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Introduction

Welcome to another course in the STEP series, Siemens Technical Education Program, designed to prepare our distributors to sell Siemens Industry, Inc. products more effectively. This course covers Basics of Busway and related products.

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

• 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

• Summarize key points from National Electrical Code® Article 368 that apply to busway installation.

• Identify the major components of Siemens busway systems and describe their functions

• Describe how a cost savings is realized when busway is selected over cable and conduit

• Describe how to measure and layout a basic busway system

• Identify various ratings of Siemens busway
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 Basics of Busway. An understanding of many of the concepts covered in Basics of Electricity is required for Basics of Busway.

After you have completed this course, if you wish to determine how well you have retained the information covered, you can complete a final exam online as described later in this course. If you pass the exam, you will be given the opportunity to print a certificate of completion from your computer.

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National Electrical Manufacturers Association is located at 2101 L. Street, N.W., Washington, D.C. 20037. The abbreviation “NEMA” is understood to mean National Electrical Manufacturers Association.

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A power distribution system is a group of components that carries 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. They include 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 to ensure that the distribution system safely and efficiently supplies adequate electric service for both present and possible future loads.
**Power Source Example**

The following illustration shows the secondary windings of a three-phase transformer for a power distribution system. Power to the primary of this transformer (not shown) is supplied by the power company. In this example, the secondary winding phase-to-phase voltage is 480 VAC and the phase-to-neutral voltage is 277 VAC. This is only one example of a power source used for an industrial or commercial facility. Many other configuration examples are possible.

![Diagram of a three-phase transformer](image)

**Feeders**

A **feeder** is a set of conductors that originates 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.

![Diagram of feeders and branches](image)
Busway Purpose and Definition

Commercial and industrial distribution systems use various methods to conduct electrical energy. These methods often include heavy conductors run in trays or conduit.

Cable and conduit assemblies are costly and time consuming to install. Once installed, they are difficult to change. To eliminate these shortcomings, power is often distributed using enclosed bus bars. 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. Busway bus bars 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 with which busway sections are connected. Electrical power can be supplied to any area of a building by connecting standard lengths of busway. It typically takes up to 35% fewer man-hours to install or change a busway system than cable and conduit assemblies.
Many power distribution systems use both busway and cable and conduit. In the following example, power from the utility company is metered and enters the plant through a **switchboard**. The switchboard includes ground fault protection and serves as the main power shutoff point.

The feeder on the left feeds a distribution switchboard, which, in turn, feeds a panelboard and a 480 volt, three-phase motor.

The middle feeder supplies another switchboard, which divides the power into three, three-phase, three-wire circuits. Each circuit feeds a busway run to 480 volt, three-phase motors.

The feeder on the right supplies 120/208 volt power, through a step-down transformer, to **panelboards** with branch circuits that supply power for lighting and outlets throughout the plant.
Busway is used in a wide variety of applications, including complex industrial plants, data centers, offices, high-rise buildings and many other types of facilities. Generally, there are two major types of busway installations: horizontal and vertical. Horizontal busway is often used in industrial locations to supply power to heavy equipment, lighting, and air conditioning. Vertical busway, also referred to as busway risers, can be installed economically in high-rise buildings where it is used to distribute lighting and air conditioning loads.

**Horizontal Busway**

Horizontal busway applications generally feature the following attributes:
- More than 70% bus duct
- Greater amount of plug-in busway
- Little or no riser bar
- Large number of fittings
- Greater than 20% bus plugs (initially)
- Continued replacement, growth and maintenance requirements

**Vertical Busway**

These features are typically found in vertical busway applications, such as high-rise buildings:
- More than 90% bus duct
- Large amount of feeder busway
- Large amount of riser bar
- Relatively few fittings
- Less than 10% bus plugs
- Little or no replacement and minimal maintenance requirements.
Sentron Busway

Throughout this course, Siemens Sentron busway is used to explain and illustrate basic principles and features. Sentron busway is available with continuous current ratings from 225 to 5000 amperes and meets the requirements of most applications.

