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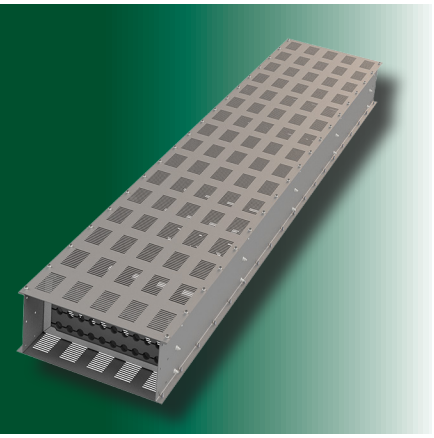

01.4IB.81000
Metal-Enclosed Cable Bus

600V - 38kV, 800A - 6000A

Contact Information

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Service Division
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Signal Words

As stated in ANSI Z535.4-2023, the signal word is a word that calls attention to the safety sign and designates a degree or level of hazard seriousness. The signal words for product safety signs are **"Danger"**, **"Warning"**, **"Caution"** and **"Notice"**. These words are defined as:

⚠ DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

NOTICE is used to address practices not related to personal injury.

Qualified Person

For the purposes of this manual, a qualified person, as stated in NFPA 70E®, is one who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved. In addition to the above qualifications, one must also be:

1. trained and authorized to test, energize, deenergize, lock out, tag, clear, and ground circuits and equipment in accordance with established general and site-specific safety practices.
2. trained in the proper selection, care, and use of personal protective equipment (PPE) including but not limited to insulating gloves, hard hat, safety glasses or face shields, arc flash rated clothing, etc., in accordance with established general and site-specific safety practices.
3. trained in rendering first aid if necessary.

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Ch 1 General Information

⚠ WARNING

The equipment described in this document may contain high voltages and currents which can cause death or serious injury.

The equipment is designed for use, installation, and maintenance by knowledgeable users of such equipment having experience and training in the field of high voltage equipment. This document and all other documentation shall be fully read, understood, and all warnings and cautions shall be abided by. If there are any discrepancies or questions, the user shall contact Powell immediately at 1.800.480.7273.

⚠ WARNING

Prior to adjustments, servicing, maintenance, or any act requiring the operator to make physical contact with the equipment, the power source must be disconnected and the equipment grounded. Failure to do so could result in death or serious injury.

NOTICE

The information in this instruction bulletin is not intended to explain all details or variations of the Powell equipment, nor to provide for every possible contingency or hazard to be met in connection with installation, testing, operation, and maintenance of the equipment. For additional information and instructions for particular problems, which are not presented sufficiently for the user's purposes, contact Powell at 1.800.480.7273.

NOTICE

Powell reserves the right to discontinue and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.

A. Scope

The information in this instruction bulletin describes the following Powell Metal-Enclosed Cable Bus.

- 600V, 800A - 6000A
- 5 - 38kV, 800A - 6000A

B. Purpose

The information in this instruction bulletin is intended to provide details required to properly operate and maintain the metal-enclosed cable bus described in *Ch 1 General Information, A. Scope*.

This instruction bulletin provides:

1. Safety guidelines
2. General descriptions of the operation and maintenance of the metal-enclosed cable bus
3. Instructions for installation and placing the metal-enclosed cable bus into service
4. Instructions for part replacement
5. Information for ordering renewal parts
6. Illustrations, photographs, and description of the metal-enclosed cable bus

The illustrations contained in this document may not represent the exact construction details of each particular type of metal-enclosed cable bus. The illustrations in this document are provided as general information to aid in showing component locations only.

All illustrations and photos are shown using deenergized equipment.

⚠ WARNING

Follow the appropriate safety precautions while handling any of the equipment. Failure to do so could result in death or serious injury.

To the extent required, the products described herein meet the applicable ANSI, IEEE, and NEMA Standards; however, no such assurance is given with respect to local codes and ordinances which may vary greatly.

C. Instruction Bulletins Available Electronically

NOTICE

Changes to the instruction bulletin may be implemented at any time and without notice. Go to powellind.com to ensure use of the current instruction bulletin for Powell equipment.

For more information visit *powellind.com*. To contact the Powell Service Division call 1.800.480.7273 or 713.944.6900, or email *serviceinfo@powellind.com*.

For specific questions or comments pertaining to this instruction bulletin email *documents@powellind.com* with the IB number in the subject line.

Ch 2 Safety

A. Safe Work Condition

The information in Section A is quoted from *NFPA 70E 2018 - Article 120, 120.1 Establishing an Electrically Safe Work Condition.*

NFPA 70E is periodically updated. Refer to the latest version for any additional updates.

120.1 Process for Achieving an Electrically Safe Work Condition

1. Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.
2. After properly interrupting the load current, open the disconnecting device(s) for each source.
3. Wherever possible, visually verify that all blades of the disconnecting devices are fully open or that drawout-type circuit breakers are withdrawn to the fully disconnected position.
4. Release stored electrical energy.
5. Release or block stored mechanical energy.
6. Apply lockout/tagout devices in accordance with a documented and established procedure.
7. Use an adequately rated portable test instrument to test each phase conductor or circuit part to verify it is deenergized. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on any known voltage source.

N *Exception No. 1: An adequately rated permanently mounted test device shall be permitted to be used to verify the absence of voltage of the conductors or circuit parts at the work location, provided it meets the all following requirements: (1) It is permanently mounted and installed in accordance with the manufacturer's instructions and tests the conductors and circuit parts at the point of work; (2) It is listed and labeled for the purpose of verifying the absence of voltage; (3) It tests each phase conductor or circuit part both phase-to-phase and phase-to-ground; (4) The test device is verified as operating satisfactorily on any known voltage source before and after verifying the absence of voltage.*

N *Exception No. 2: On electrical systems over 1000 volts, noncontact test instruments shall be permitted to be used to test each phase conductor.*

Informational Note No. 1: See UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements,* for rating, overvoltage category, and design requirements for voltage measurement and test instruments intended for use on electrical system 1000 volts and below.

