Installation manual
Effective February 2025

B-LINE SERIES

Cable bus installation manual

Powering Business Worldwide

⚠ WARNING

BEFORE CARRYING OUT ANY WORK ON THE CABLE BUS, SWITCH OFF THE POWER SUPPLY TO THE CABLE BUS AND USE VOLTAGE DETECTION DEVICE TO CONFIRM ABSENCE OF VOLTAGE. FAILURE TO DO SO MAY RESULT IN INJURY OR DEATH FROM ELECTRIC SHOCK.

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- Follow all information that is found on safety labels on the product and packaging.
- Familiarize yourself with the various console components described within this manual.
- The use of personal protective equipment such as safety glasses, work gloves and steel toed shoes are required during the unpacking and set-up of the console.
- Read, understand and follow the guidelines and limitations herein for loading your console.
- Familiarize yourself with the warning symbols that appear throughout this manual.

⚠ DANGER

DANGER INDICATES A HAZARDOUS SITUTATION WHICH, IF NOT AVOIDED, WILL RESULT IN DEATH OR SERIOUS INJURY.

⚠ WARNING

WARNING INDICATES A HAZARDOUS SITUTATION WHICH, IF NOT AVOIDED, COULD RESULT IN DEATH OR SERIOUS INJURY.

⚠ CAUTION

CAUTION INDICATES A HAZARDOUS SITUTATION WHICH, IF NOT AVOIDED, COULD RESULT IN MINOR OR MODERATE INJURY.

NOTICE

NOTICE IS USED TO ADDRESS PRACTICES NOT RELATED TO PHYSICAL INJURY. NOTICE POINTS OUT SOMETHING OF SPECIAL INTEREST TO THE READER IN DIRECT CONTEXT OR RELATIONSHIP TO THE IMMEDIATE TOPIC OR STEP BEING PERFORMED.

Contents

1. Introduction

This manual and the drawings furnished with the cable bus must be studied before beginning the installation process. Because cable bus is highly variable equipment, custom designed for the particular application, neither these instructions nor the drawings are complete without reference to one another. Recommended procedure for putting into service should strictly be followed.

This manual contains:

1. General cable bus description
2. Safety rules
3. Installation instructions
4. Maintenance instructions

2. General cable bus description

The cable bus supplied has been designed and fabricated to meet the specific job requirements. For a complete installation all of the necessary parts are packaged and marked for easy installation.

The cable bus enclosure is typically made from non-coated, high strength aluminum alloy consisting of two side rails and factory-installed, ventilated top and bottom covers for indoor and outdoor installation, unless otherwise specified. The top cover is held in place with a minimal number of screws for handling prior to installation and needs to be removed in order for cable to be installed.

Cables are supported in the bus housing with custom molded glass reinforced polyester blocks or specially designed non-toxic, treated maple blocks. All support blocks have been sized to accept the particular cable for the specific installation. The support blocks have been designed to provide the proper cable spacing and phase balance to meet the system specification.

3. Safety

⚠ DANGER

HAZARD OF ELECTRICAL SHOCK OR BURN. INSTALLING, OPERATING, OR MAINTAINING THE EQUIPMENT OUTSIDE OF ITS RATINGS OR IN VIOLATION OF SAFETY CODES, STANDARDS, AND REGULATIONS MAY CAUSE FAILURE RESULTING IN PROPERTY DAMAGE, SEVERE PERSONAL INJURY, OR DEATH.

THE CABLE BUS DESCRIBED IN THIS MANUAL, WHEN IN SERVICE, WILL BE ENERGIZED BY VOLTAGES THAT MAY CAUSE SEVERE INJURY OR DEATH IF CONTACTED.

To ensure the safety of personnel associated with the installation, operation, and maintenance of cable bus, the following rules must be followed:

1. Only qualified personnel trained in the installation, operation, and maintenance of electrical power equipment should be allowed to work on this cable bus.
2. Work on an energized cable bus must never be performed.
3. Climbing, walking, or sitting on the cable bus is not allowed.
4. The cable bus should never be used for support of other equipment.
5. For the safety of personnel performing maintenance operations on the cable bus or on connected equipment, all components must be disconnected by means of a visible break and securely grounded.

4. Assembly drawings

A set of specific, detailed assembly drawings is provided for each bus system. An understanding of the organization of these drawings is the key to ensuring a fast, trouble-free installation. The bus assembly drawings with the bills of material (BOM) are the primary drawings that reference and coordinate all the other drawings and procedures.

The typical drawing package provided will consist of the following:

4.1 Master layout

This drawing depicts an overview of the entire project showing the routing of all of the individual bus runs being supplied, along with dimensional relationships to existing equipment, buildings, column lines, etc. Based on the scope of the project, the master layout drawing will indicate actual type and locations of structural steel supports or just show the recommended support locations.

The master layout BOM will identify the individual bus runs and structural steel support assemblies.

4.2 Project specification

This drawing depicts all aspects of the project in a concise, one-page overview based on the cable bus cross-section showing the specific requirements of the project including cable bus nominal dimensions, phase arrangement, electrical properties, site criteria, material type, hardware type, insulation, etc.

4.3 Individual bus run layout

These drawings will point out all details relative to that particular run of bus, showing the location of each bus section and all other required parts and supplies to completely install this run of bus including, but not limited to the following: fire barriers, wall plates, section tag numbers, shipping splice numbers, and cable interleave start/stop locations.

The BOM on this drawing will identify all cable bus sections, various project-specific ship-loose kits (duct connection kits, fire stop kits, wall plate kits, solar shield kits, etc.), and specify the number of “cable pulls” required (along with the recommended length of the cable per pull).

4.4 Termination drawings

These drawings will show the cable bus connection details to the termination equipment (i.e., switchgear, transformer, etc.) along with all requirements for insulating the connection.

The termination drawing BOM will list all components required to complete the termination, such as cable lugs, insulating tape, copper mesh, cable termination kits (heat or cold shrink), copper adapter bars, connection hardware, etc.

4.5 Miscellaneous drawings

In addition to the aforementioned drawings, additional “kit” drawings will be included to depict a more precise, detailed graphic representation of various stages of cable bus installation, such as fire-stop kits (showing how to complete the fire barrier), duct connection kits (showing how the bus sections are connected together), wall plate kits (showing how to install the wall plate components), solar shield kits (showing how to attach the solar shield to the top cover), etc.

Included on all kit drawings will be a BOM listing all required parts to successfully complete the installation.

4.6 Structural support drawings and analysis

If the cable bus steel support is within the scope of Eaton’s B-Line

series cable bus, a set of steel support assembly drawings will be provided, along with the structural analysis showing the foundation reaction loads. These drawings will show all details about the steel support structure and will provide a guide through all steps of the installation process.

The BOM on these drawings will identify the support structures, list all connection hardware, and specify the number of hold-down clips required to connect the cable bus to the support structure.

5. Receiving, unpacking, storage & handling

5.1 Receiving

Upon delivery, a complete visual inspection must be performed for any signs of possible shipping damage.

Any such indications must be noted on the shipping papers when accepting delivery. The equipment should be inspected for concealed shipping damage as soon as practicable. If any indication of damage is found, the carrier inspection should be arranged immediately. Damaged equipment must remain in its crate as received until the carrier's inspection is completed. Photographs must be taken to support the claim. Eaton's B-Line Division must be contacted immediately so that corrective action can be initiated. If the terms of the shipment are FOB plant, it is the buyer's responsibility to file a claim with the carrier. If the terms are FOB destination, then Eaton's B-Line Division will file a claim with the carrier. In all cases, it is the buyer's responsibility to follow proper receiving procedures. Incoming materials should be carefully checked against the shipping manifest to verify that no shipping losses have occurred, and against the bills of material to verify that all items have been received. Shortages of materials must be reported to the carrier and Eaton's B-Line Division within 30 days of receipt. Claims for shortages after this period will be chargeable.

5.2 Unpacking

Unpacking must be done in accordance with these guidelines:

1. All sections of the cable bus must be carefully unpacked. To avoid damage to the cable bus, band cutters must be used on all bands securing the packages, and nail pullers must be used for unpacking wooden crates.
2. Any temporary support blocks or other fasteners which may have been used for shipping purposes only must be carefully removed.
3. If the cable bus is not going to be completely installed immediately, all packing and wrapping materials should be saved for reuse later while the cable bus is in storage.
4. All tags and markings should not be removed until after cable bus has been installed.

5.3 Storage

Bus systems as shipped must be protected from bad weather conditions at all times. Failure to store and protect bus components properly can cause serious damage and WILL VOID THE WARRANTY.