In addition to Sentron busway, Siemens manufactures the following other types of busway to provide components for repairing or expanding existing systems or to meet highly specialized requirements of certain applications:

**BD Busway** has set the industry standard for more than 70 years.

**XJ-L Busway** is an excellent choice for high-tech or light industrial applications.

**XL-U Busway** is designed for voltage-sensitive, heavy-duty applications, such as welding.

These other types of Siemens busway are discussed later in this course.
Types and Application

**Feeder Busway**

There are two types of busway: *feeder* and *plug-in*. Many industrial and large commercial applications have long runs from the power source to a single load or to a panelboard, switchboard, or motor control center lineup for further distribution. Feeder busway is intended for these applications or other applications that do not require power drops over the length of a busway run.

**Service Entrance**

The *service entrance* is the point of entry for supply conductors to a building or other structure. Feeder busway can be used as service entrance conductors to bring power from a utility transformer to a main disconnect inside the building. Both outdoor and indoor types of feeder busway are available.
Plug-in Busway

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

Review 1

1. A power _______ 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 part of many commercial and industrial power distribution systems and is made up of heavy bus bars in an enclosure.

4. It typically takes up to 35% fewer man-hours to install or change a _______ system than cable and conduit assemblies.

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

6. Both indoor and outdoor types of _______ busway are available. _______ busway is for indoor use only.
Several organizations provide standards that influence the design, construction, installation, and performance for busway. The following list includes some of these organizations:

**Underwriters Laboratories, Inc. (UL).** Busway bearing the Underwriters Laboratories listing mark must pass a series of performance tests described in the UL 857 standard. These tests and standards relate to the strength and integrity of a busway system when subjected to specific operating and environmental conditions.

**National Electrical Manufacturers Association (NEMA).** NEMA standards for busway are listed in BU 1.1. It is important to note that NEMA short-circuit ratings require a 3-cycle short-circuit rating. This means the busway was tested and rated on the basis of successfully experiencing three cycles of peak current (IP). Sentron busway is tested and rated at 6 and 60 cycles, which exceeds NEMA requirements and competitive ratings.

**International Electrotechnical Commission (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.

Additional organizations publish electrical codes. The following list includes some of these organizations.

**National Fire Protection Association (NFPA).** NFPA publishes NFPA 70®: National Electrical Code® (NEC®). The National Electrical Code® is updated every three years. Each version must subsequently be adopted by the authority having jurisdiction. This code 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 are applicable in certain situations. Thorough familiarization of the NEC® requirements for busway is recommended.
State and local governments. State and local electrical codes are determined by their respective governmental organizations and, in some cases, may be more stringent than the national organizations.

Electrical utilities. Busway used for the main electrical service, is connected to distribution transformers owned by local electric power companies. These companies have their own requirements for methods of connecting to busway.
Circuit Protection

This section describes important concepts associated with circuit protection. As with other type of conductors, circuit protection is important for busway systems.

Current flow in a conductor always generates heat. As current flow increases, the conductor must be sized appropriately to compensate for increased heat. Excess heat is damaging to electrical components. For that reason, conductors have a rated current carrying capacity or **ampacity**.

**Overcurrent** is any current that exceeds the ratings of the equipment or conductors. **Overloads, short circuits**, and **ground faults** are types of overcurrents. Ground fault protection is beyond the scope of this course to discuss, but the following paragraphs discuss devices designed to provide overload and short circuit protection.

**Overcurrent Protection**

Circuit protection would be unnecessary if faults could be eliminated. Unfortunately, faults do occur. Overcurrent protection devices are designed to 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 recognize the difference between overloads and short circuits and respond as required. Protection devices use an inverse time-current characteristic. Slight overcurrents can be allowed to continue for a limited time, but as the current magnitude increases, the protection device must open faster. Short circuits, for example, must be interrupted instantly.

![Inverse Time-Current Characteristic](image)

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.

![Fuse Construction](image)
Overloads

Current flowing through the element generates heat, which is absorbed by the filler material. When an overcurrent occurs, the temperature of 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, however, the heat melts open a gap in the element, thus stopping the flow of current.

Short Circuits

When a short circuit occurs, current quickly rises, generating extreme heat which can melt several element segments simultaneously. When these segments melt, current is quickly removed from the load. Typically fuses cut off short-circuit current in less than half a cycle, before it can reach its full value.

Non-Time-Delay Fuses

Non-time-delay fuses provide excellent short circuit protection. However, short-term overloads, such as motor starting current, may cause nuisance openings of non-time-delay fuses. They are best used in circuits not subject to large transient surge currents. Non-time-delay fuses usually hold 500% of their rating for approximately one-fourth second, after which the 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

A fuse has an **ampere rating** which specifies its the amount of current the fuse can continuously carry at a specified temperature without opening.

