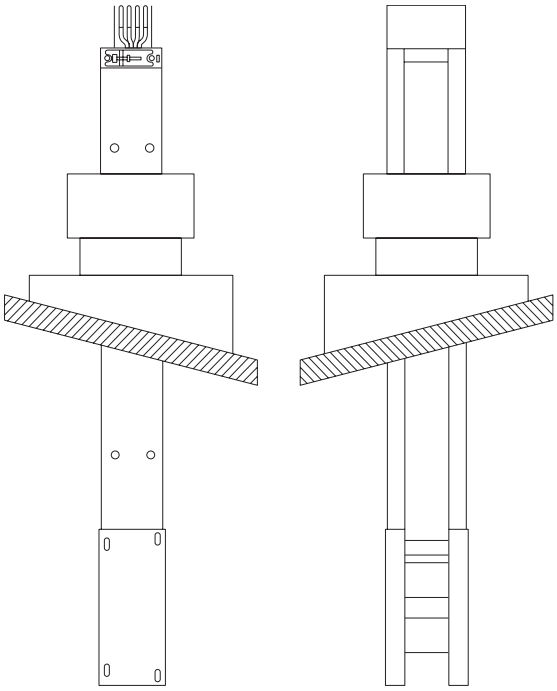


Flanges

Wall, ceiling, and floor flanges are designed to close off the area around the busway as it passes through a wall, ceiling, or floor. The flange does not provide an air tight seal around the busway.

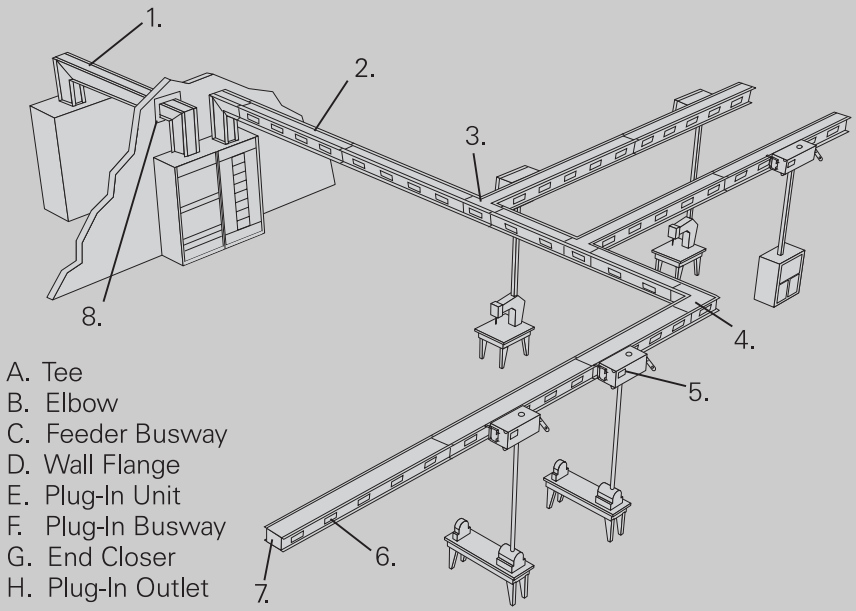


Roof flanges provide a watertight seal when outdoor rated busway enters through a roof. The pitch or angle of the roof must be specified when ordering roof flanges.



Review 4

Identify the components in the following illustration:

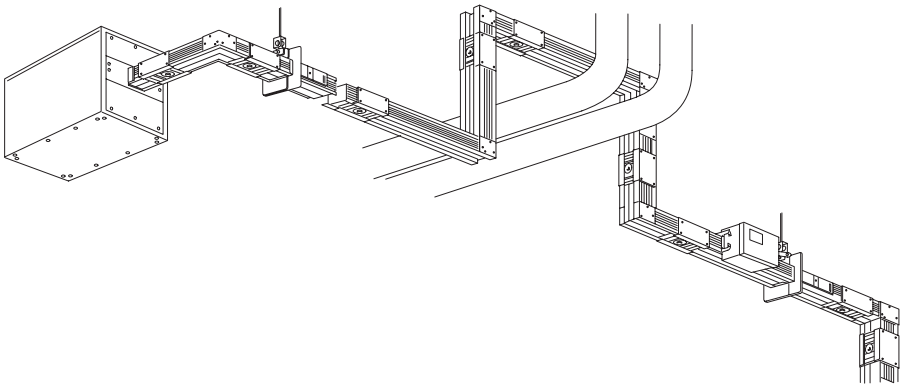


A. Tee
B. Elbow
C. Feeder Busway
D. Wall Flange
E. Plug-In Unit
F. Plug-In Busway
G. End Closer
H. Plug-In Outlet

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Sentron Low Amp Busway

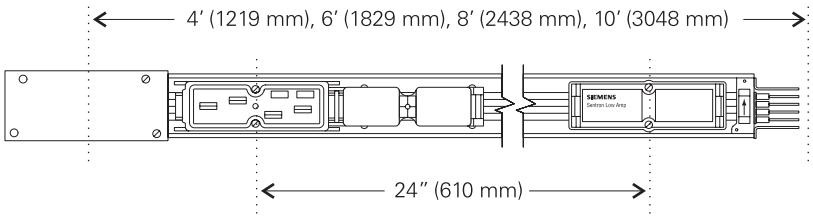
Sentron Low Amp Busway is a member of the Siemens Sentron Busway family. Sentron Low Amp Busway specifically addresses the needs of low amp power distribution applications, with ratings from 225A to 800A UL and 100A to 800A IEC. Low Amp Busway provides all the features and advantages of Sentron Busway.



Plug-In Sections

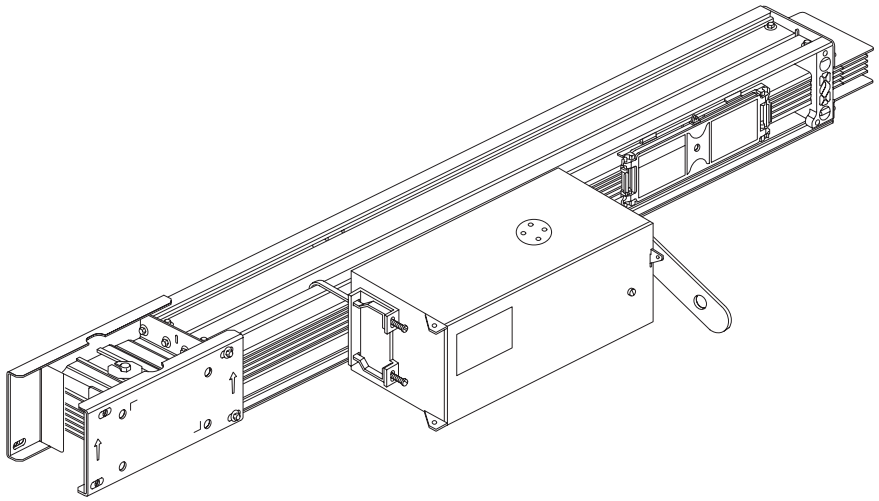
Sentron Low Amp is available as plug-in only, with aluminum or copper bus bars. Aluminum bars are available in 225 - 600 ampere sections. Copper bars are available in 225 - 800 ampere sections. Sections include an integral housing ground. An optional copper internal or isolated ground is available in most ratings.

Sentron Low Amp plug-in sections are available in 4’ (1219 mm), 6’, (1829 mm) 8’ (2438 mm), and 10’ (3048 mm) sections. Plug-in openings are centered on 24” (610 mm) and staggered on both sides of the busway. Plug-in outlets, like standard Sentron, are finger safe and IP 2X rated. Plug-in sections are protected to IP40 specifications. IP54 is optionally available.



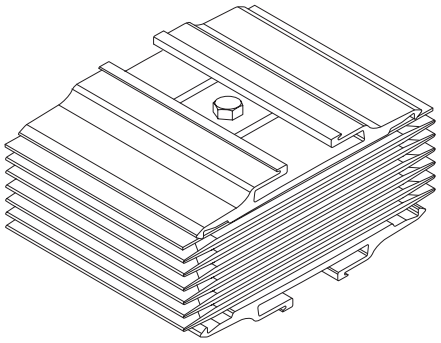
Bus Plugs

Sentron II bus plugs used with standard Sentron can also be used with Sentron Low Amp.



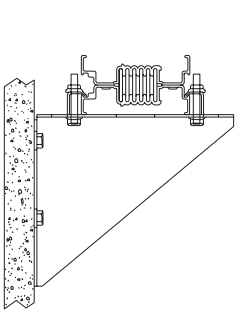
Joint Stack Assembly

Sentron Low Amp uses the same joint stack assembly design as standard Sentron.

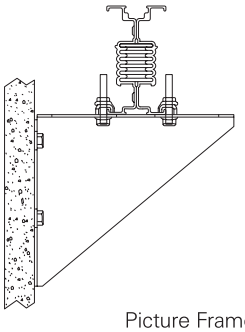


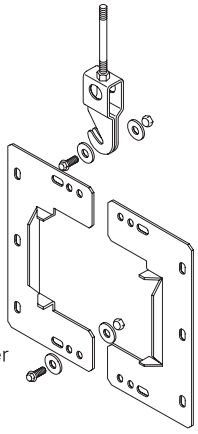
Hangers

In addition to the hanger shown below, Sentron Low Amp is available with the same type hangers and supports as available with standard Sentron.

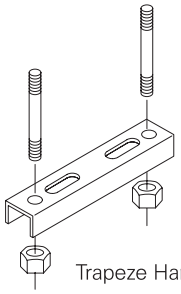


Wall Support Hangers

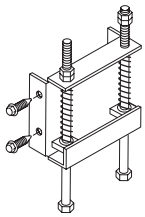


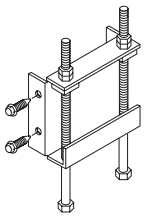


Picture Frame Hanger



Trapeze Hanger

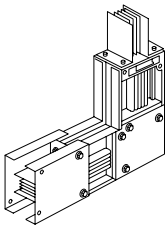




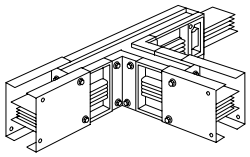
Floor Support Hangers

Components

Sentron Low Amp is available with a full range of elbows, tees, offsets, tap boxes, flanged ends, expansion fittings, reducers, and phase rotation fittings.

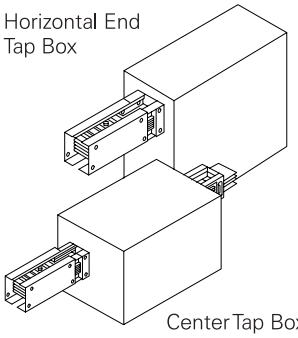


Edge Up Elbow

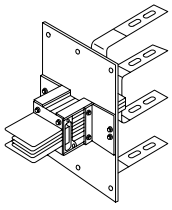


Flat Right Tee

Horizontal End Tap Box



Center Tap Box



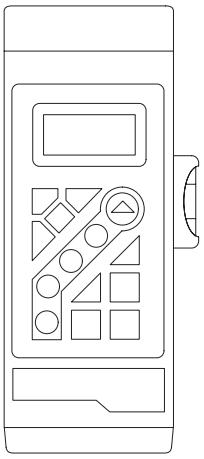
Flanged End

There are several considerations when planning a busway run. The best route would require the fewest fittings and the maximum number of 10’ straight sections.

There are a number of techniques to ensure an accurate measurement before purchasing and installing busway. The following procedures are given as an example and are useful in obtaining a correct measurement.

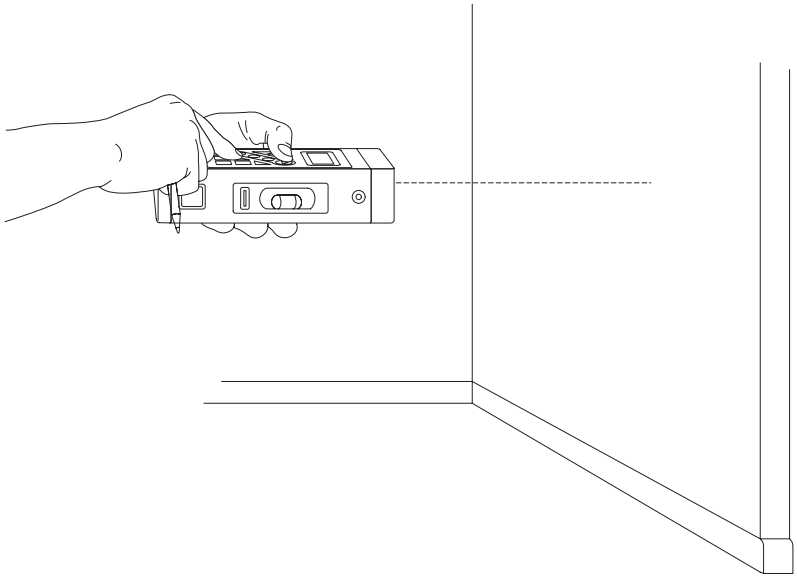
Laser Measuring Device

Laser measuring devices, such as the one illustrated below, provide an easy and highly accurate means of measuring a busway run.