N Informational Note No. 2: For additional information on rating and design requirements for voltage detectors, refer to IEC 61243-1, *Live Working - Voltage Detectors - Part 1: Capacitive type to be used for voltages exceeding 1kV a.c.,* or IEC 61243-2, *Live Working - Voltage Detectors - Part 2: Resistive type to be used for voltages of 1kV to 36kV a.c., or* IEC 61243-3, *Live Working - Voltage Detectors - Part 3: Two-pole voltage type.*

8. Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being deenergized could contact other exposed energized conductors or circuit parts, apply temporary protective grounding equipment in accordance with the following:

   a. *Placement.* Temporary protective grounding equipment shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to a shock hazard (i.e., hazardous differences in electrical potential). The location, sizing, and application of temporary protective grounding equipment shall be identified as part of the employer's job planning.
   b. *Capacity.* Temporary protective grounding equipment shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.

N Informational Note: ATSM F855, *Standard Specification for Temporary Protective Grounds to be Used on De-energized Electric Power Lines and Equipment,* is an example of a standard that contains information on capacity of temporary protective grounding equipment.

   c. *Impedance.* Temporary protective grounding equipment and connections shall have an impedance low enough to cause immediate operation of protective devices in case of unintentional energizing of the electric conductors or circuit parts.

B. Safety Guidelines

Study this instruction bulletin and all other associated documentation before uncrating the equipment.

Each user has the responsibility to instruct and supervise all personnel associated with usage, installation, operation, and maintenance of this equipment on all safety procedures.

Furthermore, each user has the responsibility of establishing a safety program for each type of equipment encountered.

The safety rules in this instruction bulletin are not intended to be a complete safety program. The rules are intended to cover only some of the important aspects of personnel safety related to metal-enclosed cable bus.

C. General

1. Only supervised and qualified personnel trained in the usage, installation, operation, and maintenance of the metal-enclosed cable bus shall be allowed to work on this equipment. It is mandatory that this instruction bulletin, any supplements, and service advisories be studied, understood, and followed.
2. Maintenance programs must be consistent with both customer experience and manufacturer's recommendations, including service advisories and instruction bulletin(s). A well planned and executed routine maintenance program is essential for bus duct's reliability and safety.
3. Service conditions and applications shall also be considered in the development of safety programs. Variables include ambient temperature; humidity; actual continuous current; thermal cycling; and any adverse local conditions including excessive dust, ash, corrosive atmosphere, vermin and insect infestations.

D. Specific

1. **DO NOT WORK ON ENERGIZED BUS ASSEMBLIES.**

2. **DO NOT climb on, walk on or sit on the metal-enclosed cable bus. It is NOT designed to support the weight of a person.**

3. **DO NOT use the metal-enclosed cable bus for support of other equipment. It is not designed to support the extra weight.**

4. **For the safety of personnel performing maintenance operations on the metal-enclosed cable bus or on connected equipment, all components should be disconnected by means of a visible break and securely grounded.**

5. See additional safety precautions in *Ch 4 Installation*.

E. Safety Labels

The equipment described in this document has **DANGER**, **WARNING, CAUTION,** and instruction labels attached to various locations. All equipment **DANGER**, **WARNING, CAUTION,** and instruction labels shall be observed when the metal-enclosed cable bus is handled, operated, or maintained.

NOTICE

Danger, Warning, and Caution labels are located in various places. Do NOT remove or deface any of these warning/caution labels.

Ch 3 Equipment Description

A. General

NOTICE

Powell is committed to continuous product improvement.

It is possible that improvements occurred between revisions to this document and therefore, may not be described in these instructions. If the equipment does not resemble the photographs and descriptions contained herein, do not attempt to perform the actions. Contact the Powell Service Division.

The metal-enclosed cable bus duct supplied has been designed and fabricated to meet the specific job requirements. All of the necessary parts, for a complete installation, 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 engineered polymer support 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.

Bus assemblies are normally used to connect two pieces of electrical power equipment, such as two units of metal-enclosed switchgear, a transformer and a switchgear unit, a large rotating machine and a switchgear unit, or a switchgear and/or switchboard. The metal-enclosed cable bus may be located either indoors or outdoors, or the metal-enclosed cable bus may pass from indoors to outdoors one or more times.

In addition to the items described in the definition of cable bus, bus assemblies frequently include other special features such as vapor barriers, fire barriers, or termination sections to match switchgear, transformers, or rotating machines. The metal-enclosed cable bus or the termination section may include such items as current transformers, voltage transformers, surge arresters or surge capacitors, if required by the installation.

Bus assemblies are not self-supporting and must be supported at installation. Indoor bus assemblies are normally supported by hanging from the ceiling, supported from floors or walls or from other pieces of equipment, such as switchgear units. Outdoor bus assemblies are normally supported from the ground. Supports for bus sections are normally furnished by the user or the installing contractor. See *Ch 4 Installation* for further information on metal-enclosed cable bus supports.

Ch 4 Installation

A. Receiving

When the material is received, unpack it sufficiently to inspect it for concealed damage and to determine that the shipment is complete and correct. If damage is found or suspected, or if the shipment is incomplete, file claims as soon as possible with the transportation company and notify the nearest Powell representative.

Powell metal-enclosed cable bus is packaged and labeled by section. When multiple sections of cable bus are received at site, material is labeled and identified by each individual section. Each piece comprising the section is also labeled and identified.

Metal-enclosed cable bus shipped as part of a Powell Engineered To Order (ETO) Project, will include detailed labels for each section matching up to the Powell provided drawings.

Metal-enclosed cable bus shipped as part of a Catalog Order (CTO), will include labels that call out only part numbers for each section, without identifying the location on the run.

Metal-enclosed cable bus will be shipped as components and assemblies consisting of:

- Assembled sections of enclosure with preinstalled bottom support blocks
- Installation hardware and other accessories as detailed in the final engineering drawing package (custom engineered drawings provided only for ETO projects)
- Crated components used to secure cables during installation

B. Unpacking

1. Carefully unpack all sections of the metal-enclosed cable bus. To avoid damage to the metal-enclosed cable bus, band cutters should be used on all banding securing the packages and nail pullers should be used for unpacking wooden crates.
2. Carefully remove any blocking or other temporary fasteners which may have been used for shipping.
3. If the metal-enclosed cable bus is not to be installed immediately, save all packing and wrapping materials for reuse while the metal-enclosed cable bus is in storage.