Voltage Rating

The **voltage rating** of a fuse must be at least equal to the circuit voltage. It 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 can not be used in a 480 volt circuit.

Interrupting Rating

Fuses are also rated by the level of fault current they can interrupt. This is referred to as **interrupting rating** (also referred to as **breaking capacity**). A fuse must be selected that 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.

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.

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

*Current Limiting Fuses
Circuit Breakers

A circuit breaker is another device used for overcurrent protection. A circuit breaker automatically opens when it senses an overcurrent and also provide a manual means to disconnect power from 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.

For additional information refer to Basics of Circuit Breakers.

Review 2

1. Organizations that maintain standards that relate to busway include: ________, ________, ________, and ________.

2. Article ____________ in the National Electrical Code® specifically applies to busway.

3. The current carrying capacity of a conductor is referred to as its ________.

4. ________ is any current that exceeds the ratings of equipment or conductors.

5. The current carrying capacity of a fuse is also referred to as its ________ rating.
Busway Construction

Bus Bars

A better understanding of busway 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 used in feeder busway differ from those found in plug-in busway. Plug-in busway includes a **tab**, or other fixture, to connect a plug-in device, such as a disconnect.
Bus bars found in Sentron busway are separated electrically with epoxy insulation.

Enclosure

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

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

<table>
<thead>
<tr>
<th>Ampere Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aluminum</strong></td>
</tr>
<tr>
<td>800</td>
</tr>
<tr>
<td>1000</td>
</tr>
<tr>
<td>1200</td>
</tr>
<tr>
<td>1350</td>
</tr>
<tr>
<td>1600</td>
</tr>
<tr>
<td>2000</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Ampere Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aluminum</strong></td>
</tr>
<tr>
<td>2500</td>
</tr>
<tr>
<td>3000</td>
</tr>
<tr>
<td>4000</td>
</tr>
</tbody>
</table>
**NEMA Phase Arrangement**

Bus bars are required by NEMA to have phases in sequence so an installer will find the same fixed phase arrangement at each termination point. 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 a neutral or ground is used.
200% Neutral

Certain loads on the distribution system generate non-sinusoidal current which includes harmonics. These harmonics cause circulating currents which increase the heat in the system and shorten component life. Siemens Sentron busway is available with a 200% neutral within the bus bar housing. The 200% neutral capacity minimizes overheating.

Ground

The National Electrical Code® requires the metal enclosure of any busway run to be grounded at the service entrance. 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 with a 50% internal ground added. This means 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 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 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. Feeder busway does not have plug-in outlets.
1. Sentron busway with aluminum bus bars is available with ampacities up to ________ amperes and Sentron busway with copper bus bars is available with ampacities up to ________ amperes.

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

![Illustration of bus bars]

a. ________  b. ________

3. Sentron plug-in busway is available in ________, ________, ________, and ________ lengths.

4. Sentron plug-in outlets are located on ________ centers.

5. Sentron feeder busway sections are available in the same lengths as plug-in busway and in 0.125 inch increments from ________ to ________.
Busway System Components

This section describes the components that make up a busway system. Unless otherwise noted, Siemens Sentron busway is described. For more information on any Sentron busway component, consult the Sentron Busway System Selection and Application Guide.

Although the components used in various busway systems perform the same or similar functions, they can’t be interchanged from one busway system to another. Systems are tested and rated as a complete unit. Ratings and system integrity could not be guaranteed if components were 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, while Siemens BD busway is bolted together.
Joint Stack

The Siemens Sentron busway system uses a single-bolt joint stack to connect two busway sections.

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

**Elbows** enable turns and height changes in the busway system. An elbow can turn the busway system right or left, up or down. Elbows are supplied with a joint stack and covers. Elbows may be ordered as stacks or sections. **Elbow stacks** are joint stacks that are angled “edge wise” (for up or down changes) or “flat wise” (for left or right changes).

Combination Elbows

**Combination elbows** can route the busway system up or down and right or left. They are available in a variety of configurations.
**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.