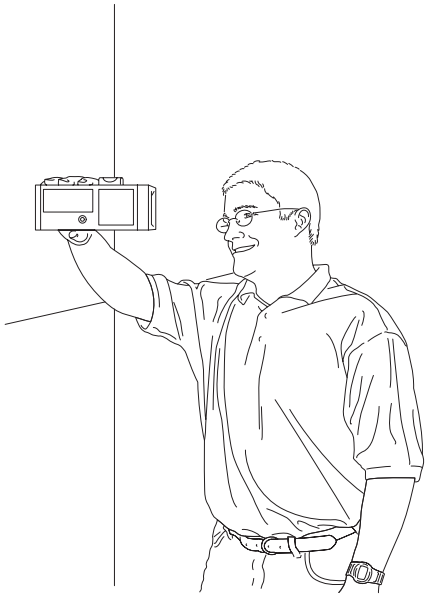


Note: Consult Busway factory for laser measuring device information.

Laser measuring devices project a laser beam which is reflected on an object such as a wall, ceiling, floor, or piece of machinery. The measuring device is able to accurately measure the distance the beam travels.

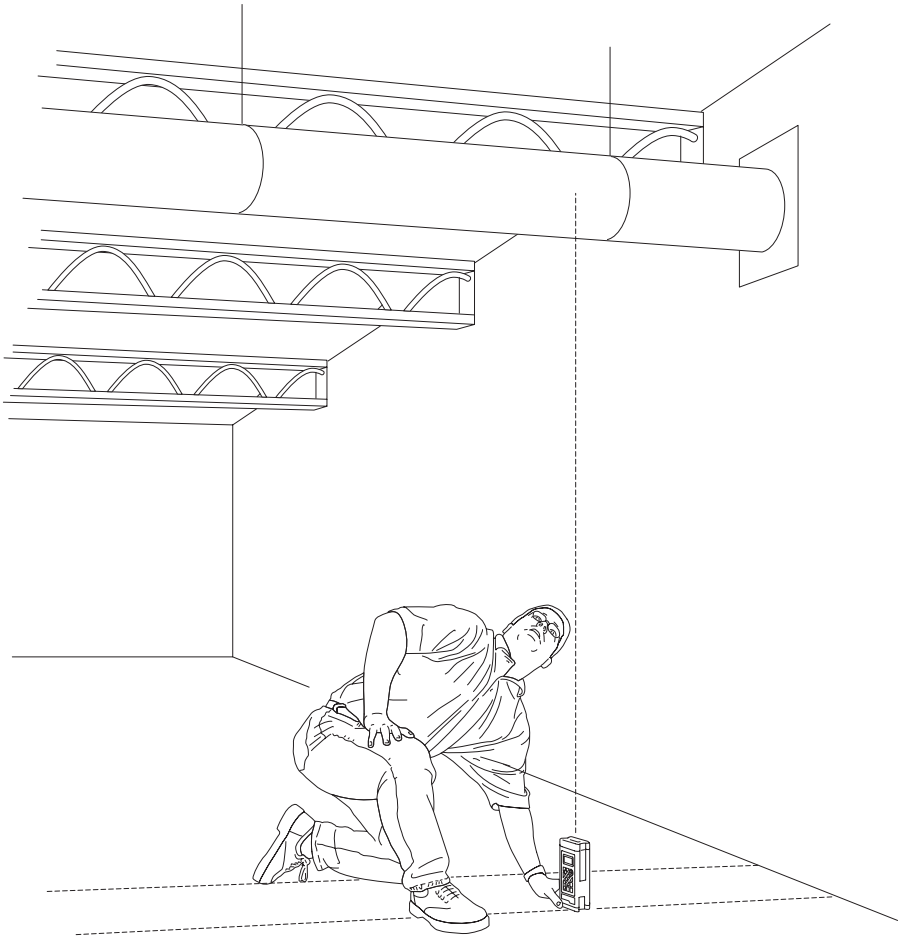


When measuring the distance from wall-to-wall or wall-to-obstruction, place the laser measuring device flat against the wall. The distance measured will be from the wall to the point the laser beam is interrupted.

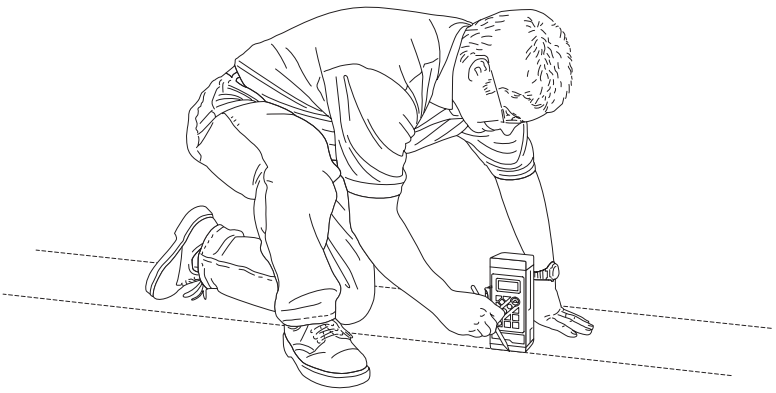


Laying Out a Run

Using the laser measuring device, determine the height and location of obstructions. Select a route requiring the fewest offsets.



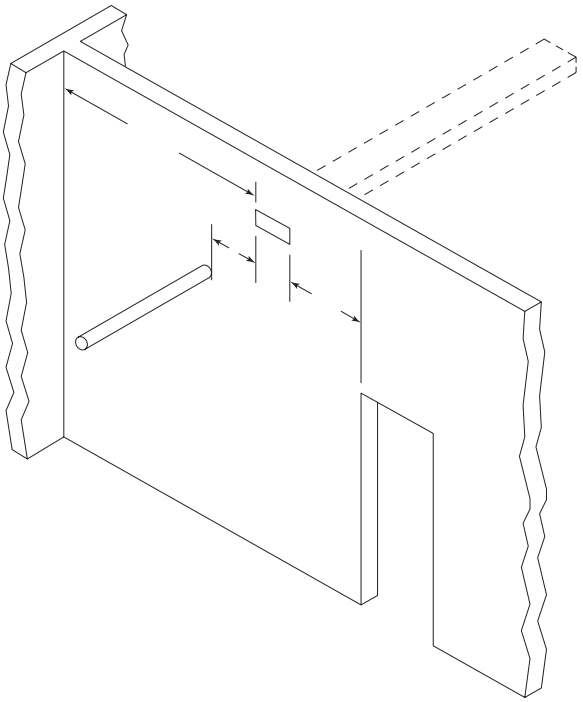
The planned route can be laid out on the floor with a pencil or chalk. Transfer the position of pipes, ducts, beams, and other obstructions to the floor. It will be easier to transfer the planned busway route to paper if significant portions are laid out full scale first.



Once the route is laid out the laser measuring device can be used along the run to measure distance.

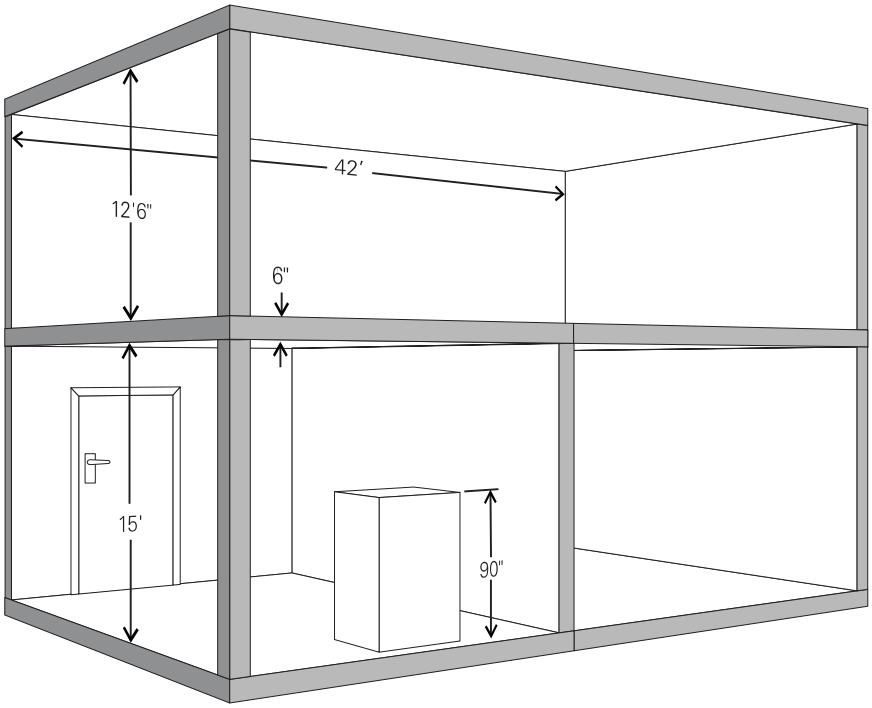
Walls, Ceilings, Floors

When piercing a wall, ceiling, or floor find a reference point which is common to both sides and measure from it. This may be a pipe, a wall, or a door.

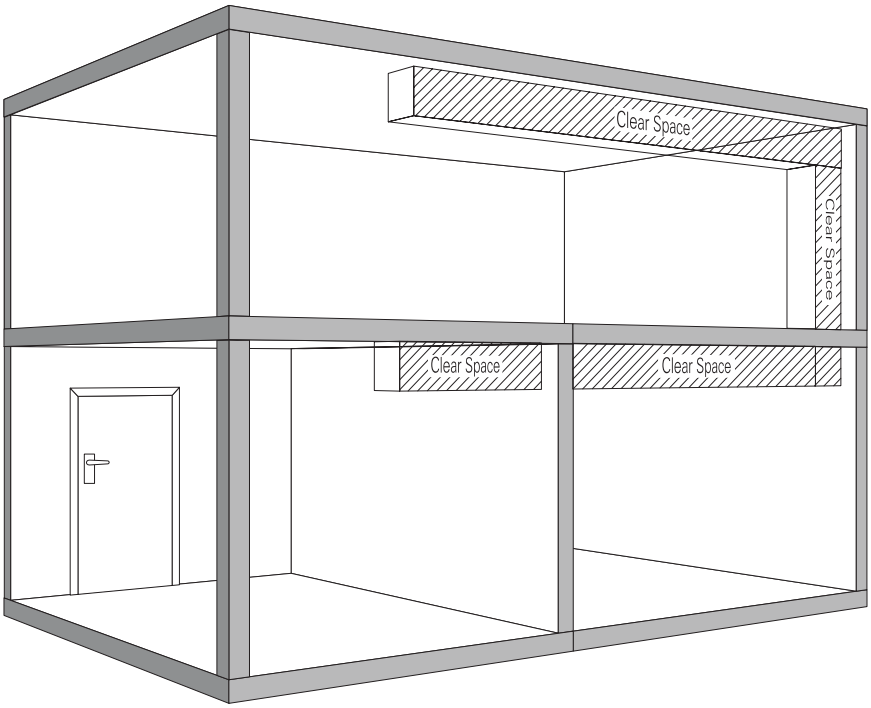


Sample Layout

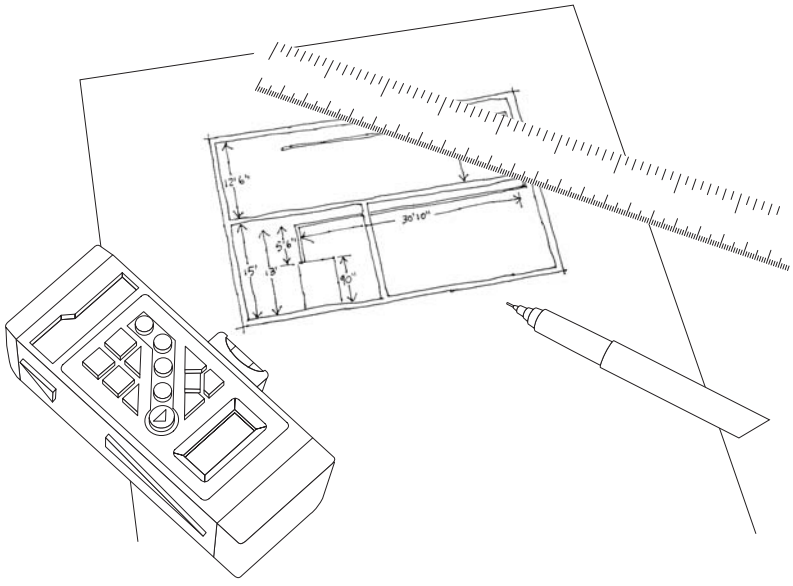
In the following example, a busway system, connected to a switchboard, will pass through three rooms. The floor to ceiling height is 15′ on the first floor, and 12′6″ on the second floor. The overall length is 42′. Walls and floors are 6″ thick. The switchboard is a standard 90″ high. Various types of equipment on the second floor will be connected to the busway through plug-in outlets along the length of the room.