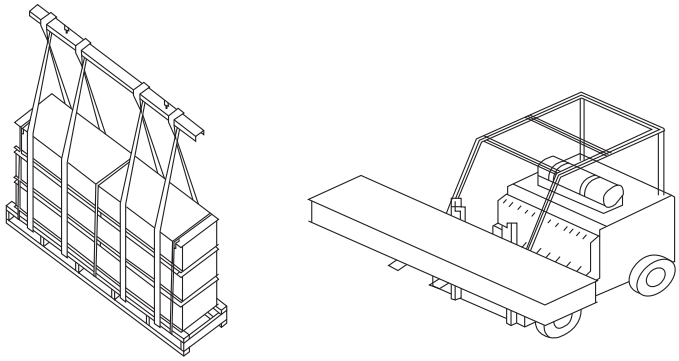
C. Handling

To help avoid personal injury and equipment damage during handling, and to facilitate moving the metal-enclosed cable bus sections and fittings at the job site, follow these guidelines:

1. Assess the weight of the bus prior to handling. Refer to Powell product documentation for approximate weight per foot. To avoid personal injury, do not attempt to lift, carry, or otherwise move metal-enclosed cable bus sections by one person. Handling an individual section of metal-enclosed cable bus by hand using two or more people is an acceptable method. For installation of material at an elevated height, proper mechanical means should be used. Be sure that the handling equipment and appropriate PPE used is capable of safely handling the metal-enclosed cable bus sections.

2. Handle metal-enclosed cable bus sections with care to avoid damage to internal components. Avoid subjecting metal-enclosed cable bus sections to twisting, denting, impact, and any rough handling. Avoid damaging to protruding objects such as flanges. Twisting, denting, impact, and rough handling the bus duct must be avoided at all times.
3. When setting metal-enclosed cable bus sections on the ground or on a floor, the main body of the enclosure should be set on a support to protect flanges and other protruding objects. A short length of 2" x 4" or 4" x 4" lumber makes a good support.
4. Do not drag metal-enclosed cable bus sections across the floor or the ground.
5. Do not use bus ends for lifting metal-enclosed cable bus sections or fittings. Lift only the metal-enclosed cable bus enclosure, using support means such as slings or lift truck forks which extend under the full width of the enclosure.
6. Platform dollies provide a simple method of moving bus assemblies on one floor level if there is little or no incline. Balance the load carefully and secure it to the dolly.
7. If a crane is used to install metal-enclosed cable bus, use nylon straps and distribute or balance the weight of each lift. If cables are used, spreaders should 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.
8. If a fork or similar hoist is used, properly position the metal-enclosed cable bus enclosure on the forks to distribute its weight. Secure the load to the forks while lifting.
9. Shipping crates should not be stacked on top of each other.
10. Although top covers should be removed in order to install the cable, moving sections of cable bus without covers should be kept to a minimum.
11. Reels of cable should not be dropped from any height.

Figure 1 Unloading and Maneuvering Bus Section



D. Storage

Shipping and storage of electrical equipment requires measures to prevent the deterioration of the apparatus over a long unused period. The mechanical and dielectric integrity must be protected. Electrical equipment is designed for use in a variety of environments. When the equipment is in transit and storage, these design considerations are not fully functional. In general, the following measures must be considered.

1. Certain accessories associated with the metal-enclosed cable bus product such as sealants, rubber goods, and termination components, may require indoor storage in a climate controlled environment prior to installation. These components will be identified and labeled as such. For these components, the temperature should be kept above 33°F/1°C and below 140°F/60°C. The relative humidity should be kept below 60% or a dew point of 59°F/15°C.

2. Any material not indicated as requiring indoor storage may be stored either in indoor or outdoor storage locations. The equipment must be inspected on a routine basis to assure its integrity.
3. Cover plates should not be stacked tightly together. Moisture can become trapped between stacked cover plates when there is limited air circulation. When cover plates are temporarily stacked during installation, trapped moisture (from rain, snow, or condensation can result in surface staining.

⚠ CAUTION

Failure to store and protect metal-enclosed cable bus components properly can cause serious damage and will void the warranty.

E. Assembly Drawings

Custom Assembly Drawings will be provided only for Engineered to Order projects.

For Catalog Orders, Powell will provide standard component level drawings.

For Engineered to Order projects, 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 metal-enclosed cable bus drawings along with the bills of material are the primary drawings which reference and coordinate all the other drawings and procedures. The typical drawing package provided from Powell will consist of the following drawings along with various other drawings showing project specific requirements for connecting sections of bus together:

1. Master Layout - shows the routing of all bus duct runs within a specific project, along with structural steel support locations or recommended structural steel support locations depending on the project scope. The bill of material on this drawing will identify the bus runs and structural steel support.
2. Bus Run Layout - shows the particular assembly of a bus duct run identifying the bus duct sections and their location within the bus run.
3. Cable Pull Schedule - shows the cable ratings, length and number of cables, total cable length, cable type, and any project or site-specific requirements. Only provided if Powell is supplying cables with the metal-enclosed cable bus system as part of the Engineered to Order project.
4. Termination Drawings - shows the bus duct connection details to the termination equipment (i.e. switchgear, transformer, etc.) along with the project requirements for insulating the connection. Only provided if Powell is supplying cables with the metal-enclosed cable Bus system as part of the Engineered to Order project.
5. Specific Drawings - shows the specific requirements of the bus duct run including electrical specifications, type of hardware to be used, etc.

F. Part Identification

For Engineered to Order projects, each section of the bus is uniquely identified on the assembly drawing by a section tag number. 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 in the field.

For Catalog Orders, each section or component will be labeled with its part number.

G. Structural Steel Support Installation

Bus ducts are not self-supporting and must be properly supported for trouble-free service. Extra supports are used at all corners. Powell provides details for the support locations shown on the master layout drawing or on the "Recommended Structural Steel Placement" document, available for both ETO and Catalog Orders. If the bus duct steel support is Powell's responsibility, a set of steel support assembly drawing will be provided. These drawings explain the details about the steel support structure and provide a guide through all steps of the installation process.

For ETO projects where Powell is providing structural supports, 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 bus duct installation process.