**Crosses**

A *cross* allows a busway run to extend in four directions.
Offsets

Offsets allow the busway system to shift left, right, up, or down while continuing in the same direction. Offsets are supplied with a joint stack. When space is tight, a single offset can be used instead of two connected elbows.

Right 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** are used to feed power to or take power from the busway run. They are installed along the length of a busway system.

![Center Cable Tap Box](image)

**Flanged Ends**

Sentron busway standard flanged ends are used to connect busway to other Siemens equipment, such as switchgear and switchboards. Sentron busway flanged ends can be shipped pre-installed in Siemens switchboards and switchgear. This eliminates the field labor required to connect the busway to the switchboard, saving time and money.
**Flanged ends** can be used with existing equipment. Siemens can furnish the outline drawings of a flanged end for use in equipment design or installation.

**Service Heads**

**Service heads** are used to connect the busway to the electrical service. Sentron busway can be supplied with a single service head that has all three phases or three separate heads, one for each phase.
**Riser Adaptors**

A *riser* is a length of vertical busway. Panelboards and meter centers can be mounted directly to risers with a **side-mounted adapter**. For vertical applications, Sentron plug-in busway can be ordered with the plug-in receptacles located only on one side. This is called **riser busway**. The phasing on vertical busway should be A,B,C,N from left to right on the predominant side of the busway. This ensures proper bus plug orientation.

**Phase Rotation**

Some applications require a phase rotation of power supply connections. For example, the direction of rotation of a three-phase AC motor is determined by the phase sequence of the power supply. **Phase rotation fittings** are available as **phase-and-ground**, **phase-only**, or **ground-only rotations**. Note: phase rotation fittings are difficult to manufacture and should be used only when an alternative approach is not practical.
Reducers

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

Article 368.17 of the NEC® requires overcurrent protection where busway in reduced in ampacity. However, there is an exception to this requirement for industrial applications where the smaller busway length is 15 m (50’) or less and its ampacity is at least one-third the rating of the higher current busway. It must also be free from contact with combustible material.

Sentron busway offers fused reducers to meet the overcurrent protection requirement of NEC® Article 368.17, and non-fused reducers for use when the exception is allowed. The following illustration shows a fused reducer.
**Expansion Fittings**

Expansion fittings accommodate expansion and contraction of a busway run due to building movement. A Sentron expansion fitting is configured with a sliding enclosure and flexible connectors that allow up to 2 inches of movement. Expansion fittings are typically installed in the middle of long busway runs, and at the beginning of certain riser runs.

One expansion section should be used for every 200’ of continuous busway run and for each building expansion joint. The busway run must be positioned accordingly to accommodate the expansion sections.

---

**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. Modifications are available to accommodate key interlocks, ground fault detectors, and power monitors.
**End Closers**

*End closers* are used to safely terminate a run of busway and protect the bus bar ends. They can be easily removed to extend a busway run.

**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 mount it on a wall.

Trapeze Hanger

Wall Mounted Hanger

Single-drop Rod Hanger

Structural Steel Hanger

**Flanges**

**Flanges** are used when the busway run passes through a roof, wall or ceiling. It is important to note that flanges do not support the busway; rather they provide a means of covering the hole through which the busway passes. Sealant, may be required to meet fire codes or other local requirements. Sealant, caulking, or gaskets are not provided with Sentron 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.
**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.

**Bus Plugs**

Sentron **bus plugs** are available with Siemens molded case circuit breakers (for 15 to 800 ampere trip ratings) or Siemens fusible switches (for 30, 60, 100, 200, 400, or 600 ampere fused ratings).
Sentron bus plugs are engineered to be easy to install and use. Installation is simplified by features, such as factory installed circuit breakers, compact footprint, generous wire bending space, and dual interlocks. User-oriented features include a visible position indicator and a spring loaded padlock latch which prevents access by unauthorized personnel.

Sentron bus plugs are designed with an interlock device to prevent the door from being opened when the disconnect is on. This also prevents the disconnect from being turned on while the door is open. The interlock ensures that the protective device is off prior to installation or removal of the bus plug.