For storage periods of 90 days or less, the bus may be stored in outdoor areas that are marked and designated for storage. This area must be well drained, gravel covered or paved, and reasonably remote from construction areas and traffic. Items should be placed on pallets or shoring to allow for air circulation and to avoid trapping water. A weatherproof covering should be applied in such a manner that it protects the equipment yet allows for air circulation to minimize condensation. The equipment must be inspected and corrective action taken as required.

For storage periods longer than 90 days, the bus must be stored in a clean dry space having a moderate, uniform temperature, in the range of 40° - 100° F. Preferably, cable bus sections should be placed in a heated building having adequate air circulation, and protected from dirt, fumes, water and physical damage.

Special precautions must be followed for handling and storage of the cable.

THE CABLE MANUFACTURER STORAGE INSTRUCTIONS MUST BE STRICTLY FOLLOWED.

Some basic cable storage requirements are:

1. The weight of the reel and cable must be carried at all times by the reel flanges. Cable reels should be stored on a flat, hard surface to prevent flanges from settling into soft ground.
2. Cable reels must remain in the upright position and not be stacked.
3. Whenever possible, the factory applied lagging (protective cover) should be left in place. Additional covering such as masonite or a dark film wrap may be used to block the sunlight.
4. Cable ends are sealed prior to shipment. If the factory seals are removed or damaged, new tape seals must be applied to prevent moisture entry into the cable.

5.4 Handling

To help avoid personal injury and equipment damage during handling, and to facilitate moving the cable bus sections, fittings and cable reels at the job site, these guidelines must be followed:

1. To avoid personal injury, cable sections should not be lifted, carried or moved by hand. Appropriate mechanical means (shown on Figure 1) capable of safety handling the cable bus sections must be used.
2. Bus ends must not be used for lifting cable bus sections or fittings. Only lift the cable bus enclosure using support means, such as slings or lift truck forks which extends under the full width of the enclosure as shown on Figure 1.
3. If a fork or similar hoist is used, the cable bus enclosure must be properly positioned and secured on the forks to distribute its weight, as shown on Figure 1.
4. Platform dollies may be used to move cable bus on one floor level if there is little or no incline; however, the load must be balanced carefully and secured to the dolly.
5. If a crane is used to install cable bus, nylon straps must be used, and weight of each lift must be balanced and evenly distributed. If cables are used, spreaders must be used to avoid damage to the metal housing. Lifting straps and cables must have sufficient strength to hold the load of the section to be lifted.
6. Cable bus should be handled with care to avoid damage to internal components, the enclosure with its finish or any protruding objects such as flanges. Twisting, denting, impacting or otherwise handling the cable bus in a way which may damage it must be avoided at all times.
7. Cable bus sections must never be dragged across the floor or the ground.
8. Shipping crates should never be stacked on top of each other.
9. All flanges and other protruding objects must be protected when setting cable bus sections on the ground or on a floor.
10. Although top covers should be removed in order to install the cable, cable bus sections may not be moved or transported with top covers removed.
11. Cable reels must never be shipped or moved upended (flat side down).
12. Under no circumstances should reels be dropped from any height.

13. Reel handling must be accomplished so that equipment used is contacting both flanges of the reel and is not contacting the cable surface (protective wrap if used) at all times, as shown on **Figure 1**.
14. Cable reels can be rolled only in the direction indicated by arrows painted on reel flanges and over firm surfaces clear of debris, protruding stones, humps, etc.

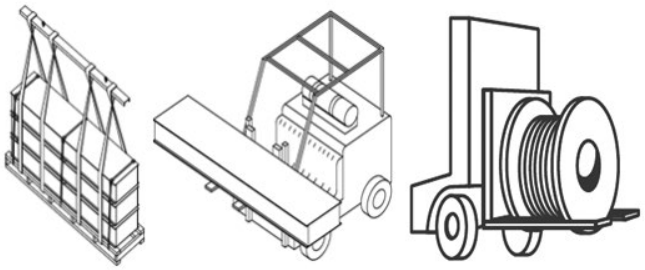

Figure 1. Proper handling cable sections & reels

6. Installation

6.1 Alignment

Before installing a run of cable bus, the location of the apparatus to be connected by the cable bus should be carefully checked. The relative location of the two ends of the cable bus run and all walls penetrated by the cable bus must be as shown on the layout drawings for the cable bus to fit properly.

6.2 Installation checklist

⚠ WARNING

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This checklist has all the steps necessary for installation of the cable bus. Additional details for many of these steps are given in the subsequent sections, which should be reviewed before proceeding with the installation.

1. The cable bus should be laid out on the ground, if possible, and checked along with the ship-loose kits (duct connection kits, fire stop kits, wall plate kits, solar shield kits, termination kits, etc.) against the bills of material and the shipping documents. Eaton's B-Line Division should be notified of any discrepancies.
2. All top access covers must be removed from the cable bus. These covers must be identified and stored carefully, since they may not be interchangeable, and may need to be reinstalled in their original position.
3. The installation starts at one termination point, and proceeds forward, attaching and adjusting all cable bus sections one to another using the provided duct connection kits, leveling and plumbing the duct, as necessary.

   All side rails should be LOOSELY BOLTED together using the splice plates, all bottom covers should be connected together with the joiner strips and the cable bus sections should be attached to the support structure with the hold down clips (shown in Section 6.5). Temporary support may be needed during this process.
4. When the entire run of bus is installed and connected to the termination equipment all bolting connections must be tightened according to the torque values stated in **Table 2**.
5. Next, the lower row of cable support blocks and seal plates must be attached to the factory installed support brackets and seal frames. More details are given in **Section 6.6**.
6. The first row of cables must be pulled into the housing and laid onto the installed bottom support blocks and seal plates as outlined in Section 6.6. All remaining rows of support blocks, seal plates and cable pulls must be installed layer by layer in the same manner as the first row.
7. All cable ends must be prepared and insulated following the instructions for:
   a. cable interleaving (explained in **Section 6.8**)
   b. cable lug installation (shown in **Section 6.9**)
   c. insulation of cable ends with heat shrink, cold applied or tape termination kits (**Section 6.9**)
8. Grounding of the enclosure, ground wires and all cable shields must be done next (**Section 6.9 & 13**).
9. All vapor and fire barrier assemblies must be completed as explained in **Section 6.10 & 11**.
10. All removed covers must be reinstalled matching the cover with the section from which it was removed as explained in Section 6.12. All TEK screws must be tightened according to the torque values stated in Table 2.
11. Acceptance tests for cable continuity, correct phasing and cable reliability must be completed next as explained in Section 6.1 of the next chapter.
12. All cables can be connected to the terminating equipment. Cable bus is ready for energizing when overall phase insulation is completed as shown in **Section 6.9**.

6.3 Part identification

Each section of the bus is uniquely identified on the individual bus run layout drawing by a section tag number and shipping splice numbers. This identification is also marked on each bus section. Identifying and locating the sections on the corresponding assembly drawings will assist in determining the sequence of installation of the bus equipment.

6.4 Structural support installation

Cable buss are not self-supporting and must be properly supported for trouble-free service. Extra supports are used at all corners. Eaton's B-Line Division provides details for the support locations shown on the master layout drawing. Installation of

the steel support structures must be done per the instructions from the master layout drawing and the support steel assembly drawings in order to support the bus correctly.

All steel support structures need their foundations completed prior to the installation and must be positioned and installed with elevations as stated on the master layout drawing before continuing with the cable bus installation process.

6.5 Cable bus enclosure installation

It is recommended that erection of the duct housing begin at one termination and proceed forward. The termination section bus end flange should be loosely bolted to the appropriate terminating equipment. Each section must be properly supported during assembly and attached to the next section by installing the bottom cover joiner strip and FINGER TIGHTENING the bolts on the splice plates as shown on **Figure 2 & Figure 3**.

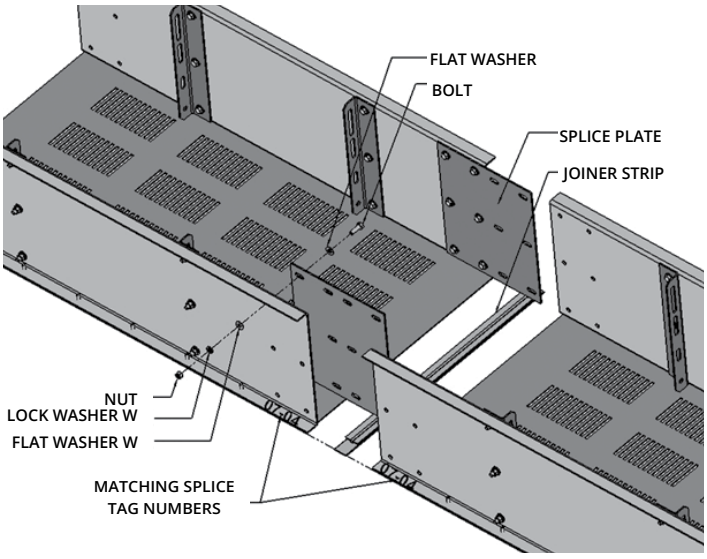

Figure 2. Joiner strip and splice plate assembly

Joiner strips are not secured to side rails. These strips are held in place by the cover penetrating the grooves.