It is determined that a clear space is available 13′ above the floor in the switchboard room (5′6″ from the top of the switchboard). The clear space extends on the other side of the wall in the second room to the far right wall. It is also clear on the second floor along the far right wall and 10′ above the floor for the length of the second floor.



A rough sketch can now be made of the proposed busway system route.



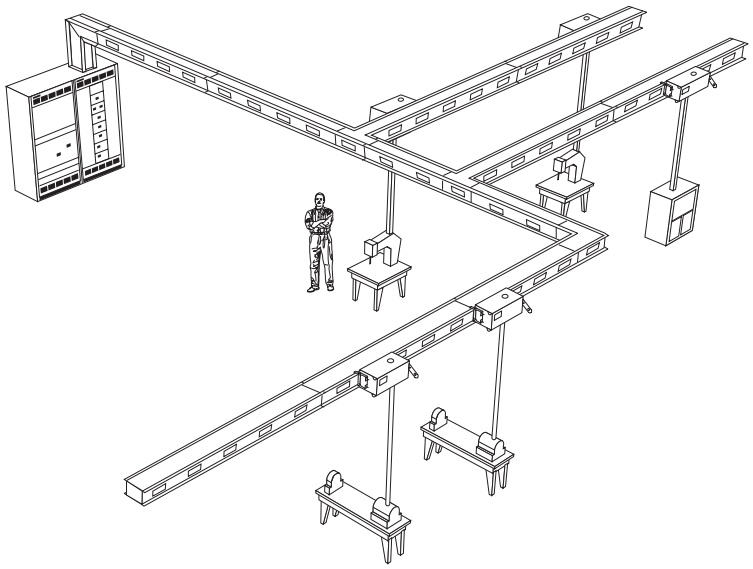
NEC® Requirements

An important part of applying a busway system is to be sure that the system meets the requirements of The *National Electrical Code*®.

Article 368.4

According to *NEC*® Article 368.4, *busways shall be permitted to be installed where they are located as follows:*

(1) Located in the open and are visible, except as permitted in 368.6 or



(2) Installed behind access panels, provided the busways are totally enclosed, of nonventilating-type construction, and installed so that the joints between sections and at fittings are accessible for maintenance purposes. Where installed behind access panels, means of access shall be provided, and the following conditions shall be met:

a. The space behind the access panels shall not be used for air-handling purposes; or

b. Where the space behind the access panels is used for environmental air, other than ducts and plenums, in which case there shall be no provisions for plug-in connections, and the conductors shall be insulated.

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Article 368.4 also restricts the use of busway in conditions where it may be damaged or cause damage.

Busways shall not be installed as follows:

(1) Where subject to severe physical damage or corrosive vapors
(2) In hoistways
(3) In any hazardous (classified) location, unless specifically approved for such use
(4) Outdoors or in wet or damp locations unless identified for such use.

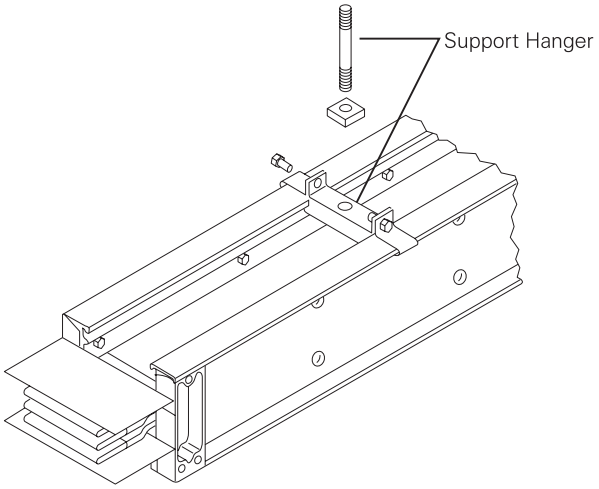
Lighting busway and trolley busway shall not be installed less than 2.5 m (8 ft) above the floor or working platform unless provided with a cover identified for the purpose.

Article 364.5

Article 368.5 requires adequate support for the busway. The following drawing illustrates one type of support available for Siemens Sentron™ busway.

Busways shall be securely supported at intervals not exceeding 1.5 m (5 ft) unless otherwise designed and marked.

Note: Picture frame and trapeze hangers used with Sentron Busway are designed on a maximum of 3.05 m (10 ft) centers.



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Article 368.6

Article 368.6 allows busway to pass through walls and floors provided there are no section joints in the wall or floor and vertical busway extends at least 6 feet through the floor. In addition, certain applications a curb may be required around busway passing through two or more dry floors. This will help eliminate the possibility of spilled liquid from running down the busway causing damage to the electrical system.

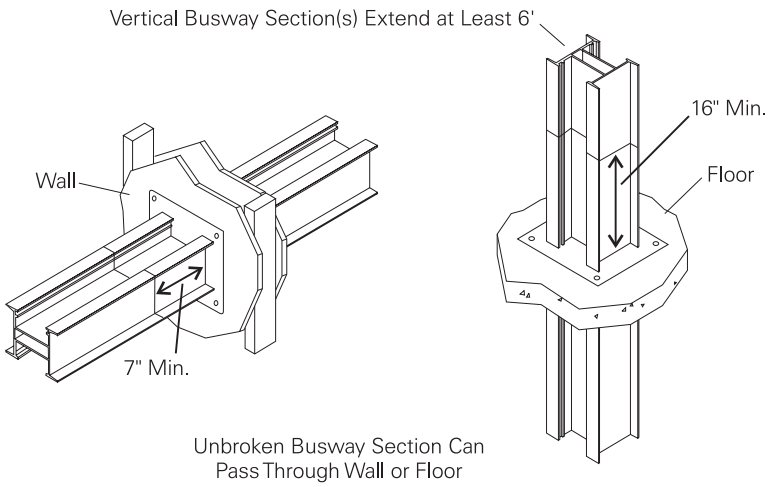
(A) Walls. Unbroken lengths of busway shall be permitted to be extended through dry walls.

(B) Floors. Floor penetrations shall comply with (1) and (2):

(1) Busways shall be permitted to be extended vertically through dry floors if totally enclosed (unventilated) where passing through and for a minimum distance of 1.8 m (6 ft) above the floor to provide adequate protection from physical damage.

(2) In other than industrial establishments, where a vertical riser penetrates two or more dry floors, a minimum 100 mm (4 in.) high curb shall be installed around all floor openings for riser busways to prevent liquids from entering the opening. The curb shall be installed within 300 mm (12 in.) of the floor opening. Electrical Equipment shall be located so that it will not be damaged by liquids that are retained by the curb.

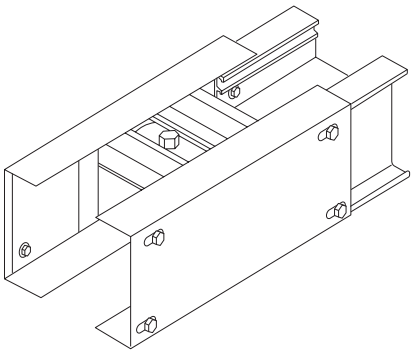
In addition to *NEC®* requirements, Sentron busway requires a minimum of 7" from a wall to a joint where a new section of busway begins. Sentron busway passing through a floor requires a minimum of 16" between the floor and a joint. This space is required for the floor supports.



Unbroken Busway Section Can Pass Through Wall or Floor

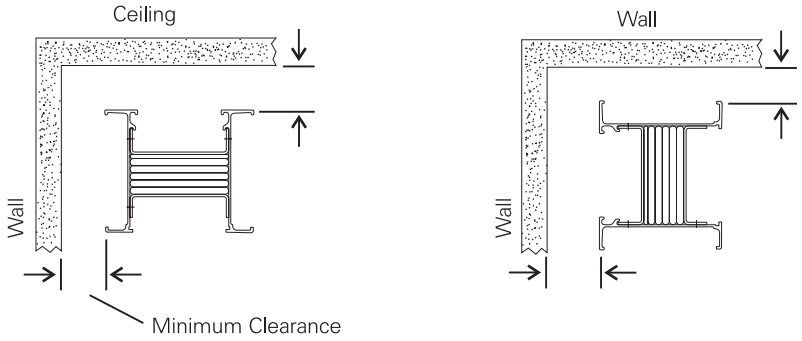
Article 368.7

Article 368.7 states that *a dead end of a busway shall be closed*. The following drawing illustrates the end closer used on Sentron busway.



Minimum Clearance

There are certain minimum clearances required when installing busway near a wall, ceiling, or another busway run. It is beyond the scope of this course to cover in detail the minimum clearances of every component. The minimum clearances of Sentron busway components are listed in the *Sentron™ Busway Systems Selection and Application Guide*. Specifications for other systems are listed in their respective selection and application guides.

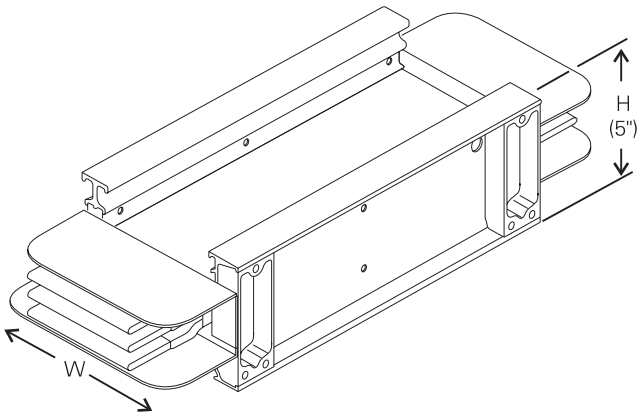


Dimensions

Component dimensions must also be considered when planning a busway system. The dimensions given in the following examples are for illustrative purposes. For a complete listing of Sentron busway components refer to the *Sentron™ Busway Systems Selection and Application Guide*. Specifications for other systems are listed in their respective selection and application guides.

Section Dimensions

It has already been mentioned that Sentron plug-in busway is available in 4′, 6′, 8′, and 10′ sections, and feeder busway is available in lengths from 2′ to 10′ in increments of 0.125″. The height of Sentron busway is 5″. The width varies with the maximum amperage rating. The width of 800 amp, one-bar-per-pole aluminum Sentron busway, for example, is 4.5″ wide.