Alignment and interlock stabs are engineered to prevent improper installation. Guide stabs prevent installing the bus plug 180 degrees out of rotation and provide support in vertical applications. The bus plug ground stabs are designed to ensure positive contact with both the integral and optional internal busway grounds before the bus plug fingers contact the phase and neutral bars. Sentron bus plugs also feature bolt-on mounting to the busway housing for secure attachment.
Identify the components in the following illustration:

A. Tee
B. Elbow
C. Feeder Busway
D. Plug-in Unit
E. Plug-in Busway
F. End Closer
G. Plug-in Outlet

1. ____________
2. ____________
3. ____________
4. ____________
5. ____________
6. ____________
7. ____________
Planning a Sentron Busway System

There are many factors to consider when planning a busway run. The most efficient route is the one that requires the fewest fittings and utilizes 10’ straight sections wherever possible.

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.

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 accurately displays the distance traveled by the beam.
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 at which 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, such as a pipe, wall, or door, which is common to both sides and measure from it.

---

**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 via plug-in outlets along the length of the room.
In this example, it was 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 the system meets both national and local regulatory requirements.

The *National Electrical Code®* allows busway to be installed in applications where it is exposed or where it is concealed. Concealed busway must be non-ventilated, totally enclosed, and joints between sections must be accessible for maintenance purposes. In addition, the space behind the access panels cannot be used for air handling, there can be no plug-in connections, and the conductors must be insulated.

The *NEC®* restricts the use of busway in conditions where it may be damaged or cause damage. For example:

- Where corrosive vapors are present
- In hoistways
- Outdoors or in hazardous or wet locations, unless approved for such use

For additional information, refer to *NEC®*. Article 368.

**Busway Support**

The *National Electrical Code®* requires adequate support for busway. Busway must be supported at intervals of 1.5 m (5') or less, unless it is specifically designed for fewer supports. The following drawing illustrates one type of support available for Siemens Sentron busway.

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

The NEC® 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’ through the floor. In addition, certain applications may require the use of a curb around busway passing through two or more dry floors. This is intended to reduce the possibility of spilled liquid running down the busway causing damage to the electrical system.

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 must have a minimum of 16” between the floor and a joint. This space is required for the floor supports.

Busway End Closer

The NEC® requires the dead end of a busway to be closed. The accompanying 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.

Component Selection

After all these factors have been considered, the components for the sample application described earlier can now be selected. 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 are used.
We now have the dimensions needed to assemble a bill of material for our example project.

<table>
<thead>
<tr>
<th>Qty</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Bus Plugs</td>
</tr>
<tr>
<td>1</td>
<td>0’8” Stub</td>
</tr>
<tr>
<td>1</td>
<td>4’0” Feeder</td>
</tr>
<tr>
<td>3</td>
<td>10’0” Feeder</td>
</tr>
<tr>
<td>1</td>
<td>4’10” Feeder</td>
</tr>
<tr>
<td>1</td>
<td>6’0” Feeder</td>
</tr>
<tr>
<td>3</td>
<td>Edge Elbow</td>
</tr>
<tr>
<td>3</td>
<td>10’0” Plug-In</td>
</tr>
<tr>
<td>1</td>
<td>End Closer</td>
</tr>
<tr>
<td>1</td>
<td>Floor Flange</td>
</tr>
<tr>
<td>2</td>
<td>Floor/Wall Flange</td>
</tr>
<tr>
<td>12</td>
<td>Hangers</td>
</tr>
</tbody>
</table>
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

Consult the Sentron Busway Quick Reference, Busway Order Check Entry List, and other relevant documents available on the busway technical information section of the Siemens Industry, Inc. web site for additional information.

Review 5

Complete the following statements consistent with National Electrical Code® requirements for busway installations.

1. Busway may be _______ or concealed.

2. Concealed busway must be _______, totally enclosed, and joints between sections must be accessible for maintenance.

3. Busway must be supported at intervals of _______ or less, unless it is specifically designed for fewer supports.

4. Busway may pass through _______, provided it complies with all the requirements for such applications.

5. A busway dead end must be _______.
Cable and Conduit Conversion

Busway can be used in many applications where cable and conduit are more commonly used.

Benefits of Busway

However, 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.

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 up to 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’ 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.