Wall penetration sections containing fire barriers must be positioned so that the barrier is within the thickness of the wall through which it passes and may be held in place with temporary support. Wall plate installation should not be completed at this time.

In the specific situation when bus end vapor barriers (explained in **Section 6.10**) are positioned away from the termination equipment, that portion of the bus needs to be totally enclosed with solid covers. **Figure 3** shows the different hardware configuration (seal washer) for a splice in the totally enclosed area.

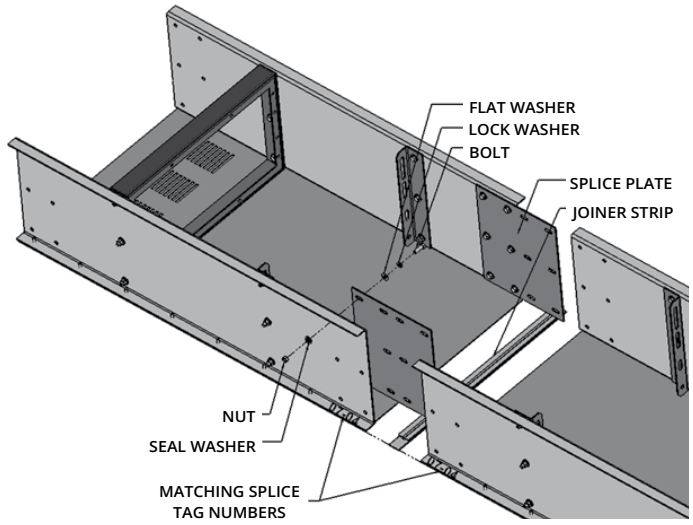

Figure 3. Joiner strip & splice plate assembly in totally enclosed portion of the bus

When the cable bus housing is in position, it is secured to the supporting steel structure with hold down clips (**Shown on Figure 4 and Figure 5**) and the support steel hardware is tightened according to **Table 1**.

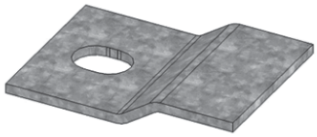

Figure 4. Hold down clip

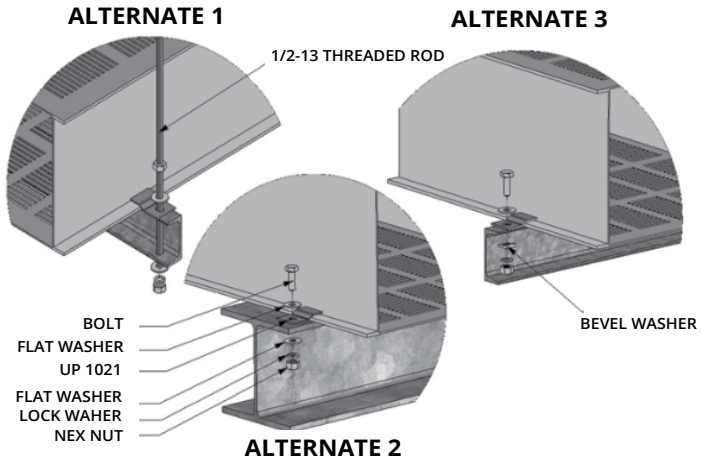

Figure 5. Hold down clip mounting detail alternatives

Table 1. Maximum steel support hardware torque values

	1/2-13 Hex head bolt		5/8-11 Hex head bolt		3/4-10 Hex head bolt		7/8-9 Hex head bolt		1-8 Hex head bolt	
	Ft-Lbs	N-m	Ft-Lbs	N-m	Ft-Lbs	N-m	Ft-Lbs	N-m	Ft-Lbs	N-m
A325 GALVANIZED STEEL **LUBRICATED**	52	70.5	82	111.2	122	165.4	169	229.1	222	301
A325 GALVANIZED STEEL **UN-LUBRICATED**	104	141	165	223.7	245	332.2	339	459.6	444	602

THE ENTIRE RUN OF CABLE BUS SHOULD BE INSTALLED AND ADJUSTED AT ALL TERMINATING EQUIPMENT BEFORE FINAL TORQUING OF CONNECTING BOLTS.

Any adjustments to obtain proper alignment must be distributed evenly throughout the bus system. If necessary, a small amount of additional adjustment can be obtained by using the mounting slots provided in splice plates and bus end flanges to adjust the position of those accessories.

Once the cable bus routing is completed, all bus end flanges securely connected to the terminating equipment and the cable bus completely secured to the steel support structures, all connecting hardware must be tightened according to **Table 2**.

Table 2. Maximum hardware torque values

	Maximum hardware torque values															
	#10 Hex head screw		#12 Hex head tek screw		#12 Sheet metal screw		1/4-20 Hex head screw		5/16-18 Hex head bolt		3/8-16 Hex head bolt		1/2-13 Hex head bolt		5/8-11 Hex head bolt	
	In-Lbs	N-m	In-Lbs	N-m	In-Lbs	N-m	In-Lbs	N-m	Ft-Lbs	N-m	Ft-Lbs	N-m	Ft-Lbs	N-m	Ft-Lbs	N-m
ZINC PLATED STEEL	36	4.1	N/A	N/A	N/A	N/A	75	8.4	13	17.6	23	31.2	55	74.6	110	149
18-8 STNLS STEEL	36	4.1	N/A	N/A	N/A	N/A	75	8.4	11	14.9	19.7	26.7	43	58.3	92.5	125
316 STNLS STEEL	36	4.1	N/A	N/A	36	4.1	79	8.9	11.5	15.6	20.6	27.9	45.2	61.3	96.7	131
410 STNLS STEEL	N/A	N/A	36	4.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SILICON BRONZE	36	4.1	N/A	N/A	N/A	N/A	68	7.7	10.3	14	18.3	24.8	40	54.2	85.8	116

6.6 Cable loading

After completing the cable bus enclosure installation and tightening all connecting hardware according to Table 2 above, the lower row of cable support blocks and seal plates must be installed and attached to the factory installed support brackets and seal frames as shown on **Figure 6 & Figure 7**.

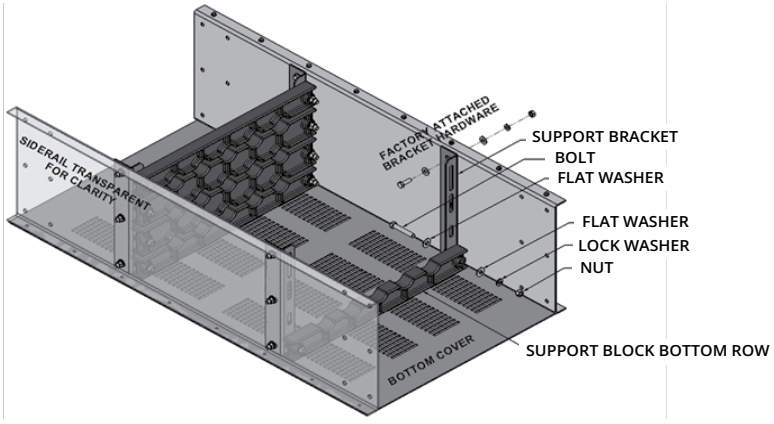

Figure 6. Support block assembly

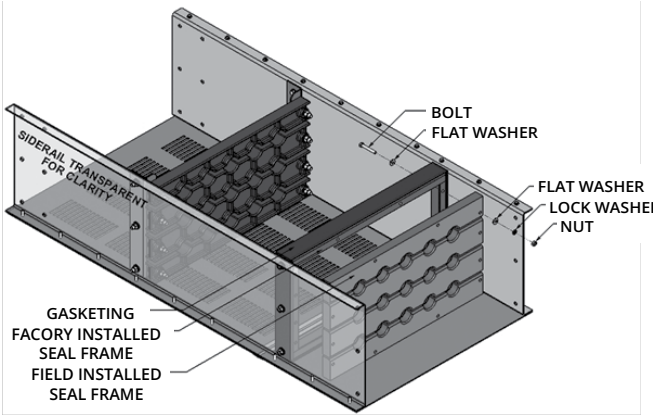

Figure 7. Seal plate assembly

Eaton's B-Line Division provides the hardware for fastening the support blocks and seal plates to the brackets and seal frames. These bolts should be tightened according to maximum hardware torque values in **Table 2**. Upon completion of this, the lower row of cables can be pulled into the housing and laid into the bottom blocks.