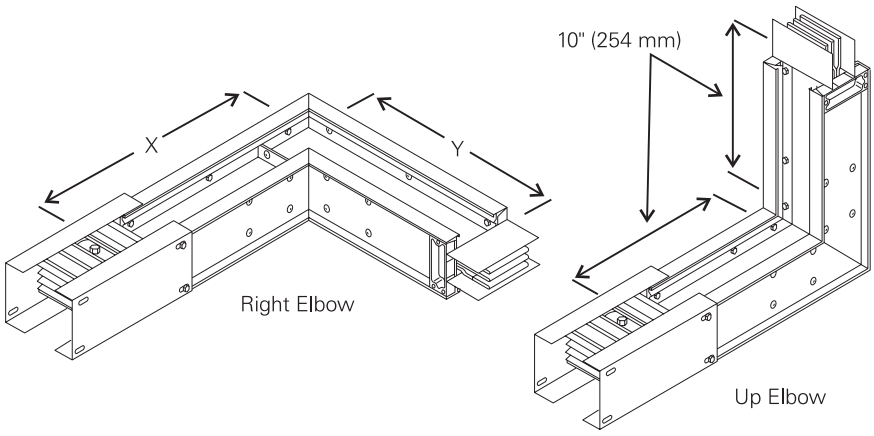


Aluminum	
Ampere Rating	Width (W) In. (mm)
800	4.5" (115)
1000	5.4" (137)
1200	6.5" (166)
1350	7.5" (191)
1600	8.6" (219)
2000	10.9" (277)

Copper	
Ampere Rating	Width (W) In. (mm)
800	3.9" (99)
1000	4.4" (112)
1200	5.0" (128)
1350	5.6" (143)
1600	6.6" (169)
2000	8.1" (207)
2500	10.6" (270)

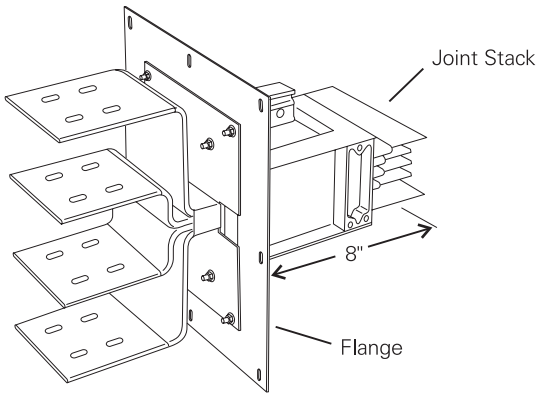
Other Component Dimensions

Other components, such as elbows, offsets, and tees must also be considered. Right and left elbows, for example, vary from 12" x 12" to 24" x 24". This is due to the variance of bus bar width with amperage rating. An 800 ampere aluminum system, for example, would be 12" x 12". Up or down elbows are 10" x 10".



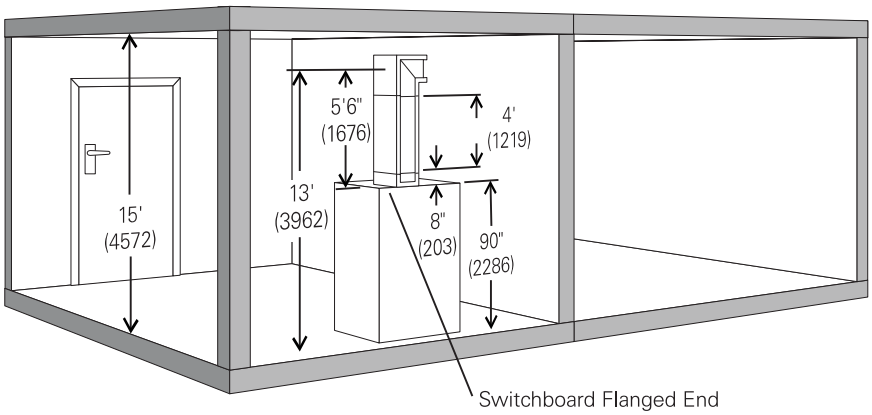
Left or Right Elbows					
Aluminum			Copper		
Ampere Rating	X In. (mm)	Y In. (mm)	Ampere Rating	X In. (mm)	Y In. (mm)
800 - 1350	12" (304)	12" (304)	800 - 2000	12" (304)	12" (304)
1600 - 3000	18" (457)	18" (457)	2500 - 4000	18" (457)	18" (457)
4000	24" (610)	24" (610)	5000	24" (610)	24" (610)

In the example busway system, the busway will be connected to a switchboard. A flanged end must also be selected. The flanged end is 8" long from the flange to the joint stack.

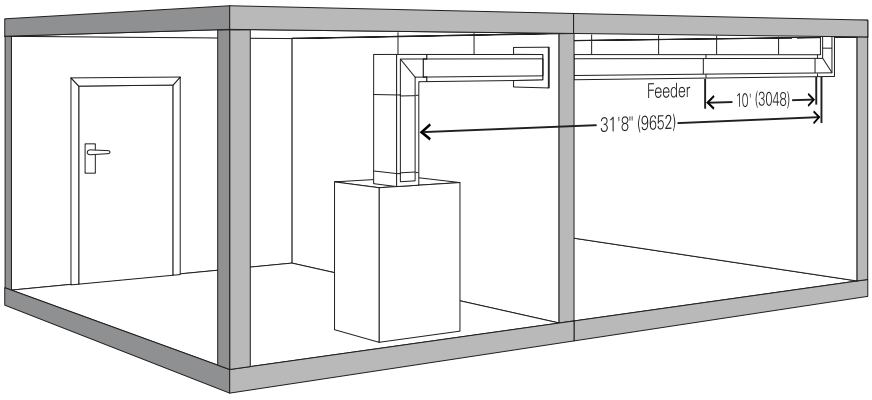


System Assembly

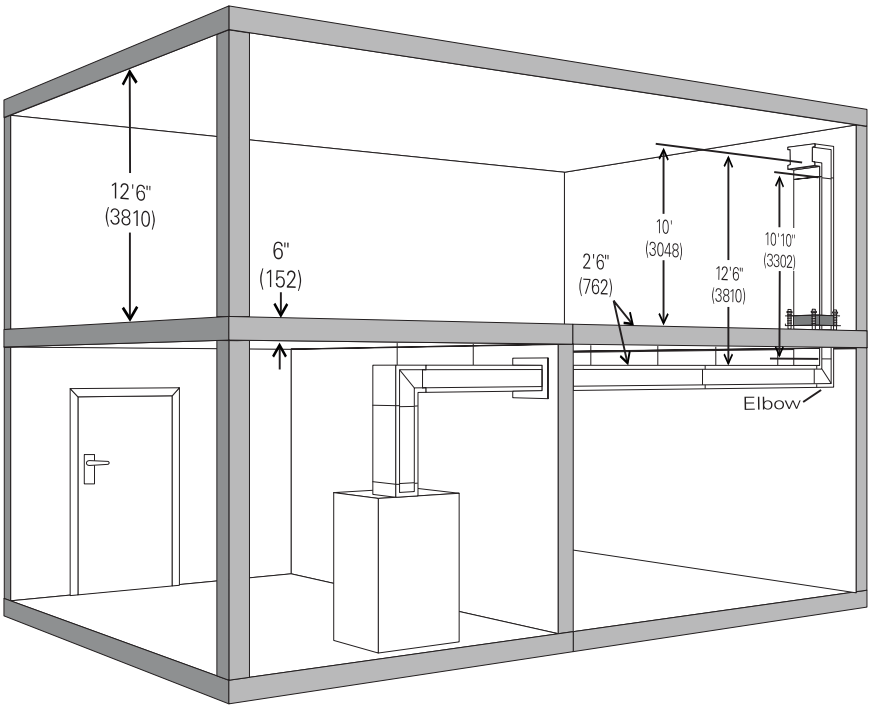
The components can now be selected for the installation. A switchboard flanged end (8″(203 mm)), a 4′ (1219 mm) length of feeder busway, and one elbow (10″ (254 mm)) is selected. The total height is 5′6″ (1676 mm).



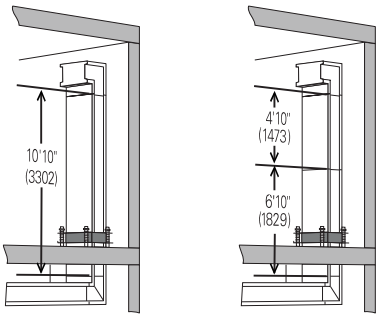
The busway runs horizontally on the first floor 31′8″ (9652 mm) before making its second turn. Feeder busway is selected because no equipment will be connected to it on the first floor. A second elbow and three 10′ (3048 mm) feeder sections are selected.



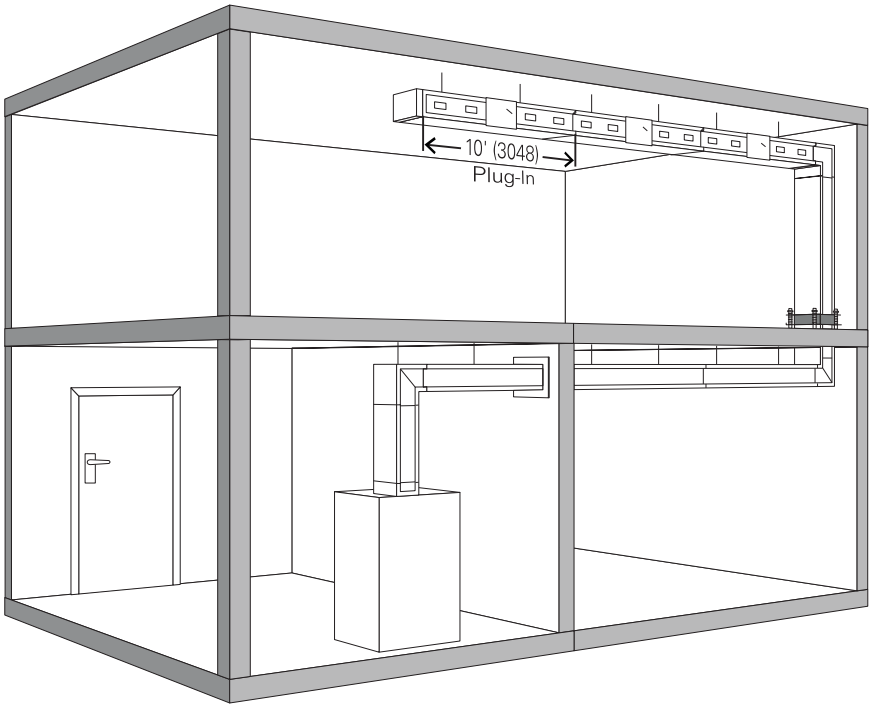
It is 2’6” (762 mm) from the top of the horizontal feeder run to the second floor level. The horizontal busway run on the second floor will be installed 10’ (3048 mm) from the floor, for a total rise of 12’6” (3810 mm). One elbow is already installed on the first floor horizontal feeder busway run. A second elbow will be needed at the top of the vertical riser. Each elbow is 10” (254 mm), which is subtracted from the total rise of 12’6” (3810 mm). 10’10” (3302 mm) of vertical riser will complete the vertical rise.



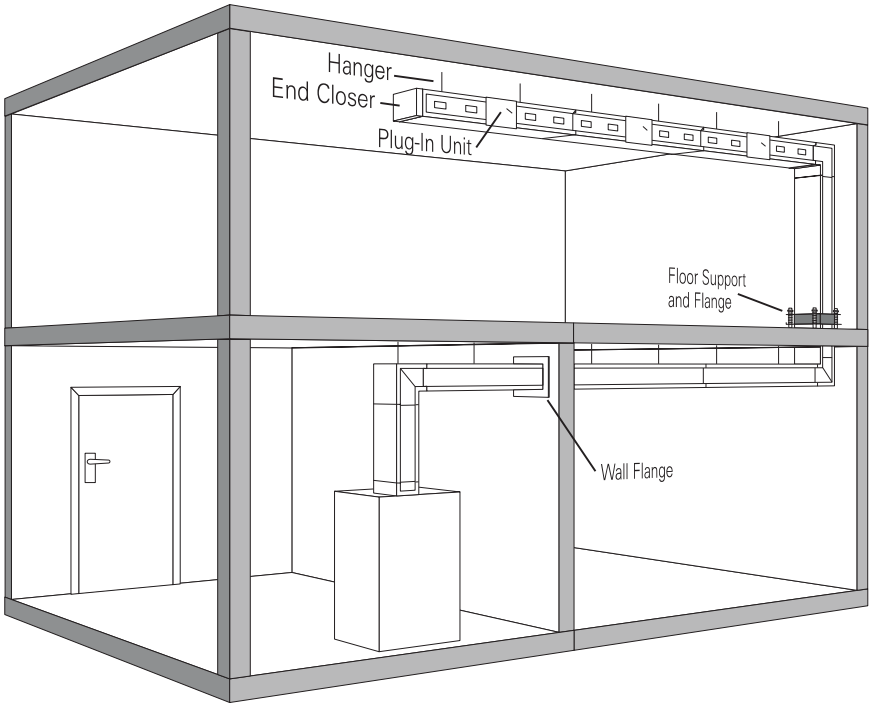
In addition to the standard lengths of 4’ (1219 mm), 6’ (1829 mm), 8’ (2438 mm), and 10’ (3048 mm), Sentron feeder busway also comes in any length from 2’ (609 mm) to 10’ (3048 mm) in 0.125” (3.17 mm) increments. One solution for the vertical riser might be to select one 6’ (1829 mm) and one 4’10” (1473 mm) section.