<table>
<thead>
<tr>
<th>Material</th>
<th>Material Cost</th>
<th>Installation Labor</th>
<th>Total Installed Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable/Conduit</td>
<td>$73,977</td>
<td>$16,925 (455 hrs. @ $37.15/hr)</td>
<td>$90,902.24</td>
</tr>
<tr>
<td>Sentron Busway</td>
<td>$73,212</td>
<td>$4,996 (134 hrs. @ $37.15/hr)</td>
<td>$78,208.89</td>
</tr>
</tbody>
</table>

**Savings with Sentron** $12,693
XJ-L Busway

Siemens XJ-L Busway offers a lower cost solution, compared to cable and conduit, sandwich-style busway or even light duty track busway. Snap together installation requires no special tools and is fast, easy, and maintenance free. XJ-L Busway is well-known for its outstanding performance, providing flexible modular power distribution in high tech environments, schools, laboratories, and hospitals.

Ratings and Dimensions

Continuous current: 100, 225, or 400 A
Voltage: 600 VAC max.
Bus bar material: Copper
Configurations: three-phase, three-wire or three-phase, four-wire
Neutral: 100% or 200%
Ground: Standard Housing (Hsg), Internal (G), or Isolated (IG)

Straight sections are available in 2’ (0.616 m), 5’ (1.524 m), or 10’ (3.048 m) standard plug-in lengths. XJ-L Busway offers layout flexibility to meet custom requirements. XJ-L offers twelve plug-in outlets, six per side on 10 foot sections. For convenience, the openings are located in alternate positions from side to side and are all usable simultaneously.
**Installation**

Installation is fast and easy. Joint connections simply snap together without special tools, housing couplers, or bus connector. 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.

![Installation Image]

XJ-L busway is suitable for horizontal and vertical mounting and under-the-floor applications. A wide variety of straight lengths, elbows, tees, crosses, and tap boxes that can be installed and then readily expanded or reconfigured to meet changing requirements. Custom fittings and straight lengths can be engineered to tailor the busway system to application-specific customer requirements.

**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

XJ-L Bus plugs are available with fusible or circuit breaker disconnects, configured with a wide variety of optional receptacles, branch circuit breakers, drop cords, power monitoring, indicator lights, etc. 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.

XJ-L Bus plugs are readily installed on energized busway and are fully interchangeable between 100 A, 225 A, and 400 A configurations.
Siemens 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 on 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).
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, has one bar per phase. A section of 1000 ampere aluminum busway has two bus bars per phase. The following busway table provides ampere ratings and dimensions for BD busway.

<table>
<thead>
<tr>
<th>Ampere Rating</th>
<th>Width (W)</th>
<th>Fig #</th>
<th>Ampere Rating</th>
<th>Width (W)</th>
<th>Fig #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td></td>
<td></td>
<td>Copper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>225</td>
<td>4 1/16” (103 mm)</td>
<td>1</td>
<td>225</td>
<td>4 1/16” (103 mm)</td>
<td>1</td>
</tr>
<tr>
<td>400</td>
<td>4 1/16” (103 mm)</td>
<td>1</td>
<td>400</td>
<td>4 1/16” (103 mm)</td>
<td>1</td>
</tr>
<tr>
<td>600</td>
<td>6 1/16” (154 mm)</td>
<td>1</td>
<td>600</td>
<td>6 1/16” (154 mm)</td>
<td>1</td>
</tr>
<tr>
<td>800</td>
<td>6 1/16” (154 mm)</td>
<td>1</td>
<td>800</td>
<td>8 1/8” (206 mm)</td>
<td>1</td>
</tr>
<tr>
<td>1000</td>
<td>12 1/8” (308 mm)</td>
<td>2</td>
<td>1000</td>
<td>12 1/8” (308 mm)</td>
<td>2</td>
</tr>
<tr>
<td>1200</td>
<td>12 1/8” (308 mm)</td>
<td>2</td>
<td>1200</td>
<td>12 1/8” (308 mm)</td>
<td>2</td>
</tr>
</tbody>
</table>

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)
XL-U Busway

XL-U busway is designed for grueling duty cycles required by applications such as heavy-duty welding. 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 busway is available for three-phase, three-wire and three-phase, four-wire applications.

Paired Phases

XL-U is available with a paired-phase bus bar scheme. Bus bars are grouped in pairs so that the alternating current in each pair is nearly equal in magnitude and opposite in direction. Two bus bars per phase are used. The phases are paired as shown in the following illustration. The result is a minimized magnetic field. Current is balanced, temperature rise is kept to a minimum, and the voltage drop is reduced. XL-U busway can be used on any application within its ratings 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 10’ (3048 mm) to 14” (356 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.