H. Alignment of Apparatus

Before installing a run of bus assemblies, carefully check the location of the apparatus to be connected. The relative location of the two ends of the metal-enclosed cable bus must be as shown on the layout drawing for proper connection.

For Catalog Orders, Powell recommends checking alignment of the cable bus enclosure against the layout drawings (not provided by Powell) prior to installation.

NOTICE

The entire run of metal-enclosed cable bus should be installed and adjusted at all terminating equipment before final torquing of connecting bolts.

Any adjustments to obtain proper alignment should 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.

For a typical metal-enclosed cable bus of about 20 feet, the relative locations of the two end connections should not deviate from the layout drawing by more than ½" total. Location of walls which are penetrated by a metal-enclosed cable bus should also be checked. The center lines of the wall cutout should not deviate from the center lines of the metal-enclosed cable bus by more than ½", and the location of the wall along the length of the metal-enclosed cable bus should not deviate from its position on the layout drawing by more than ¼ of the thickness of the wall, to ensure that vapor barriers fall within the thickness of the wall, where they will be effective.

If the terminal points of the metal-enclosed cable bus are not aligned within these limits, corrective action must be taken. If at all possible, the apparatus to which the metal-enclosed cable bus connects should be moved so that the alignment is within limits. If this is not possible, contact Powell with all necessary dimensions, so that corrective action can be taken.

Do not rely on flexible connectors at the terminations of a metal-enclosed cable bus to correct misalignment problems beyond the limits given above. Flexible connectors are furnished to limit stress on apparatus terminations caused by thermal expansion and vibration, and to correct very minor (<¼") misalignments.

Bus assemblies must have sufficient horizontal and vertical clearance from walls and ceilings to provide easy access to joints, both for original installation and for maintenance, including the possible removal of a section.

I. Installation Checklist

This checklist lists the steps necessary for installation of the metal-enclosed cable bus in the order in which they should be performed. More detail about many of these steps is given in subsequent sections, which should be reviewed before installation.

1. Check the material received, including loose items such as hardware, splice plates, insulating material and gaskets, against the drawings and/or shipping documents. Notify Powell of any discrepancies.
2. Lay out the metal-enclosed cable bus on the ground where it will be installed.
3. For standard cable bus projects the installation starts at one termination point and proceeds forward attaching and adjusting all bus duct sections one to another leveling and plumbing the duct as necessary. Another option is to start installing at both ends of the run and proceeding towards the middle. All side rails should be LOOSELY BOLTED together using the provided hardware and splice plates, all bottom covers should be connected together with the joiner strips and the bus duct sections should be attached to the support steel structure with hold down clips, see *Ch 4 Installation, J. Cable Bus Enclosure Installation*. 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 should be tightened according to the torque values stated in *Table A Bolt Torque Values for Bus Assemblies*.
5. Next, the lower row of cable support blocks and seal plates should be attached to the factory installed support brackets (*Figure 5, e)* and seal frames. More details are given in *Ch 4 Installation, K. Cable Loading*.
6. The first row of cables should be pulled into the housing and laid onto the installed bottom support blocks and seal plates as outlined in *Ch 4 Installation, K. Cable Loading*. All remaining rows of support blocks and cables should be installed layer by layer in the same manner as the first row.
7. All terminations should be completed next, following the instructions for:
   - Cable Interleaving. See *Ch 4 Installation, L. Cable Interleaving*.
   - Cable-lug connection and stress cones installation. See *Ch 4 Installation, M. Cable Terminations*.
   - Grounding of cable braids and the housing. See *Ch 4 Installation, M. Cable Terminations* & *Q. Grounding*.
8. All environmental seals and fire barrier assemblies should be completed as detailed in *Ch 4 Installation, N. Vapor Barrier Assemblies* & *O. Fire Stop Barrier Assemblies*.
9. All removed covers should be installed matching the cover with the section from which it was removed. All TEK screws must be tightened according to details in *Ch. 4 Installation, P. Top Cover, Wall Plate, & Solar Shield Assemblies*.

10. Checks for correct cable phasing and cable reliability should be completed next, refer to *Ch 4 Operation, R. Checks Before Energizing*.
11. Overall phase insulation is the last step needed to be done. See *Ch 4 Installation, M. Cable Terminations*.

Table A Bolt Torque Values for Bus Assemblies

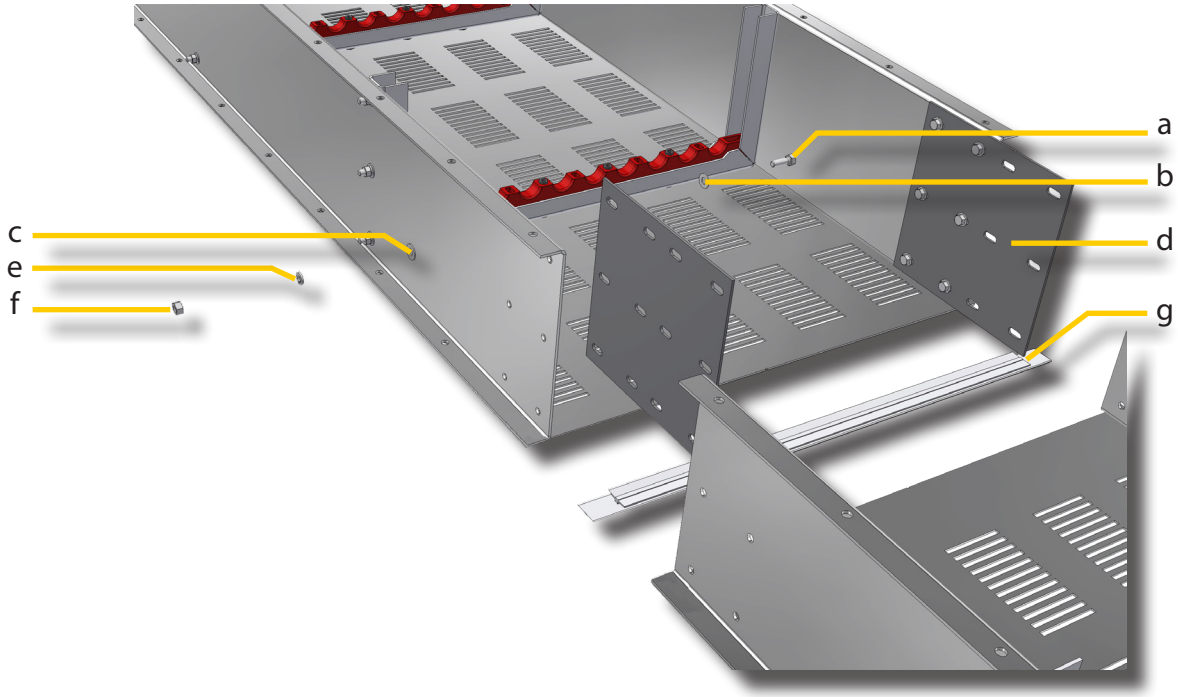
Hex Head Bolt Size	Material			
	Zinc Plated Steel	304 Stainless Steel	316 Stainless Steel	Silicon Bronze
¼"-20	75 In-Lbs	75.2 In-Lbs	78.8 In-Lbs	68.8 In-Lbs
5/16"-18	13 Ft-Lbs	11 Ft-Lbs	11 Ft-Lbs	10.3 Ft-Lbs
3/8"-16	23 Ft-Lbs	19 Ft-Lbs	20.6 Ft-Lbs	18 Ft-Lbs
½"-13	50 Ft-Lbs	43 Ft-Lbs	45.2 Ft-Lbs	40 Ft-Lbs
5/8"-11	110 Ft-Lbs	92 Ft-Lbs	96.7 Ft-Lbs	85 Ft-Lbs