Prior to cable pulling operations, the proper pulling tools must be selected and installed along the bus run. Care must be given to the run lengths, number of cable turns and cable sheave size to ensure the maximum pulling tension, minimum bending radius, and maximum allowable sidewall pressure are not exceeded, subjecting the cable to possible damage. Cable damaged during installation can cause service failures. Mechanical stresses during installation are generally more severe than those encountered while in service, so installing the cable according to this manual and the cable manufacturer's recommendations is necessary. Cable manufacturer's instructions must be followed.

To avoid abrasion and damage of the cable when guiding the cable from the reel to the duct, all guides must be in the form of large diameter, smooth surfaced, free turning sheaves or rollers **(Figure 8)**.

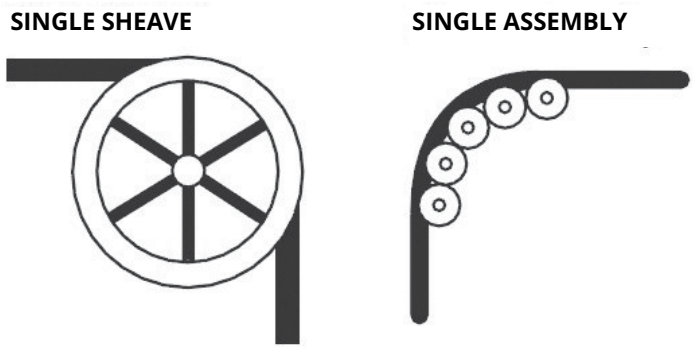

Figure 8. Cable sheaves (rollers)

Rollers must be installed along the cable bus and properly spaced to prevent the cable from touching the enclosure. The most economical spacing of the rollers depends on the weight of the cable to be pulled and must be carefully calculated based on cable manufacturer's instructions. It is essential that a sufficient number of rollers/sheaves are used at all elbows that form a sheave assembly, to guide the cable in a smooth curve of the desired bending radius from tangent point to tangent point **(Figure 8)**. Otherwise, the cable will be "kinked" around the radius of each roller.

For short runs, pulling by hand may be satisfactory, and the short length conductors can be simply laid in place.

Woven wire pulling grips or "basket grips" are often used for pulling small diameter cables or where the bus runs are relatively short and straight-forward with a low number of bends. If basket grips are used, sufficient slack must be pulled to remove at least one foot of cable beyond the inside end of the grip.

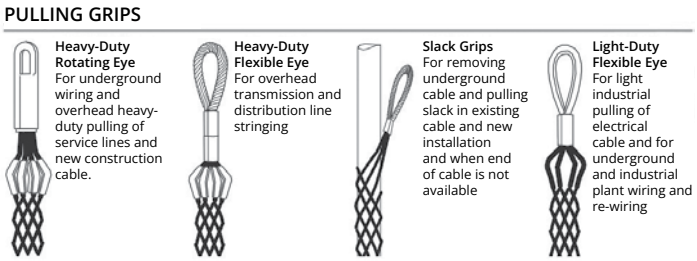

Figure 9. Basket pulling grips

Large diameter heavy cables, or cables for pulls that are particularly long or contain numerous bends, are best installed by means of a pulling eye attached directly to the leading end of the cable on the reel. These devices usually consist of a long barrel aluminum ferrule which is compressed onto the exposed conductor. A temporary seal should be made over the exposed conductor to prevent water entering the cable during the pull.

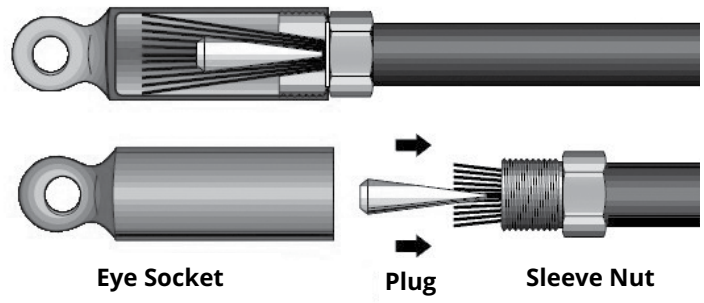

Figure 10. Pulling eye

Cable should be pulled at constant velocity, not to exceed 50 ft/min and not to be less than 15 ft/min.

In the termination areas cable interleaving instructions must be followed as outlined in Section 6.8. It is suggested that each cable be tagged or marked as installed in some manner, identifying each cable at both ends **(such as A1, C1, B2 or blue, red, yellow – as shown on Figure 13 & Figure 14)**.

The cable has been supplied on reels, which contain sufficient lengths to avoid cable splicing within the bus runs.

During the entire process of installation, particular attention must be given to safeguard cable integrity (conductor, insulation and shielding). Eaton cannot be held responsible for any failure of the system due to damage which has occurred to the cables from the time of receiving to the time of completion (energizing).

When the first row of cables is completed, the next set of support blocks should be installed. The blocks should be pressed together by hand and secured with the side mounting bolts to the side aluminum support brackets or seal frames as shown on Figure 6 & Figure 7. These steps should be repeated for all layers of cable.

After laying the upper row of cables, the top cable support blocks should also be installed in the same manner. All bolts should be tightened with max torque values given in Table 2. Excessive clamping forces must be avoided to prevent pinching & damage to the cable insulation.

6.7 Cable Support Grips

Vertical drops in excess of 25 feet or more require the addition of flexible cable support grip assemblies (Kellems) to furnish additional support and keep the cables from slipping in the cable bus assembly. Kellems support grips are used to hold the weight of the cables as it hangs in a vertical position, and at the same time, absorb additional strain from flexure, vibration, expansion and contraction.

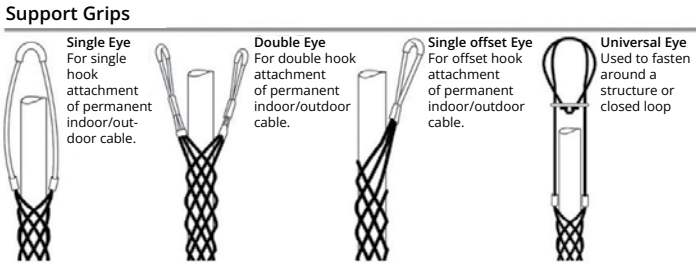

Figure 11. Kellems support grips.

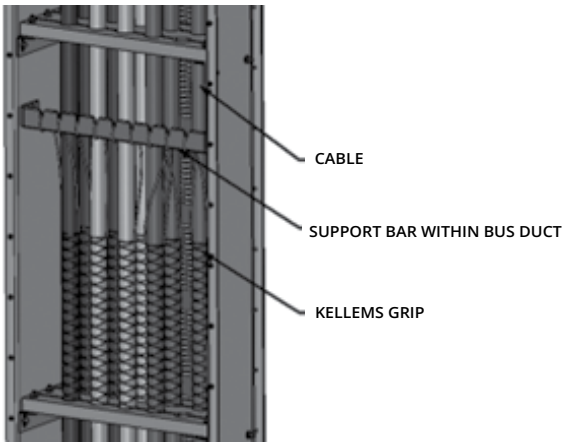

Figure 12. Kellems support assembly

Figure 13. If cable support grips are required, detailed support grips assembly drawings will be supplied for each installation. More details about the application of these devices will be given in the Kellems grip manufacturer's instructions.

6.8 Cable Interleaving

To optimize current loads within a cable bus system, Eaton utilizes a proprietary Inductive Reactance Calculation program to manage proper load balance between phases, as well as within each phase. This phase arrangement of cable interleaving is typically illustrated on the project specification drawing. Eaton recommends cable bus to be completely 100% interleaved if possible. This requires adequate space at both ends of the cable bus to properly interleave the cables without causing strain. Typically, this is accomplished within the termination enclosures at both ends of the cable bus.

However, if space is not available at one or both ends, the interleaving can occur within the first/last few support blocks. For each customer specific job, an interleaving drawing is provided, which illustrates the required steps to arrange the cables in order to achieve the desired phase arrangement. This interleaving drawing, used in conjunction with individual run layout drawings, provides the necessary instructions for field crews in their task of arranging cables. Sometimes the space needed to go from non-interleaved cable configuration to fully interleaved cable configuration and then to reverse back the positions may be greater than 50 feet.

NOTICE

PLEASE NOTE, THAT FOR SHORT CABLE BUS RUNS WITH REDUCED TERMINATION SPACE, EATON DOES NOT RECOMMEND INTERLEAVING. INSTEAD, DIRECT PHASE TO PHASE CONNECTION IS PERFORMED.