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 depend on the maximum current rating. XL-U busway can be mounted vertically or horizontally, either edgewise or flat wise. 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.

![Busway Diagram](image)

<table>
<thead>
<tr>
<th>W</th>
<th>Bus Bars</th>
<th>Copper Ampere Rating</th>
<th>Aluminum Ampere Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Conductors</td>
<td>Vent. Bars on Edge</td>
<td>Vent. Bars Flat</td>
</tr>
<tr>
<td></td>
<td>Per Ø</td>
<td>N</td>
<td>G</td>
</tr>
<tr>
<td>4.5&quot; (114 mm)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4.5&quot; (114 mm)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4.5&quot; (114 mm)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

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.

![Diagram of XL-U busway with two bars per phase]

<table>
<thead>
<tr>
<th>W</th>
<th>Bus Bars</th>
<th>Copper Ampere Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Conductors</td>
<td>Vent. Bars on Edge</td>
</tr>
<tr>
<td></td>
<td>Per Ø</td>
<td>N</td>
</tr>
<tr>
<td>4.5&quot; (114 mm)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4.5&quot; (114 mm)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4.5&quot; (114 mm)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5.5&quot; (140 mm)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5.5&quot; (140 mm)</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aluminum Ampere Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
</tr>
<tr>
<td>4.5&quot; (114 mm)</td>
</tr>
<tr>
<td>4.5&quot; (114 mm)</td>
</tr>
<tr>
<td>5.5&quot; (140 mm)</td>
</tr>
<tr>
<td>5.5&quot; (140 mm)</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>W</th>
<th>Bus Bars</th>
<th>Copper Ampere Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Conductors</td>
<td>Vent. Bars on Edge</td>
</tr>
<tr>
<td></td>
<td>Per Ø</td>
<td>N</td>
</tr>
<tr>
<td>7.5&quot; (191 mm)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>7.5&quot; (191 mm)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>9.5&quot; (241 mm)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>9.5&quot; (241 mm)</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

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)
1. XJ-L busway is available with continuous current ratings of ________, ________, or ________.

2. The ________ bus plug with fusible or circuit breaker disconnects is used with XJ-L busway.

3. ________ busway was first introduced in 1932, but older systems can still be expanded with today’s components.

4. Feeder and plug-in XL-U busway is available with continuous current ratings from ________ to ________.

5. XL-U busway incorporates a ________ bus bar scheme that minimizes the resultant magnetic field.
Review Answers

**Review 1**
1) distribution system; 2) feeder; 3) Busway; 4) busway: 5) feeder, plug-in; 6) feeder, Plug-in.

**Review 2**
1) UL, NEMA, IEC, NFPA; 2) 368; 3) ampacity; 4) Overcurrent 5) ampere.

**Review 3**
1) 4,000, 5,000; 2) a. feeder, b. plug-in; 3) 4', 6', 8', 10'; 4) 2'; 5) 1' 4.5", 10"

**Review 4**
1) C; 2) E; 3) A; 4) B; 5) D; 6) G; 7) F.

**Review 5**
1) exposed; 2) non-ventilated; 3) 1.5 m (5'); 4) floors and walls; 5) closed.

**Review 6**
1) 100 A, 225 A, 400 A; 2) XQ-R; 3) BD; 4) 225 A, 5000 A; 5) paired-phase
Final Exam

You can test your knowledge by taking the final exam for this course online at http://www.usa.siemens.com/step. This web page provides links to a variety of our quickSTEP online courses. To complete the final exam for this course, click on the Basics of Busway link.

Next, move your mouse over to the left so that the navigation bar pops out, and select the Final Exam link. The final exam page will appear. Before taking the final exam, it is recommended that you delete the temporary files on your computer. For most versions of Internet Explorer, you can do this by selecting Internet Options from the Tools menu and then clicking on the Delete Files button. If you do not perform this step, you may see a score of 0% after you submit your exam for grading.

After you complete the final exam, click on the Grade the Exam button at the bottom of the page. Your score on the exam will be displayed along with the questions that you missed.

If you score 70% or better on the exam, you will be given two options for displaying and printing a certificate of completion. The Print Certificate option allows you to display and print the certificate without saving your score in our database and the Save Score option allows you to save your score and display and print your certificate.