Note: *1. The values listed in Table A are for clean and dry parts free of lubricants unless otherwise noted.*
2. Torque wrench tolerance is +/- 10% of specified values.

J. Cable Bus Enclosure Installation

It is recommended that the erection of the duct begins with one termination section and proceed forward. Each section must be properly supported during assembly and attached to the next section by "finger tightening" the bolts on the splice plates.

Figure 2 Joiner Strip & Splice Plate Assembly



a. Bolt
b. Flat Washer
c. Flat Washer
d. Splice Plate
e. Lock Washer
f. Nut
g. Joiner Strip

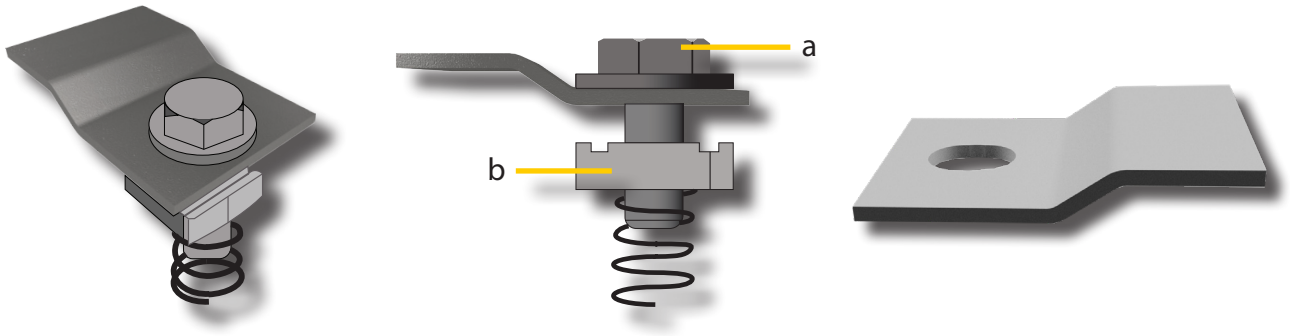
Joiner strips are not secured to side rails. These strips are held in place by the cover penetrating the grooves. In the specific situation when bus end vapor barriers are positioned away from the termination equipment, that portion of the bus needs to be totally enclosed with solid covers. *Figure 2* shows the different hardware configuration (seal washer) for a splice in the totally enclosed area.

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.

When the bus duct housing is in position it is secured to the supporting steel structure with hold down clips and the support steel hardware is tightened according to *Table A Bolt Torque Values for Bus Assemblies*.

Once the bus duct routing is completed, and after enclosure is securely connected to the terminating equipment and the bus is secured to the structural steel support, then all connecting hardware can be tightened according to *Table A Bolt Torque Values for Bus Assemblies*.

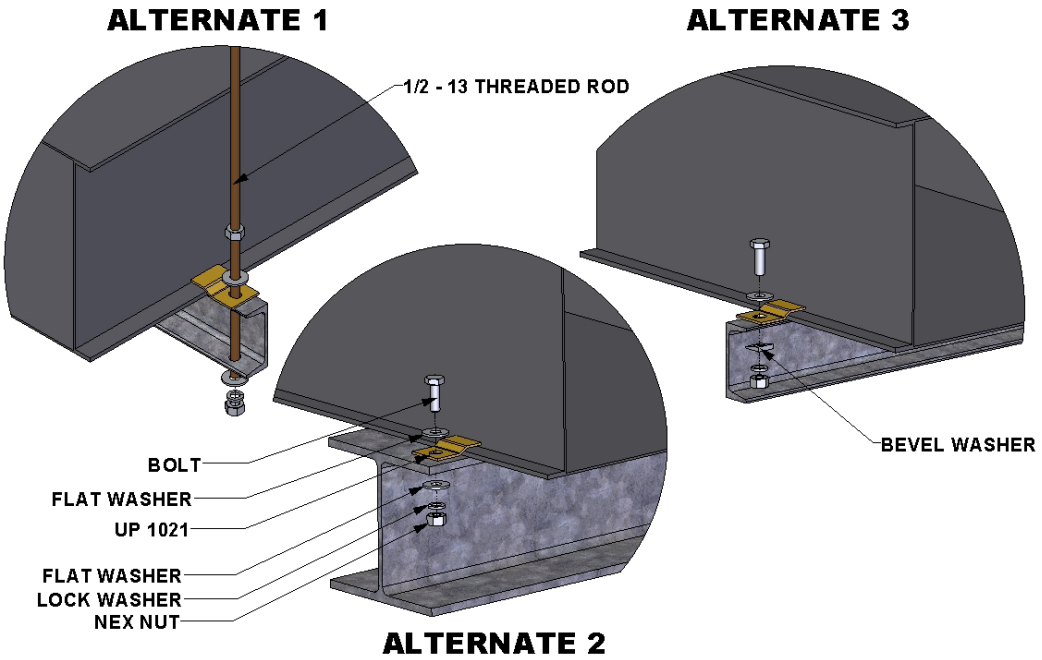
Figure 3 Hold Down Clip



a. Bolt
b. Spring Nut

Note: *Hold Down Clip may be provided by Powell when included in the scope of supply. Bolt and spring nut (Figure 3) for unistrut mount not supplied by Powell.*