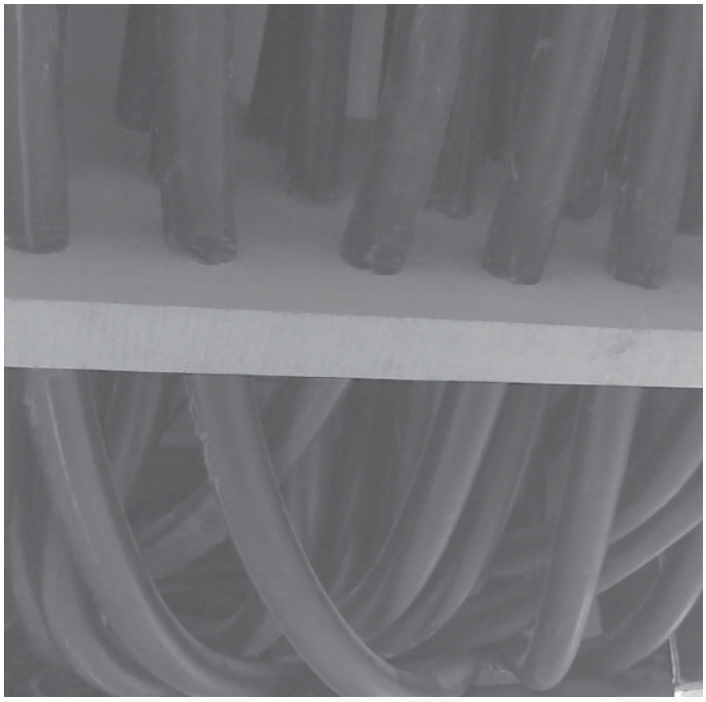

Figure 14.

⚠ CAUTION

THESE INSTRUCTIONS DO NOT PURPORT TO COVER ALL DETAILS OF VARIATIONS OF CABLE BUS, NOR PROVIDE FOR EVERY POSSIBLE CONTINGENCY OR HAZARD TO BE MET IN CONNECTION WITH INSTALLATION OF THIS EQUIPMENT.

IF FURTHER INFORMATION IS DESIRED OR SHOULD QUESTIONS ARISE THAT ARE NOT COVERED IN THIS GUIDE, PLEASE CONTACT US.

6.9 Cable Terminations

When all cables are pulled and securely supported into the enclosure, all cable ends should be prepared and insulated in strict compliance with the termination drawings provided by Eaton.

Long barrel compression connectors (cable lugs) are normally provided to assure the usage of a low resistance connection and must be installed on all cable ends at both sides. All connections between the cable lugs and the stripped cable ends must be insulated.

For low voltage non-shielded cables, general practice is to insulate the connection between the stripped cable and the cable lug with EPR and PVC tape only. Low voltage connection is shown on **Figure 14**.

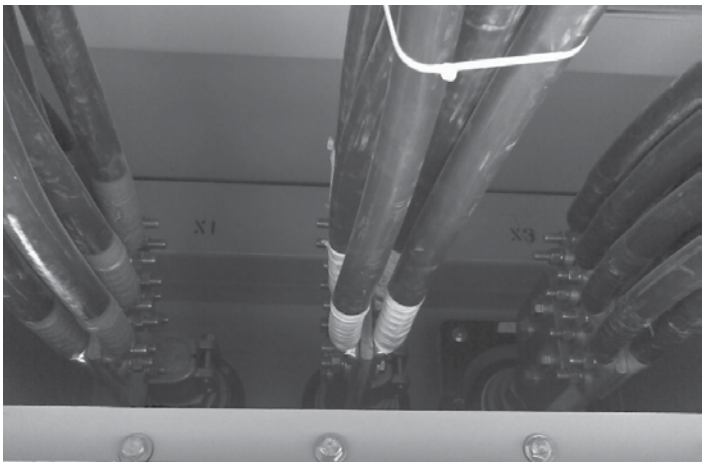

Figure 15. Non-shielded tape termination

For medium voltage shielded cables, Eaton recommends insulating the cable/lug connection with termination kits (heat or cold shrink). Every termination kit contains set of installation instructions, solder blocked ground braid, ground spring clamp, adhesive copper tape strips, sealant tape strips, stress control material and termination tube. In addition, cable preparation kit containing solvents for cleaning the cable will be provided by Eaton. The installation instructions included in the termination kit will show all detailed step by step instruction on how to strip the cables, install the ground braid to the tape shield, make lug connection, abrade the insulation and clean the cable, apply tape sealant and stress relief material, and finally install the termination tube. These instructions must be strictly followed.

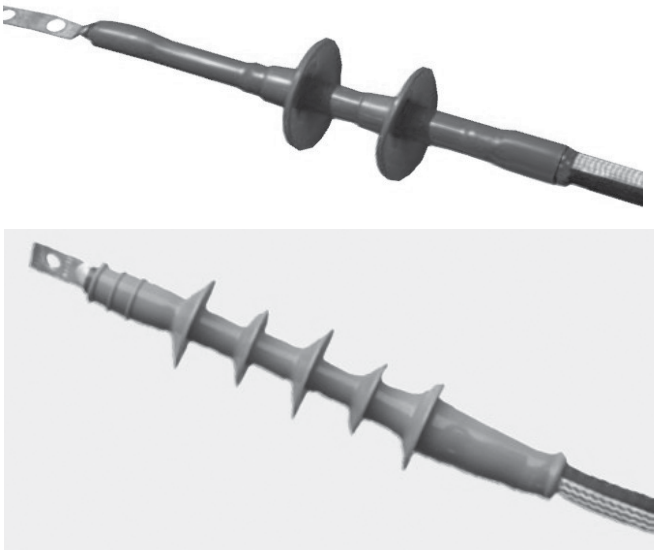

Figure 16. Termination kits (heat shrink & cold shrink)

All shielded cables must have their individual metallic shields solidly grounded on both ends. Termination kit instructions explain how to connect the ground braids to the cable shield. The termination drawing will show all details on how to bond the ground braid to the factory attached internal ground pads, provided for that purpose in the termination area using the provided ground lugs and hardware.

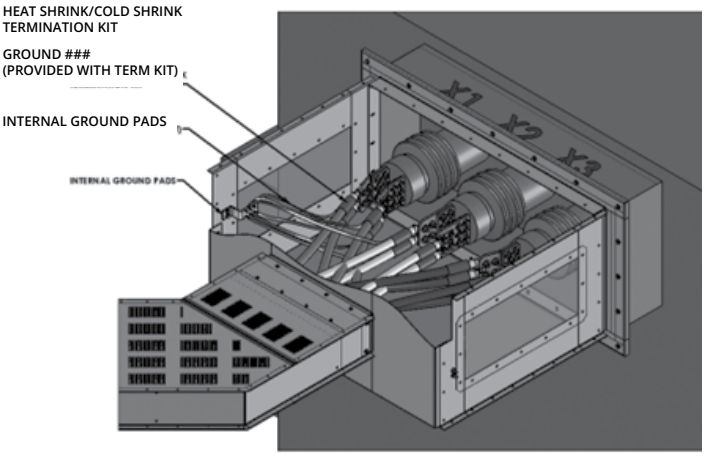

Figure 17. Cable shield ground assembly

NOTICE

AFTER INSTALLATION OF THE CABLES AND PRIOR TO MAKING FINAL CONNECTIONS TO THE TERMINATING EQUIPMENT, IT IS RECOMMENDED TO TEST THE CABLE FOR POSSIBLE DAMAGE THAT MAY HAVE OCCURRED DURING INSTALLATION.

There are several field acceptance tests that must be done before energizing the cable bus for the first time. Because of that, bus enclosure should be connected to station ground **(Section 6.13)**, all vapor and fire stop barriers completed **(Section 6.10 & 11)**, all top covers installed **(Section 6.12)** and all field acceptance tests performed accordingly, as described in **Section 6.1 of Chapter VII**, before finalizing the cable bus terminations and connecting to terminating equipment.

When all acceptance tests are completed, all cable ends must be connected to the termination equipment as shown on **Figure 17** following the instructions from the termination drawings. Particular attention must be paid to minimum cable bending radius and clearance requirements at the termination area.

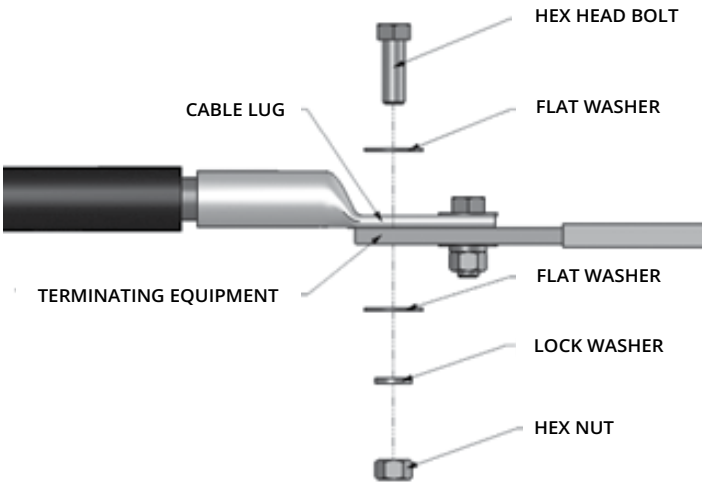

Figure 18. Termination hardware connection

The final step in completing the cable terminations is insulating all bolting connections with copper mesh, EPR tape and PVC tape. Terminations must be finalized with 1 (one) half-lapped layer of copper fill mesh applied over the connection hardware first. Then 1″ wide EPR splicing compound must be applied above all non-insulated surfaces as shown on Figure 18.