The busway run is completed with three 10’ (3048 mm) plug-in sections on the second floor.

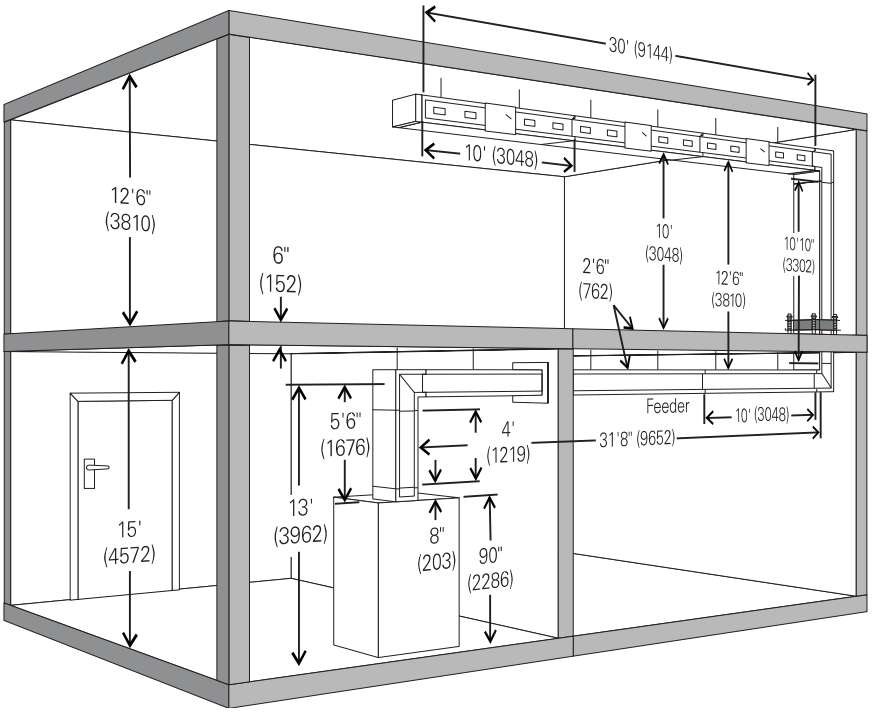


An end closer, wall and floor flanges, floor support, hangers, and the desired number of plug-in units finish the system. In this example three plug-in units were used.



Bill of Material

We now have the dimensions needed to assemble a bill of material for our example project.



Qty	Item
3	Bus Plugs
1	0'8" Stub
1	4'0" Feeder
3	10'0" Feeder
1	4'10" Feeder
1	6'0" Feeder
3	Edge Elbow
3	10'0" Plug-In
1	End Closer
1	Floor Flange
2	Floor/Wall Flange
12	Hangers

Information Needed to Order Busway

The following information is necessary when planning a busway installation or expansion:

- Description of application
- Type of busway
- Voltage and number of conductors
- Maximum current
- Length and configuration of run
- Location and type of power supply to busway
- Number of hangers
- Type and number of tap-off devices (tees, crosses)
- Type and number of accessories

Review 5

1. According to *NEC®* Article 368.7 a dead end of a busway shall be _____ .

2. Dimensions of Sentron busway can be found in the _____ .

3. A right elbow with copper bus bars, rated at 5000 amperes has an X measurement of _____ inches and a Y measurement of _____ inches.

4. According to *NEC®* Article 368.5 busway shall be securely supported at intervals not exceeding _____ feet unless the busway is otherwise designed and marked.

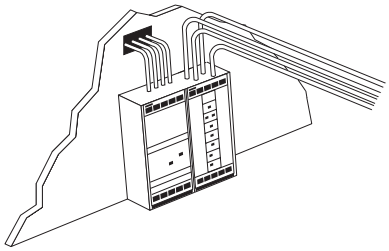
5. According to the *National Electrical Code®* it _____ to extend unbroken lengths of busway through dry walls.

   a. is permissible
   b. is not permissible

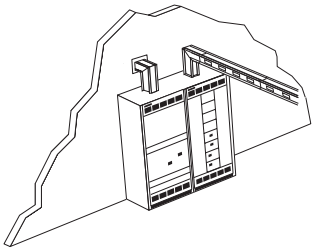
NEC® and *National Electrical Code®* are registered trademarks of the National Fire Protection Association.

Cable/Conduit Conversion

Busway can be used in many applications where cable and conduit are more commonly used. The question arises, "Why use busway instead of conventional cable and conduit?"



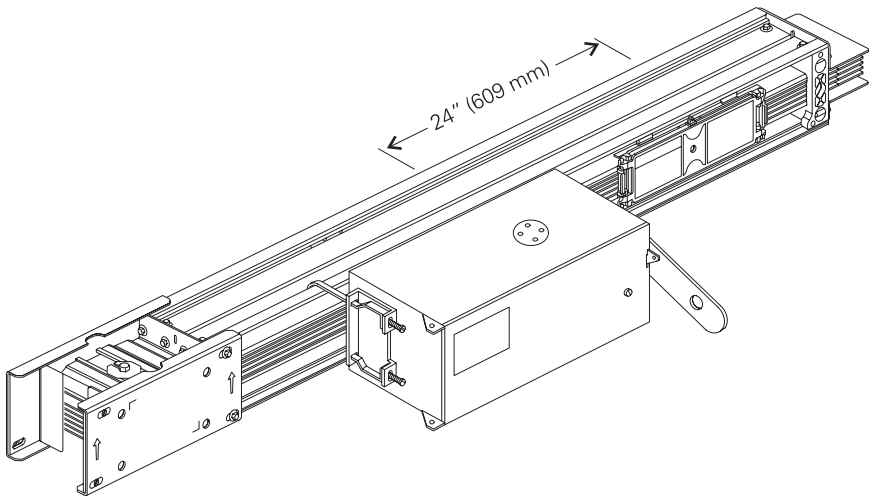
Conduit



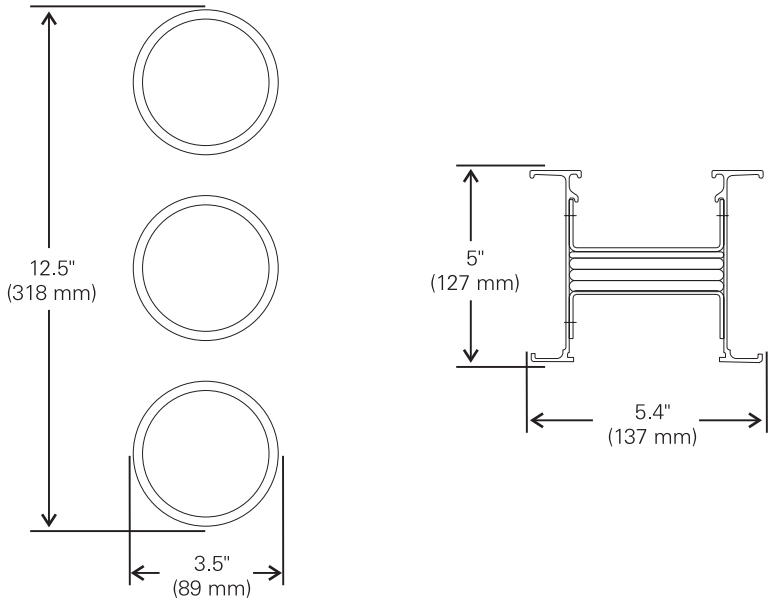
Busway

Benefits of Busway

There are several reasons why busway may be a better choice over cable and conduit. Busway provides greater flexibility by allowing equipment to be connected anywhere along the run on 24" centers. Equipment can be easily disconnected and moved to a new location without major rewiring.



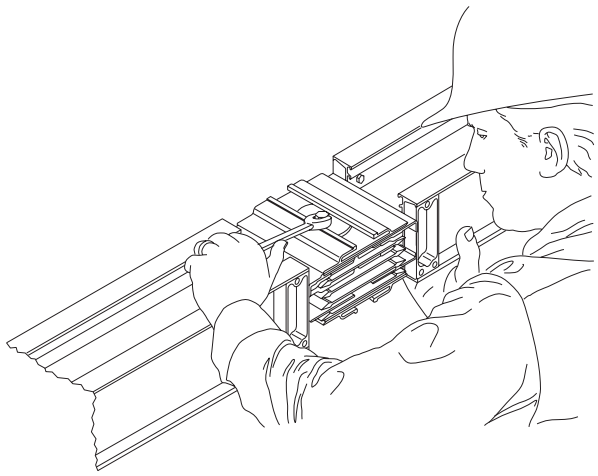
Busway has a smaller cross section. This means less installation space is required. Sentron™ busway with aluminum bus bars rated at 1000 amperes, for example, occupies a much smaller space than a comparable cable and conduit installation. The smaller cross section also means that busway is lighter in weight, by as much as half, which means less loading on the building.



Cable/Conduit

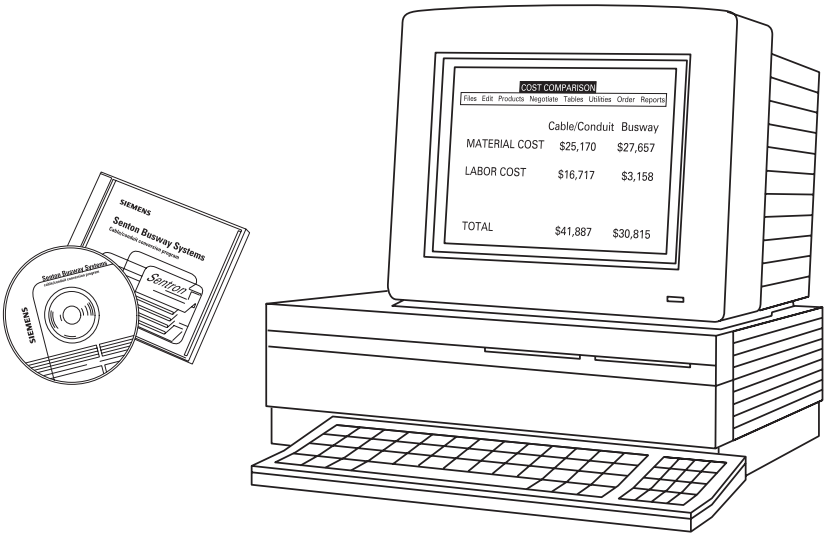
Sentron Busway

The installed cost of busway is typically less than cable and conduit. Busway is easier to install. Sections are simply hung and joined together using readily available hardware. Total installed costs associated with using Sentron busway over cable and conduit typically results in 20 - 30% lower installed cost.



Sentron Busway Estimating Program

A software program, available from Siemens, compares the total installed price of cable and conduit to Sentron busway.



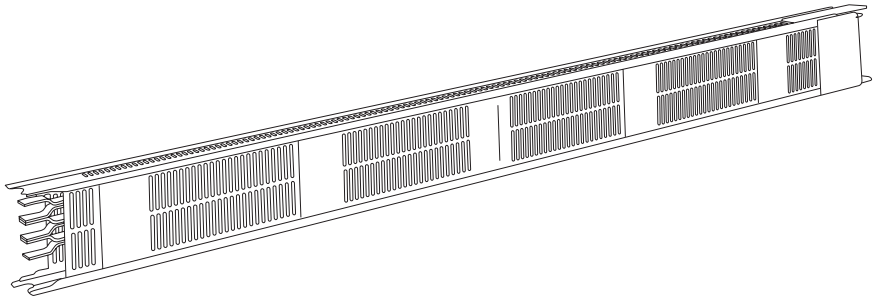
Comparison Example

The following table shows one example of the cost savings of busway over cable and conduit. The job calls for a 500 foot run of 1350 amperes. A hypothetical labor rate of $37.15 an hour is used. It will take an estimated 455 hours to install the cable and conduit. It will take an estimated 134 hours to install Sentron busway. The total savings, by using Sentron busway, is $12,693.