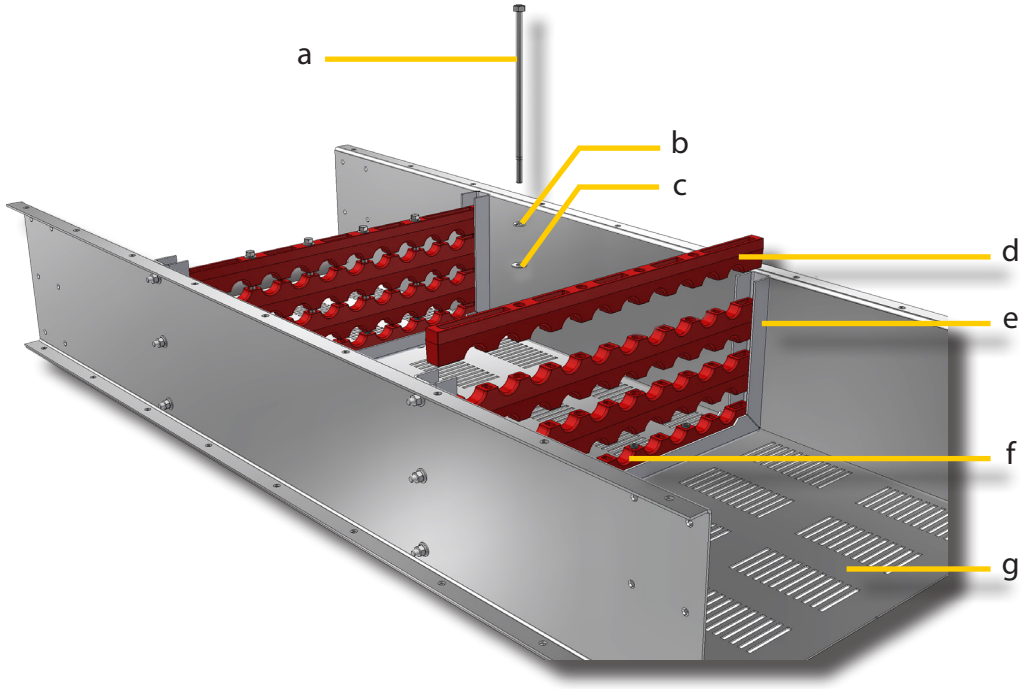
Figure 4 Hold Down Clip Mounting Details



K. Cable Loading

After the bus duct housing installation is completed and all enclosure hardware is tightened according to *Table A Bolt Torque Values for Bus Assemblies*, the lower row of cable support blocks and seal plates can be installed and attached to the factory installed support brackets and seal frames as shown in *Figure 5*.

Figure 5 Support Block Assembly



a. Bolt
b. Lock Washer
c. Flat Washer
d. Support Block Top Row
e. Support Bracket (U-Channel Frame)
f. Support Block Bottom Row
g. Bottom Cover

Powell 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 A Bolt Torque Values for Bus Assemblies*. Upon completion of this, the lower row of cables can be pulled into the housing and laid into the bottom blocks.

Cable shall be supplied in sufficient length to avoid any splicing inside of the cable bus enclosure. Prior to cable pulling operations, the proper pulling tool should be selected and installed along the bus run. The most economical spacing of horizontal rollers depends on the weight of the cable to be pulled. In general, the spacing of rollers should range between approximately 10 ft for cable weighing over 8 lbs/ft and 16 ft for cable weighing less than 2 lbs/ft.

Short length conductors or small diameter medium length conductors can be laid in place by pulling with a basket grip only, providing the pulling tension does not elongate or damage the insulation.

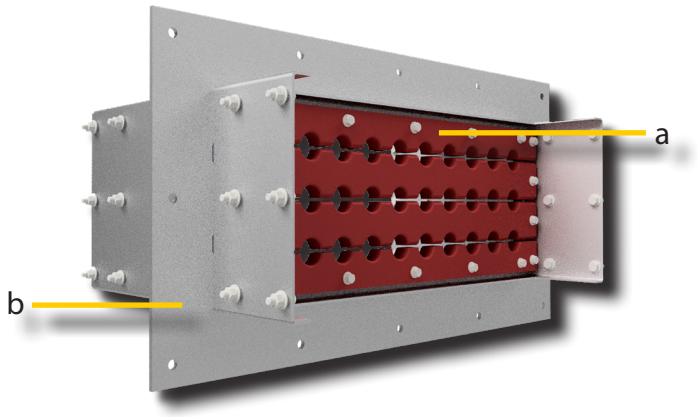
NOTICE

In no case should the cable support block be used to form the cable lay, but rather the cable should be "true" when inserted in the cable support block hole.

In the termination areas cable interleaving instructions should be followed as outlined in *Ch 4 Installation, L. Cable Interleaving*. 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).

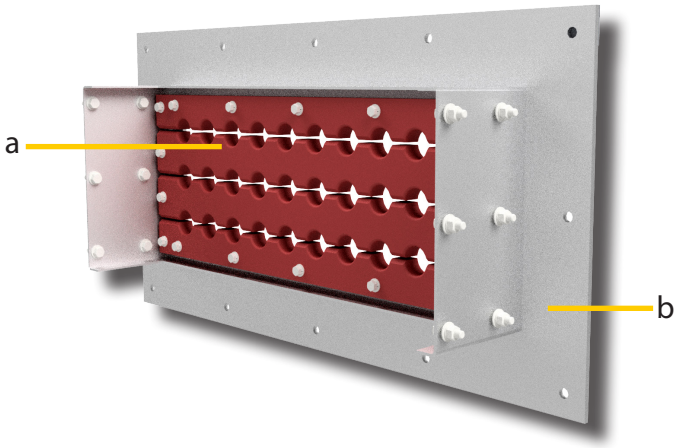
When the first row of cables is completed, the next set of support blocks should be installed. These steps should be repeated for all layers of cable. After laying the upper row of cables, the top cable support blocks should also be installed in the same manner and secured with thru-bolts *(Figure 5, a)*. All bolts should be tightened with max torque values given in *Table A Bolt Torque Values for Bus Assemblies*. Excessive clamping forces must be avoided to prevent pinching and damage to the cable insulation.