The number of EPR tape half-lapped layers needed and the insulation overlap is determined by the voltage rating:

1. up to 5kV: 2 (two) half-lapped layers of EPR tape must be applied 2″ beyond bare conductor surfaces on each side.
2. up to 15kV (95 BIL): 4 (four) half-lapped layers of EPR tape must be applied 4″ beyond bare conductor surfaces on each side.
3. 15kV (110 BIL) and above: 6 (six) half-lapped layers of EPR tape must be applied 6″ beyond bare conductor surfaces on each side.

At the end, 2 (two) half-lapped layers of flame – retardant PVC jacketing tape must be applied 1″ beyond the EPR tape on both sides as shown on **Figure 18**.

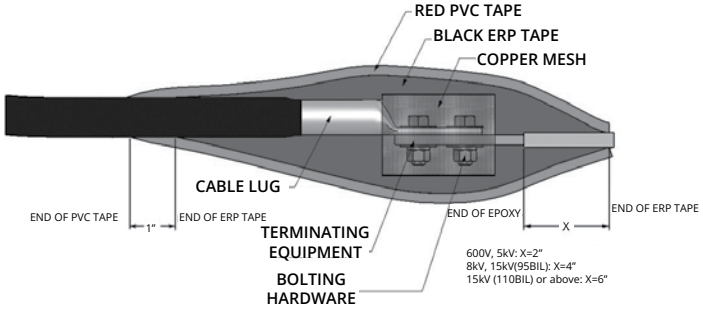

Figure 19. Overall cable termination phase insulation

6.10 Vapor barrier assemblies

Vapor barriers or bus end seal assemblies are normally required on all terminations. The seals help prevent the ingress of rainwater or other contaminants into the termination area, thereby reducing the possibility of moisture-induced electrical flashovers at the terminations. Both top and bottom covers must be vented up to the seal plate, and solid in the remaining totally enclosed part of the bus to the termination. The last vented part of the covers is used as drainage if any moisture accumulates on the vapor barrier. Eaton generally provide vapor barriers on all cable bus ends with custom designed, split 1″ thick seal plates furnished for each specific system requirement.

Seal plates must be already installed, as was described in **Section 6.6** and shown on **Figure 7**. It is very important that all seal assemblies are correctly installed. Small details, such as the position and orientation of plates, frames and bolting hardware must be observed.

Horizontally positioned vapor barriers are completed as shown on **Figure 19** with sealing compound – silicone caulk around the seal plate and all cables to create the seal.

In a situation where a vertically positioned vapor barrier is required, silicone caulk is used around the seal plate and all cables. Then, Flex 80 Putty (flexane) is used on top of the seal plate to finalize the vapor barrier. Flexane is a trowelable, two-part urethane that provides corrosion-resistant protection and forms a tough, unique system that is completely resistive to water and contaminants. The manufacturer instructions for mixing and applying the product must be strictly followed in order to achieve a complete seal. Vertical vapor barrier configuration is shown on **Figure 20**.

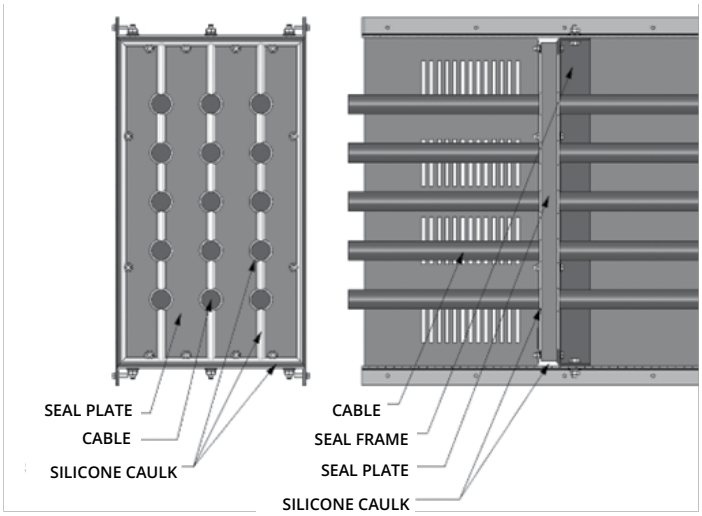

Figure 20. Horizontally positioned vapor barrier assembly

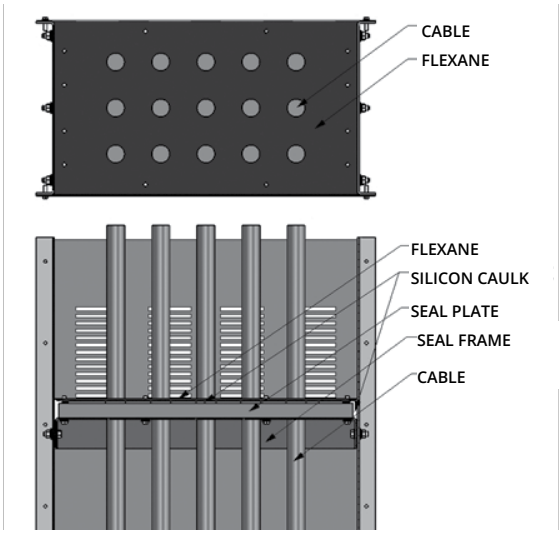

Figure 21. Vertically positioned vapor barrier assembly

6.11 Fire stop barrier assemblies

Fire stops are done by customer specific requests and are usually needed in wall and floor / ceiling penetrations.

Generally, Eaton recommends the following fire stop barriers:

1. ½ hr. fire rating (barrier created by using one seal plate, same as vapor barrier)
2. 1 hr. fire rating (barrier created by using 3M Fire Barrier Mortar Mix)
3. 2 hr. fire rating (barrier created by using 3M Fire Barrier Mortar Mix)
4. 3 hr. fire rating (barrier created by using 3M Fire Barrier Mortar Mix)

3M Fire Barrier Mortar is a fire stop product ready for mixing with potable water used to seal mechanical and electrical service penetrations in fire-resistance rated wall and floor assemblies of ratings up to 3 hours. First, water is poured into the mixing bucket. Mortar powder is added in the bucket and mixed with grout mixing paddles (or mixing drill) until the mortar mix is homogeneous and smooth, for a total of not less than 5 minutes. Special attention must be given to the bottom edges of the bucket for dry spots. Remixing more than once is not allowed.

For "remoistening" adding too much water should be avoided; the first attempt should be without adding any water. Then, the area where the mortar mix will be poured must be sprayed with water using a spray bottle or hand brush. The mortar mix must be immediately poured by filling the most difficult to reach areas first. When nearing the top of the wall opening, if the mortar wall being built becomes unstable, the best solution is to either wait until mortar has set more or to sprinkle a minute quantity of unmixed mortar powder on top. It will stiffen more quickly. When the opening is full, the mortar must be squeezed against the sides of the opening. Smoothing the surface of the mortar must be done as quickly as possible.

½ hr. fire stop barriers are shown on **Figure 19 & Figure 20** for horizontally and vertically positioned assemblies. There is no difference between ½ hr. fire stop barrier assembly and bus end vapor barrier assembly explained in **Section 6.10**.

Horizontally positioned fire stop barriers, with rating 1hr or more, are completed as shown on **Figure 21**. Seal plates are needed on both sides of the mortar mix, with the first seal plate always positioned 2" away from the outside face of the wall. This 2" extension is needed for clearance purposes so that it is possible to pour the mortar mix at the installation site.

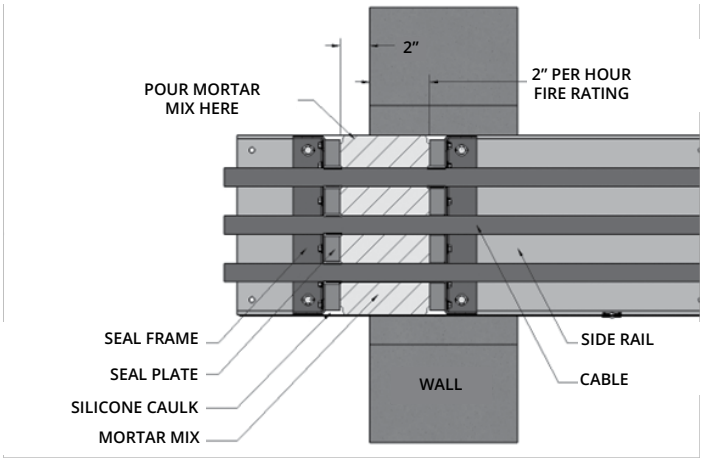

Figure 22. Horizontally positioned fire stop barrier assembly

The second seal plate's position depends on the fire rating and is to be positioned 2" per hour away from the outside face of the wall in the opposite direction from the first seal plate (shown on **Figure 21**), making the total mortar mix thickness 4", 6" or 8" for 1hr, 2hr or 3hr fire ratings, respectively.