Material	Material Cost	Installation Labor	Total Installed Cost
Cable/ Conduit	$73,977	$16,925 (455 hrs. @ $37.15/hr)	$90,902.24
Sentron Busway	$73, 212	$4,996 (134 hrs. @ $37.15/hr)	$78,208.89
		Savings with Sentron	**$12,693**

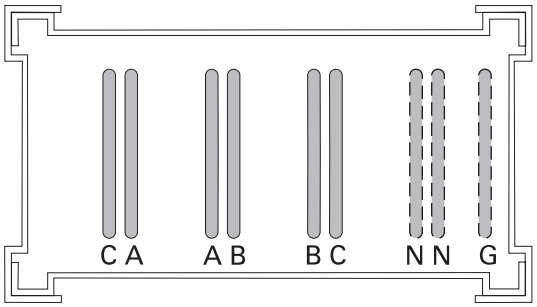
XL-U Busway

XL-U ® is available in both feeder and plug-in busway with ratings of 225 to 5000 amperes with aluminum bus bars or 225 to 6500 amperes with copper bus bars. Maximum voltage is 600 volts. XL-U feeder busway is available in either indoor or outdoor ventilated types. XL-U plug-in busway is indoor only and ventilated. XL-U is available in 3Ø3W and 3Ø4W.



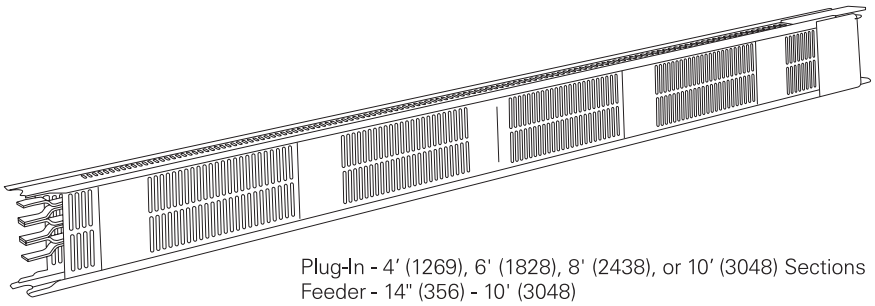
Paired Phases

XL-U is available with a paired-phase bus bar scheme. Bus bars are grouped in pairs so that AC current in each pair is nearly equal in magnitude and opposite in direction. Two bus bars per phase are used. Phase C is paired with phase A, phase A is paired with phase B, and phase B is paired with phase C. The result is a minimized magnetic field. Current is balanced and temperature rise is kept to a minimum. Voltage drop is reduced. XL-U busway can be used on any application within its current rating but it is usually used for long runs where end-of-run voltage is critical. Due to its paired-phase design, XL-U busway is known throughout the industry as the best product available for welder loads.



Sections and Components

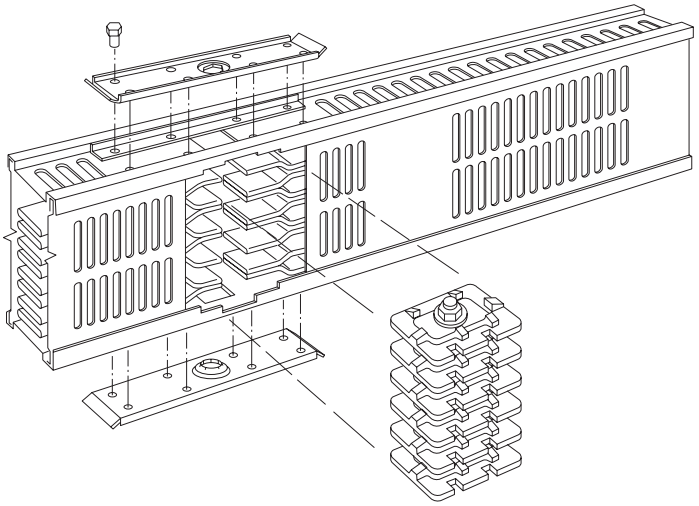
XL-U feeder busway sections can be supplied in any length from 14" (356 mm) to 10' (3048 mm). XL-U Plug-in busway is available in 4' (1269 mm), 6' (1828 mm), 8' (2438 mm), and 10' (3048 mm) sections. Elbows, tees, crosses, end closers, wall flanges, tap boxes, flanged end connections, switchboard connections, bus plugs, reducers, and hangers are available.



Plug-In - 4' (1269), 6' (1828), 8' (2438), or 10' (3048) Sections
Feeder - 14" (356) - 10' (3048)

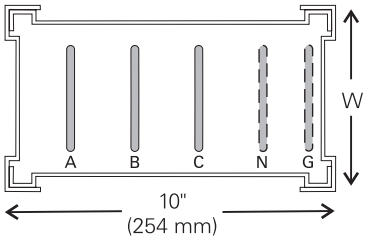
Joint Stack

XL-U busway uses a joint stack, similar to the Sentron™ busway, to connect sections together. The joint stack bolt is secured with a recommended 35 ft. lbs. of torque.



One Bar Per Phase

XL-U busway is available from 225 to 6500 amperes. The number of bus bars and the dimensions depends on the maximum current rating. XL-U busway can be mounted vertically or horizontally, either edgewise or flatwise. The cross sections illustrated below are shown edgewise mounted. The "W" dimension varies with the current rating. There are two maximum current ratings for XL-U, UL and standard rating. XL-U busway is available in a one-bar-per-phase configuration for the maximum current ratings shown in the following table.

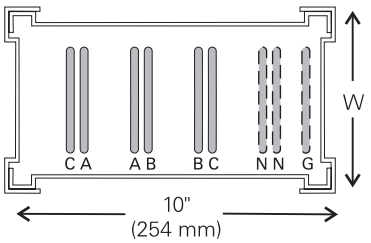


W	Bus Bars			Copper Ampere Rating					
	Number of Conductors			Vent. Bars on Edge		Vent. Bars Flat		Totally Enclosed	
	Per Ø	N	G	UL	Std.	UL	Std.	UL	Std.
4.5" (114 mm)	1	1	1	225	225	225	225	225	225
4.5" (114 mm)	1	1	1	400	400	400	400	400	400
4.5" (114 mm)	1	1	1	600	600	600	600	600	600
				Aluminum Ampere Rating					
4.5" (114 mm)	1	1	1	225	225	225	225	225	225
4.5" (114 mm)	1	1	1	400	400	400	400	400	400
5.5" (140 mm)	1	1	1	600	600	600	600	600	600

Ground Bus Capacity - 100%

Two Bars Per Phase

XL-U busway is available in a two-bar-per-phase, paired- phase configuration for the maximum current ratings shown in the following table.

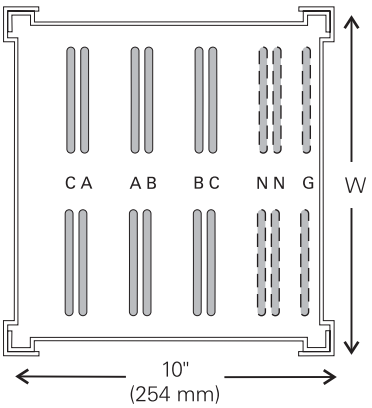


W	Bus Bars			Copper Ampere Rating					
	Number of Conductors			Vent. Bars on Edge		Vent. Bars Flat		Totally Enclosed	
	Per Ø	N	G	UL	Std.	UL	Std.	UL	Std.
4.5" (114 mm)	2	2	1	800	800	800	800		
4.5" (114 mm)	2	2	1	1200	1200	1000	1000	800	800
4.5" (114 mm)	2	2	1	1450	1350	12000	1200	1000	1000
5.5" (140 mm)	2	2	1	1700	1600	1350	1350	1100	
5.5" (140 mm)	2	2	1	2000	2000	1600	1600	1250	1200
				Aluminum Ampere Rating					
4.5" (114 mm)	2	2	1	800	800	800	800		
4.5" (114 mm)	2	2	1	1000	1000	900		800	800
5.5" (140 mm)	2	2	1	1250	1200	1000	1000	900	
5.5" (140 mm)	2	2	1	1400	1350	1200	1200	1000	1000

Ground Bus Capacity - 50%

Four Bars Per Phase

At higher current ratings bus bars are doubled up. Four bars per phase are used in the current ratings shown in the following table. Note that paired-phasing is still used.

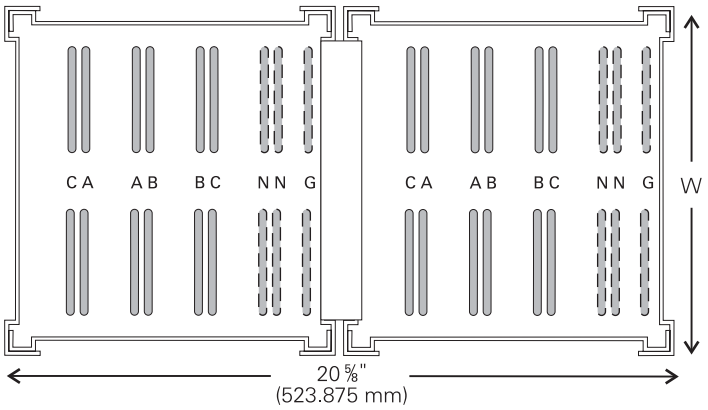


W	Bus Bars			Copper Ampere Rating					
	Number of Conductors			Vent. Bars on Edge		Vent. Bars Flat		Totally Enclosed	
	Per Ø	N	G	UL	Std.	UL	Std.	UL	Std.
7.5" (191 mm)	4	4	2	2300		2000		1400	1350
7.5" (191 mm)	4	4	2	2700	2500	2300	2000	1600	1600
9.5" (241 mm)	4	4	2	3000	3000	2500	2500	1900	
9.5" (241 mm)	4	4	2	3500	3500	2800	2800	2100	2000
				Aluminum Ampere Rating					
7.5" (191 mm)	4	4	2	1700	1600	1500	1350		
7.5" (191 mm)	4	4	2	2000	2000	1700	1600	1200	1200
9.5" (241 mm)	4	4	2	2300		1900		1400	1350
9.5" (241 mm)	4	4	2	2500	2500	2100	2000	1600	1600

Ground Bus Capacity - 50%

Eight Bars Per Phase

To accommodate even higher current levels eight bars per phase are used.



W	Bus Bars			Copper Ampere Rating					
	Number of Conductors			Vent. Bars on Edge		Vent. Bars Flat		Totally Enclosed	
	Per Ø	N	G	UL	Std.	UL	Std.	UL	Std.
7.5" (191 mm)	8	8	4	4400	4000	4000	4000	2700	2500
7.5" (191 mm)	8	8	4	5200	5000	4600	4500	3200	3000
9.5" (241 mm)	8	8	4	6000	6000	5000	5000	3700	3500
9.5" (241 mm)	8	8	4	6500	6500	5700	5500	4100	4000
				Aluminum Ampere Rating					
7.5" (191 mm)	8	8	4	3300	3000	3000	3000	2000	2000
7.5" (191 mm)	8	8	4	3900	3500	3500	3500	2500	2500
9.5" (241 mm)	8	8	4	4500	4000	3900		2750	
9.5" (241 mm)	8	8	4	5000	5000	4200	4000	3100	3000

Ground Bus Capacity - 50%

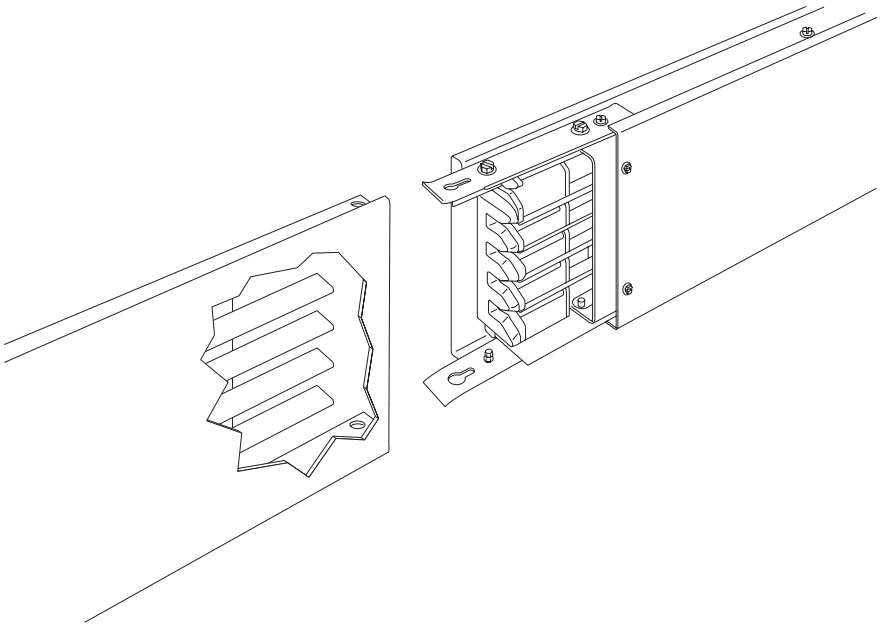
Components

The following components are available for XL-U busway:

- Hangers
- End closers
- Flanged ends
- Plug-in and center cable tap boxes
- Elbows
- Offsets
- Tees
- Crosses
- Reducers and expansion sections
- Bus plugs (circuit breaker, fusible)

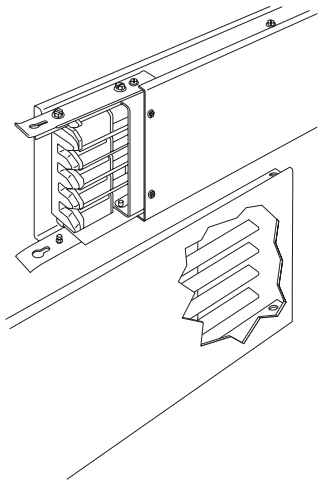
XJ-L Busway

When an application needs a horizontal run of plug-in busway with a current rating that does not exceed 200 amperes, Siemens XJ-L™ would be a good choice. XJ-L busway is available with 100 or 200 ampere capacities, three-phase, three-wire (3Ø3W), 600 VAC or three-phase, four-wire (3Ø4W), 600 VAC. The neutral bus bar in the 3Ø4W type is rated for 100%. XJ-L busway is available in 2′ (610 mm), 5′ (1524 mm), and 10′ (3048 mm) lengths. There are up to 12 plug-ins per 10′ (3048 mm) length. Plug-ins are located in alternate positions from side-to-side.