Figure 6 Seal Plate Kit - Wall Assembly



a. Seal Plate Blocks
b. Wall Flange

Figure 7 Seal Plate Kit - Termination Flange Assembly



a. Seal Plate Blocks
b. Termination Flange

L. Cable Interleaving

Interleaving of the cables either at the termination area or within the last few support blocks in the enclosure is critical to achieving a cable bus duct system with good current balance within the phase and between phases.

Powell will provide the best possible cable configuration stated on the detailed interleave drawing and run layout drawing. The instructions from the interleave drawing must be followed. Failure to do so can result in a current imbalance in excess of 30%, meaning that one phase, or one cable within the phase, could carry over 30% more current than the other phases or other cables within the phase.

Normally, Powell will not include cable interleaving if the length of the cable bus duct run is less than 50 feet. When less than 50 feet, interleaving should be done in the terminating compartments, where available. For such runs, if possible, cables are interleaved in the termination area.

M. Cable Terminations

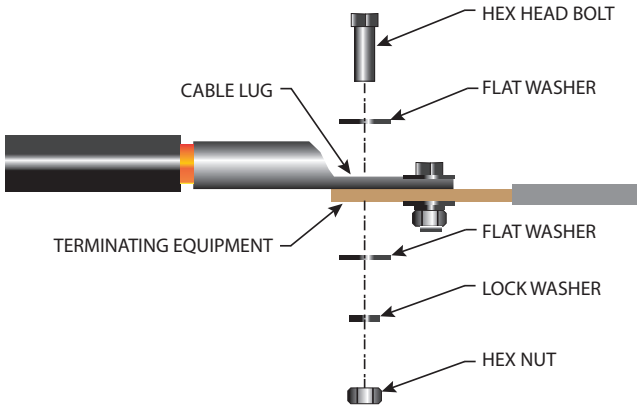
Cable terminations to customer equipment must be performed in strict compliance with termination detail drawings provided by Powell as well as to connecting equipment requirements.

The next step after all cables are installed is to connect to the existing equipment at all terminations. The electrical connectors, when supplied, are manufactured to NEMA specifications. Long barrel compression connectors (cable lugs) are normally provided to assure the user of a low resistance connection and must be installed on all cables at the termination. All connections between the lugs and the stripped cables must be insulated. Powell uses termination kits (stress cone or tape kits) for cable-lug insulation for shielded cable only *(Figure 9)*. For low voltage non-shielded cable terminations, insulation shall be limited to EPR and PVC tape only, as specified by the applicable project specification requirements. Low voltage general practice is the cable-lug connection to be insulated with shrink kits unless explicitly identified in the project drawings or associated documentation *(Figure 10)*.

The type of cable being used will determine the stress cone installation procedure to be followed explained in details in the instructions provided by the stress cone manufacturer. Both cable termination kits and cable lugs must be installed in compliance with cable termination kit and lug manufacturer recommendations.

After cable lugs have been securely attached and insulated, following the termination and interleave detail drawings, all lugs should be connected to the customer equipment as shown on *Figure 8*.

Figure 8 Termination Hardware Connection



Particular attention should be paid to minimum cable bending radius and clearance requirements. Prior to making final connections, a check must be made for correct phasing by ringing out each cable and verifying the cable tags.

Where shielded cables are used, all shields must be grounded. Normally these shield grounds are done using ground braids and ground connectors provided for that purpose on the housing. The termination detail drawings provided with the job will show more details on how to complete the cable shield grounding.

Figure 9 Insulation of Medium Voltage Cable Termination

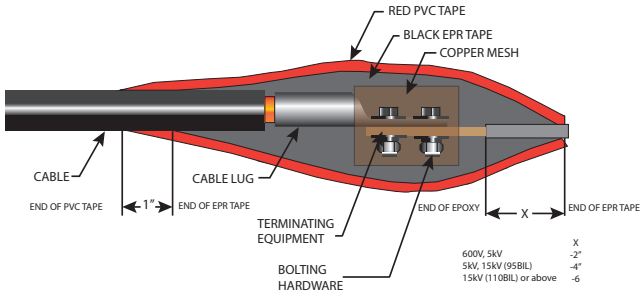
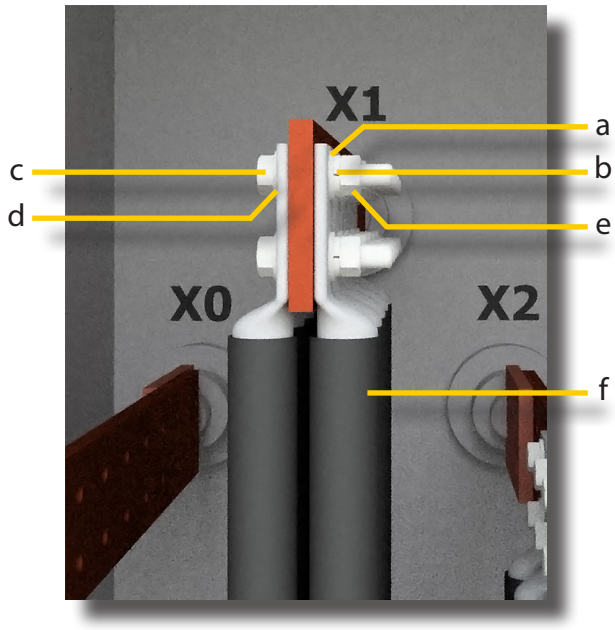


Figure 10 Insulation of Low Voltage Cable Terminations



a. Flat Washer
b. Lock Washer
c. Hex Bolt 1/2-13
d. Flat Washer
e. Hex Nut
f. Heat/Cold Shrink

The final step in completing the cable terminations is insulating all bolting connections with copper mesh, EPR tape, and PVC tape.