Both seal plates must be already installed as was described in Section 6.6 and shown on **Figure 7**, and both plates must be sealed with silicone caulk around the seal plates and all cables (shown on **Figure 19**) before pouring the mortar mix. Then, mortar mix is to be poured between the seal plates to complete the fire stop barrier.

In a situation where a vertical fire stop barrier with fire rating 1 hr. or more is required, THERE IS NO TOP SEAL PLATE. The "lower" seal plate position depends on the fire rating and it is positioned 2" per hour away from the outside face of the floor as shown on Figure 22, making the total mortar mix thickness 2", 4" or 6" for 1 hr., 2 hr. or 3 hr. fire ratings, respectively.

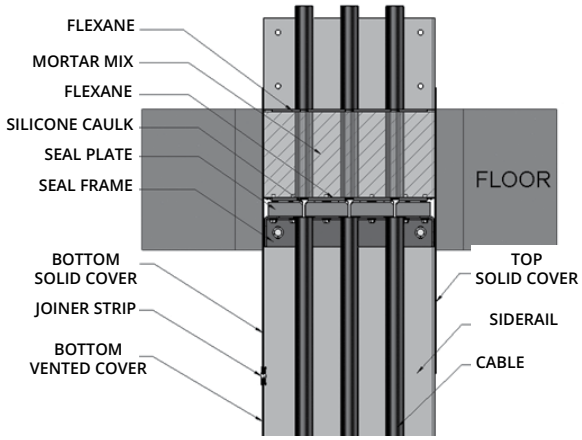

Figure 23. Vertically positioned fire stop barrier assembly

The seal plate must be already installed and is finalized in the same manner as a vertical vapor barrier with silicone caulk and flexane, as shown on Figure 20. The purpose of the caulk and the flexane is to prevent the mortar mix from flowing through gaps around the seal plate. Generally, all fire stop sections have multiple top and bottom covers with solid non-vented covers around the fire stop area.

THE SOLID NON-VENTED TOP COVER IN VERTICALLY POSITIONED FIRE STOP BARRIERS MUST BE INSTALLED BEFORE POURING THE MORTAR MIX. Top cover installation details are shown in **Section 6.12**.

Then, mortar mix is poured from above between the solid covers. After the mortar mix has cured, additional flexane is used on top of the mortar bed to complete the seal.

In special cases (customer requests or special pressure requirements), Eaton provides 2001 Silicone RTV Foam as a fire stop material along with instructions about the field installation.

All sections containing fire stop barriers must have sufficient clearance from walls and ceilings to provide easy access, both for original installation and for maintenance, including the possible removal of a section.

6.12 Top Cover, wall plate & solar shield assemblies

Following the installation process, after all cables are installed and terminated and all seals are completed, the next step will be reassembling all top covers and top joiner strips. Horizontal and vertical elbow covers are installed first. All vertically positioned sections, totally enclosed bus end sections or expansion joints having special factory built overlapping covers must be installed before the remaining straight section covers. All straight covers are normally sized for the section. Longer straight covers must be installed first; shorter covers can be cut down to size as needed.

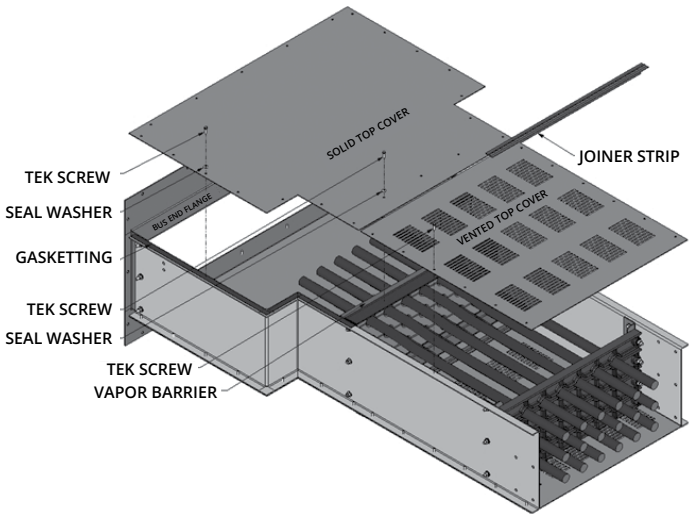

Figure 24. Top cover assembly on bus end section located outdoors

Self-drilling and tapping TEK screws are used to fasten the cover to the side rail. All covers should be positioned and clamped in place before applying the TEK screws following the drilling pattern from the cover. Top joiner strips must be installed in the same manner as the bottom ones shown on **Figure 2** at each cover joint before securing the covers. Joiner strips are not secured to side rails. These strips are held in place by the top cover penetrating the grooves.

A partially enclosed bus end section, located outdoors with solid top covers in the enclosed area, and vented top covers before that point, is shown on **Figure 23**, where the difference in the hardware (seal washers and gasketing) can be distinguish.

Wall plates are installed at all wall penetrations after the wall section top covers are installed and secured in place. Wall plate installation is shown on **Figure 24**.

Solar shields (sun shields) are used in case of direct sun exposure by customer request and are normally attached along with the top cover in outdoor sections only. Sun shield installation is shown on **Figure 25**.

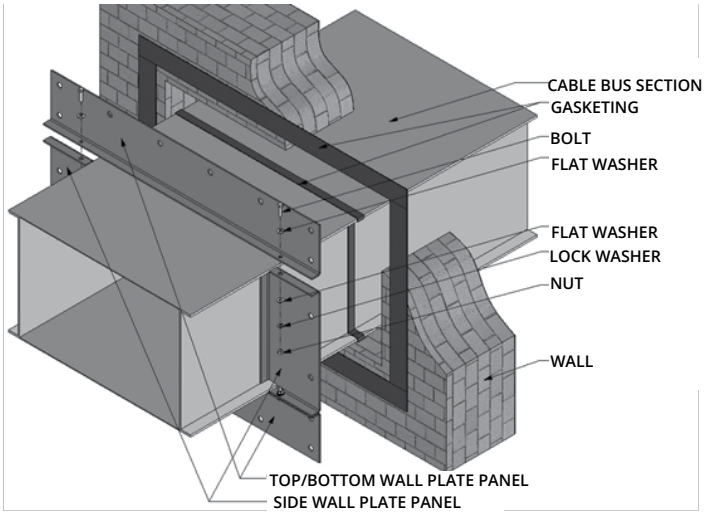

Figure 25. Wall plate assembly

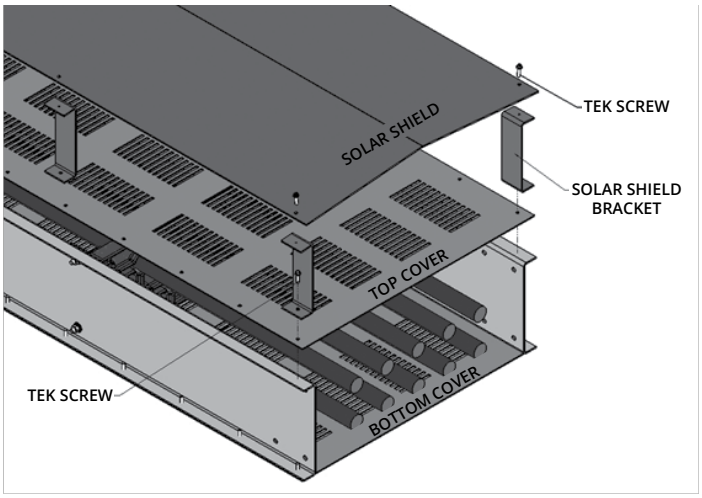

Figure 26. Solar shield assembly

6.13 Grounding

The bus housing must be properly grounded. Since the type and number of facilities required to establish adequate grounding can vary considerably depending on location, the responsibility for the design, installation, and verification of the grounding cannot be assumed by Eaton.

Ground pads are provided on the bus housings at equipment terminations for connection to station ground. The bus housing can be used to establish ground continuity in many applications. It is important that the housing splice plates, which are designed to provide a low resistance connection between adjacent bus sections, be properly installed.