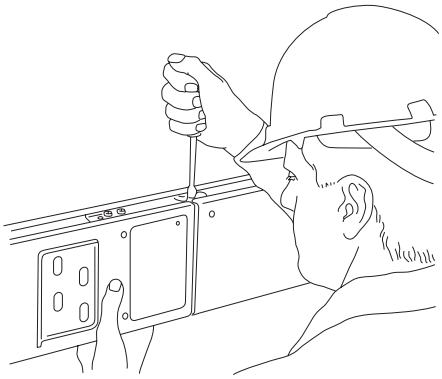


Installation

All XJ-L busway sections mate together end-to-end with overlapping joints which are held in place by integral spring pressure clips.



The sections are bolted together with captive screws.



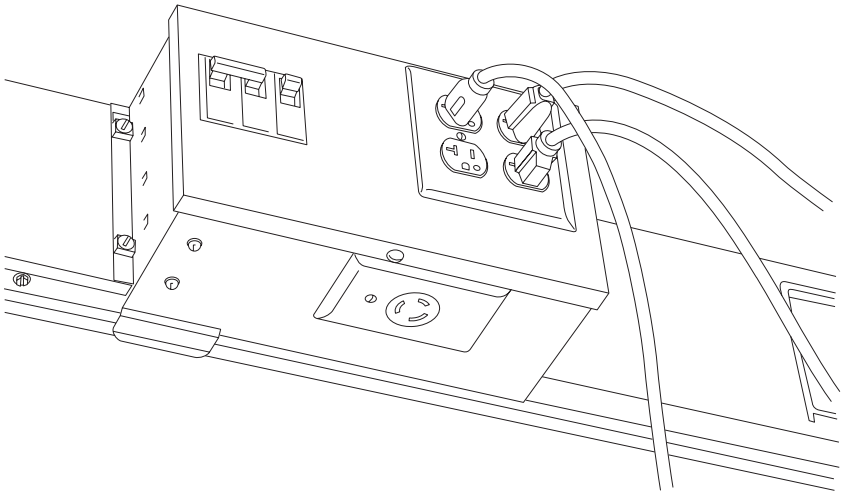
Components

The following components are available for XJ-L busway:

- Hangers
- End closers
- Flanged ends
- Plug-in and center cable tap boxes
- Elbows
- Tees
- Bus plugs (circuit breaker, fusible)

XQ-R bus plug

XQ-R bus plugs serve both 120 and 240 VAC needs. This is useful for computer applications, laboratory/test facilities, schools, hospitals, and machine shops.



Review 6

1. The installed cost of busway is typically _____ than cable and conduit.

   a. more
   b. less

2. The maximum current rating available with XL-U busway with aluminum bus bars is _____ amperes.

3. _____ _____ is a unique feature of XL-U busway that results in a magnetic field cancellation.

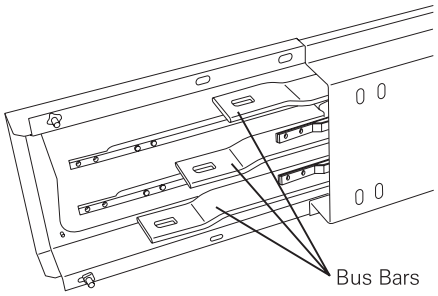
4. To accommodate levels of current in the 3000 to 5000 ampere range, using aluminum XL-U busway, _____ ___ bars per phase are used.

5. XJ-L is available in either _____ ampere or _____ ampere capacities.

6. The _____ is a bus plug available for XJ-L busway which provides 120 and 240 VAC.

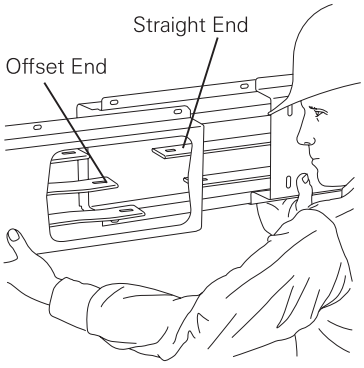
BD Busway

The BD™ busway is a general purpose power distribution busway of the plug-in design. BD busway is well established in the industry and has proven to be a dependable system. BD busway was first introduced in 1932, and with the exception of minor upgrades in materials, the basic design has remained unchanged. This means older systems can be expanded with today's BD busway components.

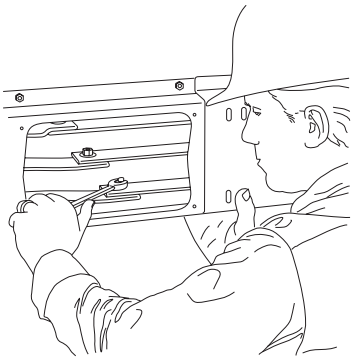


Installation

The bus bars of one end of a section are offset and the other end is straight. To connect two sections together match an offset end with a straight end. When ordering new BD busway to expand an existing system it is important to note if the new connection will be to an existing offset or straight end.



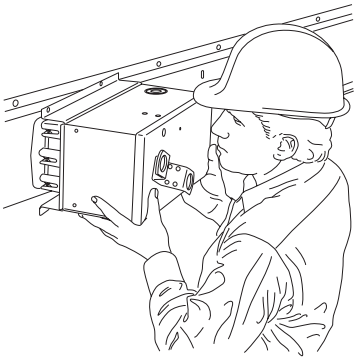
Bus bars are bolted together with a recommended 25 ft. lbs. of torque.



Plug-Ins

Each 10’ (3048 mm) section has ten bus plug receptacles, spaced alternately on each side (five on each side) of the busway section. Circuit breaker plugs are available in sizes from 100 to 800 amperes for voltages of 600 VAC or less. Fusible Vacu-Break® switch plugs are available in sizes of 30 to 600 amperes, 3-pole, 600 VAC or less, or 4-pole solid neutral, 240 or 480 VAC.

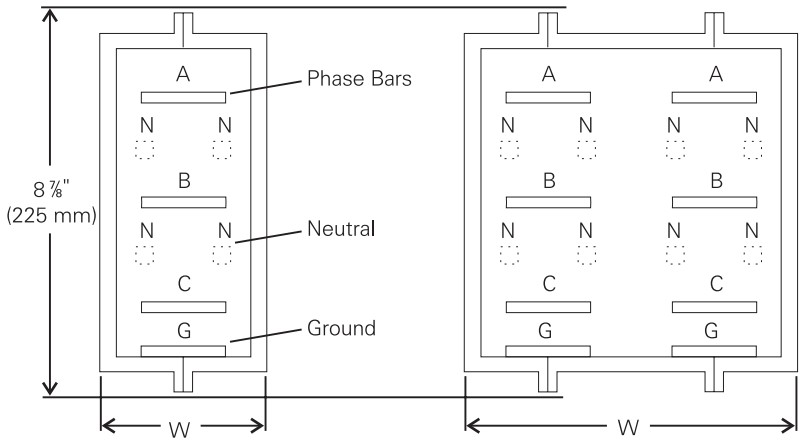
Capacitor and transformer bus plugs are also available. Capacitor bus plugs are used to reduce inductive heating and improving power factor. Transformer bus plugs furnish single-phase 120 or 240 VAC for lighting, small motors, or portable tools. Transformer plugs are also available with or without two-pole AC magnetic contactors for plugging in on three-phase 240 or 480 VAC.



Ratings and Dimensions

BD busway comes in 10' (3048 mm) lengths in current ratings from 225 to 1600 amperes. The number of bus bars per phase is determined by the current rating. A section of 225 amperes aluminum busway, for example, would have one bar per phase. A section of 1000 ampere aluminum busway would have two bus bars per phase. The following busway cross section diagram and table reflect ampere ratings and dimensions of BD busway.

Fig. 1 Fig. 2



3Ø3W			3Ø4W - 100% Neutral		
Ampere Rating	**Fig #**	**Width (W)**	**Ampere Rating**	**Fig #**	**Width (W)**
Aluminum					
225	1	4 1/16" (103 mm)	225	1	4 1/16" (103 mm)
400	1	4 1/16" (103 mm)	400	1	4 1/16" (103 mm)
600	1	6 1/16" (154 mm)	600	1	6 1/16" (154 mm)
800	1	6 1/16" (154 mm)	800	1	8 1/8" (206 mm)
1000	2	12 1/8" (308 mm)	1000	2	12 1/8" (308 mm)
1200	2	12 1/8" (308 mm)	1200	2	12 1/8" (308 mm)
Copper					
225	1	4 1/16" (103 mm)	225	1	4 1/16" (103 mm)
400	1	4 1/16" (103 mm)	400	1	4 1/16" (103 mm)
600	1	4 1/16" (103 mm)	600	1	4 1/16" (103 mm)
800	1	6 1/16" (154 mm)	800	1	8 1/8" (206 mm)
1000	1	6 1/16" (154 mm)	1000	1	8 1/8" (206 mm)
1350	2	12 1/8" (308 mm)			
1600	2	12 1/8" (308 mm)			

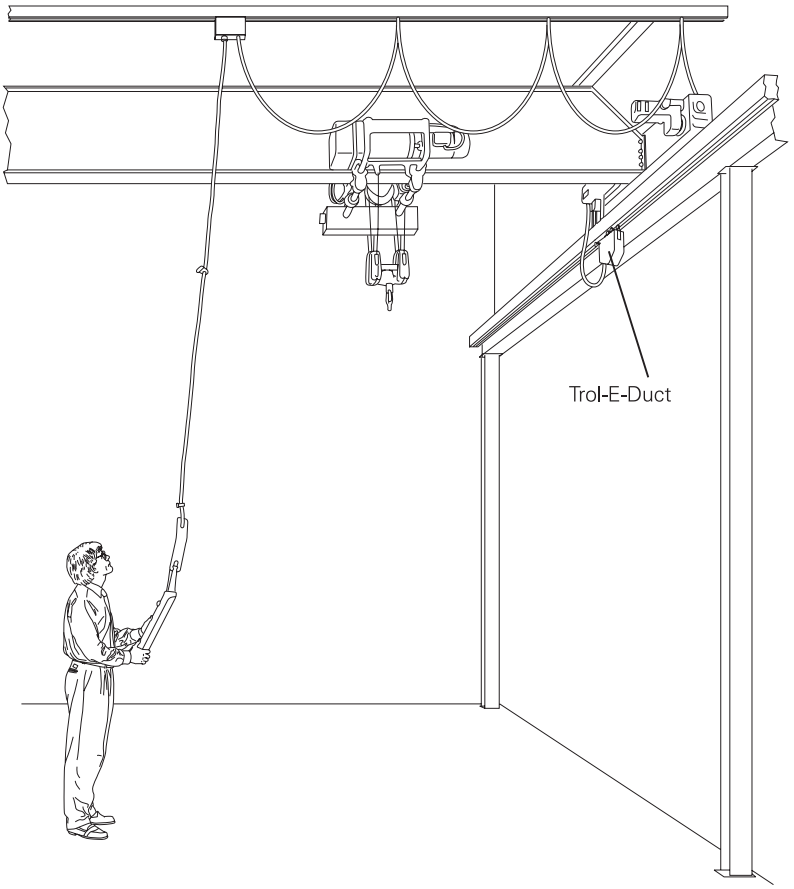
Components

The following components are available for BD busway:

- Hangers
- End closers
- Flanged ends
- Plug-in and center cable tap boxes
- Elbows
- Tees
- Crosses
- Bus plugs (circuit breaker, fusible)

Trol-E-Duct

Trol-E-Duct™ is part of the Siemens busway family. This busway is designed to provide power to indoor moving equipment, such as cranes, conveyors, hoists, mobile tools, and similar moving equipment.



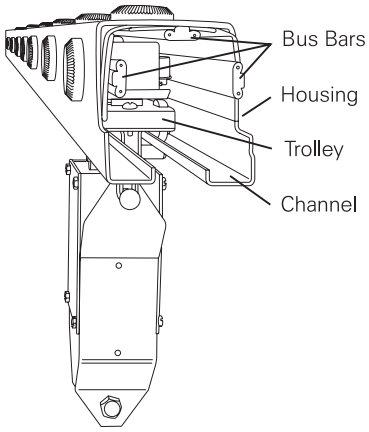
Ratings

Trol-E-Duct is available in the following ratings:

Indoor
1Ø2W, 1Ø3W, 3Ø3W, 3Ø4W
100 to 800 amperes
600 VAC

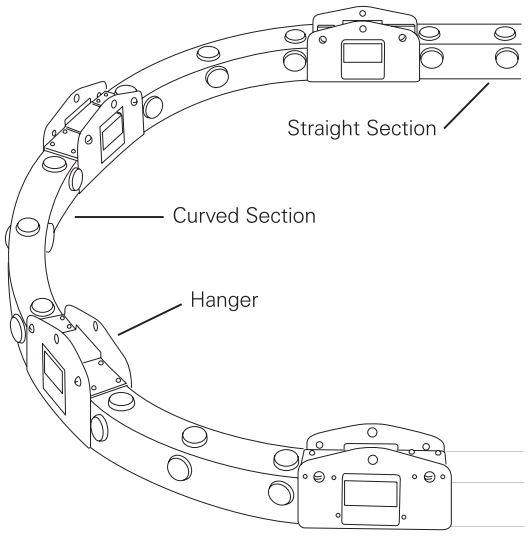
Construction

Bus bars inside a housing provide power to a trolley. Brushes, mounted on the trolley, make contact with the bus bars. The trolley can be moved along an internal channel that is part of the housing. A section of the bus bar can be removed and replaced with a spacer that can be as small as ¼" (6.35 mm) or as large as 1' (305 mm). It may be desirable to have a system that is powered only at specific locations. In these cases less expensive busless casings can be used throughout the unpowered sections.



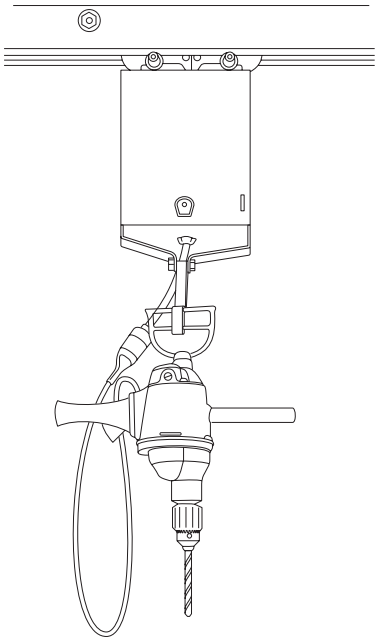
Sections

Trol-E-Duct sections can be straight or curved. Curved sections are available only for 100 ampere busway. Curved sections can either be horizontal (shown) or vertical (not shown). Curved sections join with straight sections to create a continuous Trol-E-Duct system that matches any structural pattern. Curved sections are available for any radius of two feet or greater.

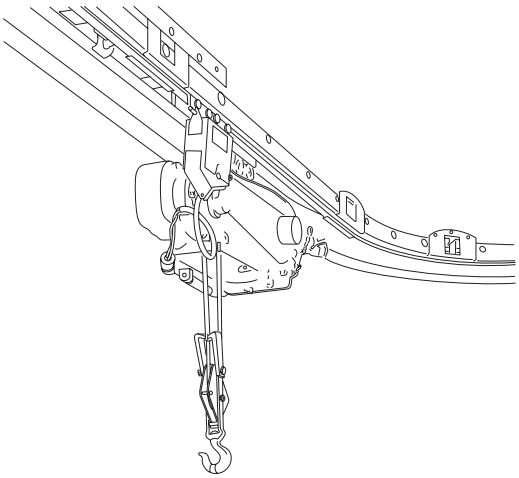


Trolleys

Several types of trolleys are available for Trol-E-Duct. There are two types of tool hanger trolleys. Types TPTH and TBTH. Both types of tool hangers should not be used on a curved section with a radius of less than 5'. Type TPTH has provision for wiring a tool to the trolley. Type TBTH also has space for starters, receptacles and fuses.



Several other types of trolleys are available for a wide variety of applications. In the following example a hoist is wired to a trolley. The hoist moves along a monorail that runs parallel to a Trol-E-Duct system.



Standard Trolleys

Standard trolleys are recommended for applications where the load current is less than 30 amperes, trolley speed is less than 5 m.p.h., and the curve radius is 5′ (1524 mm) or larger.

Heavy-Duty Trolleys

Heavy duty trolleys are used where the load current is less than 60 amperes, trolley speed is less than 5 m.p.h., and the curve radius is 5′ (1524 mm) or larger. By adding an additional pigtail between the brush and the wire grip the trolley can be rated as high as 90 amperes.

Roller-Type Trolleys

Roller-type trolleys are used on lighter duty applications. The load current is less than 20 amperes and the trolley speed does not exceed 2.5 m.p.h. Roller-type trolleys will negotiate a 5′ (1524 mm) radius curve.

Curved-Type Trolleys

Curved-type trolleys will negotiate a curve with a 3′ (914 mm) radius or greater, speeds up to 5 m.p.h., and loads as high as 60 amperes.

Button-Type Trolleys

Button-type trolleys will negotiate a curve with a 5′ (1524 mm) radius or greater, speeds up to 5 m.p.h., and loads as high as 60 amperes. Extra wheels on this trolley make it well suited for carrying a heavy weight.

Transfer Trolley

The transfer trolley is rated at 30 amperes and is suited for applications where the trolley must jump a gap in duct. Flared ends are used on the bus duct when the trolley must jump. The trolley can jump a separation as great as 3/8″ (9.5 mm) with sections misaligned as much as 3/8″ (9.5 mm). It will negotiate a curve with a radius of 2′ (610 mm) or greater.

Nylon Brush Trolley

Nylon brush trolleys have brushes which are used to remove abrasive material, such as metallic or cement dust, from the bus bars.

Abrasive Trolley

Abrasive trolleys are designed to clean and remove corrosive buildup from bus bars in harsh atmospheres.

Review 7

1. BD busway was first introduced in _____ .

2. When ordering new BD busway to expand an existing system it is important to note if the new connection will be to an existing _____ or straight end.

3. Fusible Vacu-Break switches are available in sizes of _____ to _____ amperes for BD busway.

4. _____ is a type of busway that is designed to provide power to moving equipment such as cranes or hoists.

5. Standard Trol-E-Duct trolleys can handle a curve radius of _____ feet or larger.

Review Answers

Review 1	1) distribution system; 2) feeder; 3) Busway; 4) busway: 5) feeder, plug-in; 6) Feeder, plug-in.
Review 2	1) two, three; 2) 47,000; 3) 66, 54; 4) 368; 5) 200,000; 6) 10,000, 200,000.
Review 3	1) 4,000, 5,000; 2) a. feeder, b. plug-in; 3) 4′, 6′, 8′; 4) 2; 5) 0.125, 1′ 4.5″, 10′.
Review 4	1) C; 2) F; 3) A; 4) B; 5) E; 6) H; 7) G; 8) D.
Review 5	1) closed; 2) *Sentron Busway Systems Selection and Application Guide*; 3) 24, 24; 4) 5; 5) a.
Review 6	1) b; 2) 5000; 3) Paired phases; 4) eight; 5) 100, 200; 6) XQ-R.
Review 7	1) 1932; 2) offset; 3) 30, 600; 4) Trol-E-Duct; 5) 5.

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. A grade of 70% or better is passing. Upon successful completion of the test a certificate will be issued.

Questions

1. The two types of busway are _____ .

   a. feeder and service entrance
   b. feeder and plug-in
   c. plug-in and service entrance
   d. indoor and outdoor

2. It typically takes _____ man-hours to install a busway system than cable and conduit.

   a. about the same
   b. more
   c. fewer
   d. twice as many

3. According to NEMA publication number BU 1.1-2000, the short-circuit rating of plug-in busway with a maximum continuous current rating of 1000 amperes should be at least _____ amperes.

   a. 10,000
   b. 14,000
   c. 22,000
   d. 42,000

4. According to IEC 529, a plug-in outlet that is said to be "finger safe" has an IEC code of IP _____ .

   a. 2X
   b. 40
   c. 43
   d. 54

5. General guidelines which discuss the safe application of busway are covered in the *NEC®* Article _____ .

   a. 368
   b. 445
   c. 365
   d. 450

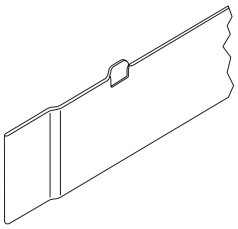
6. The interrupting rating of a class R fuse is _____ amperes.

   a. 10,000
   b. 100,000
   c. 50,000
   d. 200,000

7. The maximum current rating of Sentron™ busway with aluminum bus bars is _____ amperes.

   a. 2,000
   b. 3,000
   c. 4,000
   d. 5,000

8. The following Sentron bus bar is used for _____ busway.



   a. feeder
   b. plug-in
   c. service entrance
   d. outdoor

9. Plug-in outlets on Sentron busway are located on _____ centers.

   a. 16″ (406 mm)
   b. 2′ (610 mm)
   c. 30″ (762 mm)
   d. 3′ (914 mm)

10. A Sentron busway expansion fitting allows for an expansion compensation of ± _____ .

   a. 2″ (50.8 mm)
   b. 1′ (305 mm)
   c. 18″ (457 mm)
   d. 6″ (152 mm)

11. _____ are used to house Siemens molded case circuit breakers or fusible switches.

   a. Reducers
   b. Service heads
   c. Bus Plugs
   d. Expansion fittings

12. _____ are used to safely terminate a run of busway and protect the bus bar ends.

   a. End closers
   b. Service heads
   c. Tees
   d. Flanged ends

13. A minimum distance of _____ from the wall to a joint where the new section of busway begins is required when Sentron busway passes through a wall.

    a. 4″ (102 mm)
    b. 7″ (127 mm)
    c. 6″ (152 mm)
    d. 10″ (254 mm)

14. The dimensions of a Sentron right elbow, with aluminum bus bars, rated for 1000 amperes is _____ .

    a. 10″ x 10″
    b. 12″ x 12″
    c. 18″ x 18″
    d. 24″ x 24″

15. The paired-phase bus bar scheme is used with _____ busway.

    a. Sentron
    b. XJ-L
    c. XL-U
    d. BD

16. The maximum current rating of XL-U busway with copper bus bars is _____ amperes.

    a. 3000
    b. 4000
    c. 5000
    d. 6500

17. The maximum current rating of XJ-L busway is _____ amperes.

    a. 100
    b. 5000
    c. 200
    d. 6000

18. The type of Siemens busway that was first introduced in 1932 is _____ busway.

    a. Sentron
    b. XJ-L
    c. XL-U
    d. BD

19. _____ is the type of Trol-E-Duct tool box hanger that provides space for starters, receptacles and fuses.

    a. TBTH
    b. TPTH
    c. Transfer trolley
    d. Button-type trolley

20. Curved Trol-E-Duct sections are available for _____ .

    a. any radius of 2′ (610 mm) or greater
    b. a 2′ (610 mm) radius only
    c. any radius of 5′ (1524 mm) or greater
    d. a 5′ radius only (1524 mm)

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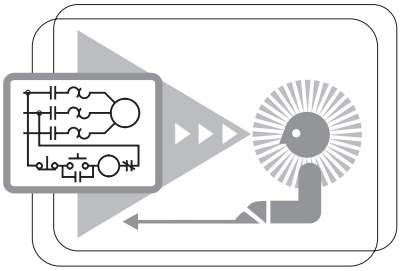

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