As a special customer request, a continuous 4/0 AWG insulated or bare copper cable is sometimes installed on the side rail for additional ground capability. This configuration is shown on **Figure 26**.

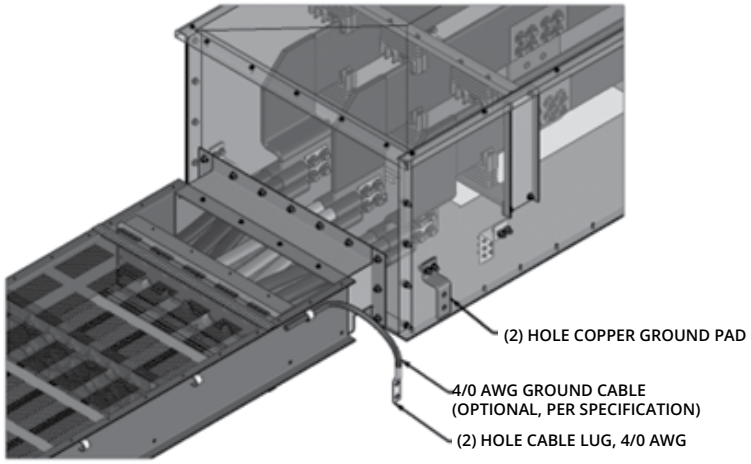

Figure 27. Ground cable assembly

7. OPERATION & MAINTENANCE

⚠ WARNING

SECTION 7.1 PROVIDES EXAMPLES OF COMMONLY USED FIELD ACCEPTANCE TESTS FOR INFORMATIONAL PURPOSES ONLY. ALL CABLE TESTING MUST BE PERFORMED ACCORDING TO THE CABLE MANUFACTURER'S DIRECTIONS. FAILURE TO DO SO MAY RESULT IN INJURY OR DEATH DUE TO ELECTRIC SHOCK.

7.1 Field acceptance tests

Before energizing the cable bus for the first time, several field acceptance tests should be conducted in order to determine the integrity of the installed system. Field acceptance tests provide the best possible assurance that the cable has not been damaged, and will perform satisfactorily when energized. All cables must be isolated from the remainder of the electrical system and not be connected to the termination equipment when conducting tests. Cable manufacturer's instructions about field acceptance testing must be strictly followed. The following types of field acceptance tests are recommended by Eaton for brand new installations:

- Conductor continuity and phasing

  Test for conductor continuity can include a simple check with device that measures conductor resistance (ohmmeter), determining if the conductors complete an electrical circuit and conductor metal has not been broken. Attention should be made for correct phasing by ensuring that the conductor is properly phased at the apparatus it is connecting to.

- Dielectric condition of the cable

  The electrical integrity of the system dielectric can be measured with insulation resistance test (megger) for non-shielded cables. For shielded cables, the more complex high voltage DC test (DC hi-pot) should be done to evaluate "leakage currents".

For low voltage, non-shielded cables, it is general practice to use a megger for checking the reliability of the circuit. This consists essentially of measuring the insulation resistance of the circuit to determine whether or not is high enough for satisfactory operation. The megger involves applying a potential to the "test cable" and connecting all other cables to the grounded enclosure and then measuring the insulation resistance. Because insulation resistance is a function of the length of a cable bus, the number of bus supports, the number of cables per phase, and other factors, there is not a fixed value of insulation resistance which is always acceptable. All details for the testing along with the desired results will be provided by the cable manufacturer and must be strictly followed. The values obtained from this test should be recorded for future use in the maintenance of the cable bus.

High voltage withstands tests help determine whether the conductor can withstand a prescribed test voltage without breakdown or failure. One way to evaluate a conductor for major defects of installation damage is to test it at a higher AC or DC voltage than the maximum operating voltage of the conductor. The cable either withstands the voltage or it breaks down. Since the DC potential does not produce harmful discharge as readily as the AC, it can be applied at higher levels without risk or damaging good insulation. So, in case of medium voltage shielded power cable, the use of DC high potential testing is standard for checking cable reliability. The field test voltages are directly proportional to the cable insulation thickness (about 300V per mil). The actual test values recommended for field acceptance test, in the case of brand new installation, and maintenance proof tests for cable bus in service less than 5 years are presented below in **Table 3**.

Table 3. DC hi-pot field test voltage

Rated Voltage	Cable Insulation	DC Hi-pot Acceptance test (15 min)	DC Hi-pot Maintenance test (5 min)
[kV]	[mils(%)]	[kV]	[kV]
5	90 (100%)	25	20
	115 (133%)	35	
15	175 (100%)	55	40
	220 (133%)	65	
25	260 (100%)	80	60
	320 (133%)	95	
35	345 (100%)	100	75
	420 (133%)	125	

DC hi-pot acceptance test requires all conductors not under test along with all cable shields to be grounded. The test should be conducted by qualified personnel only with a stable, constant voltage power source. The required DC acceptance test voltage is applied slowly in 5kV increments up to the maximum specified in Table 3. The leakage current should be allowed to stabilize for each 5kV step. When the acceptance test voltage is reached, it should be applied for 15 consecutive minutes. The leakage current should be recorded at one minute intervals for the duration of the test.

As long as the leakage current decreases or stays steady after it has leveled off, the cable is considered satisfactory. If the leakage current starts to increase trouble may be developing and the test may be extended to check if the rising trend continues. Abrupt increase in the magnitude of the leakage current and decrease in the test voltage signifies faulty condition. The results should be evaluated by the test engineer, but the shape of the resulting curve based on the recorded output current with respect to time indicates the condition of the dielectric. The results are outlined below.

- A fast rising leakage curve at a steady voltage may be indicative of faulty insulation.
- A falling leakage curve with similar levels for all phases is indicative of good insulation.
- A flat leakage curve at low value is generally indicative of acceptable insulation.
- A flat leakage curve at high value may indicate presence of moisture or contaminants.

Once these tests have been completed successfully, all connections that were disconnected for the tests should be reconnected and re-insulated, and any removed covers should be re-installed accordingly. The cable bus should now be ready for energizing.

7.2 Energizing

The cable bus systems described in this manual are self-cooled systems which have no moving components. A long reliable service life is assured by carefully following the simple installation and maintenance procedures outlined in this manual.

The bus should never be energized with the presence of heavy contamination on the interior surface of the bus. All covers must be securely in position at all times during the operation of the bus. Any dented or damaged housings must be carefully inspected and corrective action taken before energizing the bus.

⚠ WARNING

THERE SHOULD BE NO LOAD ON THE CABLE BUS WHEN IT IS ENERGIZED. SINCE CABLE BUS TYPICALLY EXTENDS BETWEEN TWO PIECES OF ELECTRICAL APPARATUS, CARE SHOULD BE TAKEN TO SEE THAT ALL DEVICES FED FROM THE CABLE BUS ARE SWITCHED TO THE "OFF" POSITION BEFORE ENERGIZING THE CABLE BUS. FAILURE TO DO SO MAY RESULT IN INJURY OR DEATH FROM ELECTRIC SHOCK.

The over-current protective devices on the source side of the cable bus must be in place and operating properly before energizing the cable bus.

The cable bus should be energized by closing the switching device which feeds it. A check along the length of the cable bus must be done to be sure no abnormal operating conditions are evident. The cable bus is now ready to be loaded by closing switching devices, feeding loads through the cable bus.

7.3 Maintenance

Field experience has verified that re-torquing of conductor connection hardware is not required on a routine basis.

Nevertheless, it is customary to schedule desired maintenance and/or maintenance proof tests to coincide with planned major shutdowns. These tests should include the following:

1. A visual check to spot any damage or changes in operational conditions.
2. Check for any equipment installed near the cable bus that may cause damage by external heating, corrosive fumes or physical stresses.
3. Check for signs of overheating at terminations, etc., or deterioration in insulating material. Conditions of overheating or deterioration must be eliminated.
4. Check for missing or broken parts, free movement, accumulation of dust, dirt or foreign matters, etc. Cleaning and replacement should be performed as required.
5. Maintenance proof tests for checking the cable reliability should be performed.
6. New gaskets are recommended when re-installing gasketed covers that have been removed for maintenance proof tests.

7.4 Spare parts

Eaton's cable bus system has been designed to eliminate any components that might require periodic routine replacement. There are no moving parts. Accordingly, it is not necessary for users to maintain a stock of spare parts.

The maintenance procedures described in **Section 6.3** may result in need for some miscellaneous materials such as gaskets, cover mounting hardware, insulating materials and touch up paint. Replacement parts may be ordered through Eaton's B-Line Division.

7.5 Field service

Eaton's B-Line Division should be contacted for further assistance. Trained and experienced field service engineers are available to provide on-site assistance when desired.

For more information, visit
Eaton.com/cablebus

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