NOTICE

When there are no disconnecting switches available to isolate the cables from the remainder of the electrical system all required checks before energizing must be completed prior to insulating all terminal connections.

Before finalizing the terminations all vapor and fire stop barriers should be completed, refer to *Ch 4 Installation, N. Environmental Seal Assemblies* and *O. Fire Stop Barrier Assemblies*, all top covers installed, *Ch 4 Installation, P. Top cover, Wall Plate, & Solar Shield Assemblies*, and cable reliability checks (megger or hipot test) performed accordingly as described in *Ch 5 Installation, R. Checks Before Energizing*.

Terminations should be finalized with one half-lapped layer of copper fill mesh applied over the connection hardware first. Then 1 inch wide EPR splicing compound must be applied above all non-insulated surfaces as shown in *Figure 9*. The number of EPR tape half-lapped layers needed and the insulation overlap is determined by the voltage rating:

- Up to 5kV - 2 (two) half-lapped layers of EPR tape should be applied 2" beyond bare conductor surfaces on each side.
- Up to 15kV (95 BIL) - 4 (four) half-lapped layers of EPR tape should be applied 4" beyond bare conductor surfaces on each side.
- 15kV (110 BIL) & Above - 6 (six) half-lapped layers of EPR tape should be applied 6" beyond bare conductor surfaces on each side.

At the end, 2 (two) half-lapped layers of flame retardant PVC jacketing tape should be applied 1" beyond the EPR tape on both sides as shown in *Figure 9*.

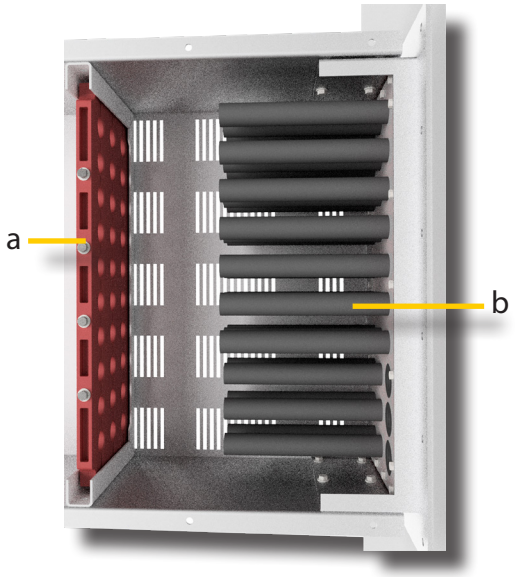
N. Environmental Seal Assemblies

Environmental 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 should 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 environmental seal. Powell generally provides environmental seals on all cable bus ends with custom designed, split 1" thick seal plates furnished for each specific system requirement.

Seal plates should be already installed as was described in *Ch 4 Installation, K. Cable Loading* and shown on *Figure 6*. 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 in *Figure 11* with sealing compound – silicone caulk around the seal plate and all cables to create the seal. This is for a case where the metal-enclosed cable bus is running horizontally and the seal plate is placed on a vertical plane.

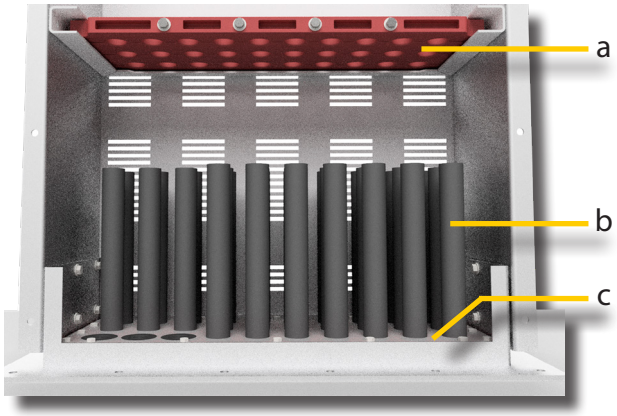
Figure 11 Horizontally Positioned Vapor Barrier Assembly



a. Cable Bus Support Kit
b. Cable

In a situation where a vertically positioned vapor barrier is required, silicone caulk is used around the seal plate and all cables. This is for a case when the metal-enclosed cable bus run is vertical, while the environmental seal plate is on a horizontal plane. Then, a two-part self leveling sealant is used on top of the seal plate to finalize the vapor barrier. The sealant 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 should be strictly followed in order to achieve a complete seal. Vertical vapor barrier configuration is shown in *Figure 12*.

Figure 12 Vertically Positioned Vapor Barrier Assembly



a. Cable Bus Support Kit
b. Cable
c. Two Part Self-Leveling Sealant

O. Firestop Barrier Assemblies

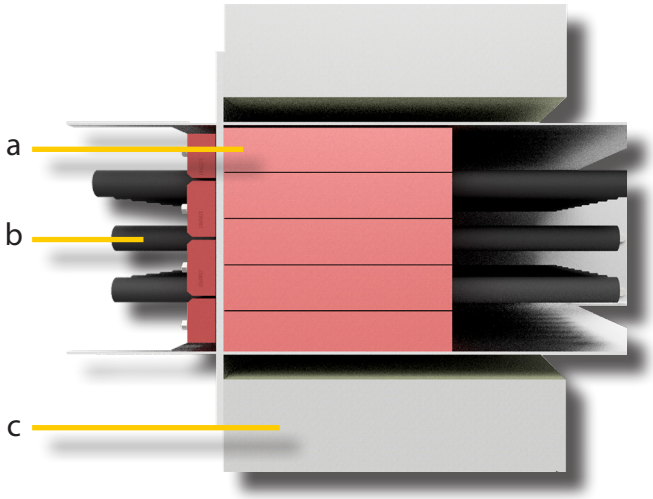
For all firestop system requirements, installation details, and final configuration, refer to the applicable OEM firewall kit and firestop information provided within the project-specific OEM drawings and documentation.

In addition to the manufacturer's specific instructions, follow these steps that are specific to cable bus installation.

1. Pull the first set/row of cables into the bus duct enclosure, position and secure them in place.
2. Begin installing firestop blocks around that set/row of cables and trimming as needed to match the cable radii.
3. Repeat the process; pull the next row of cables and secure them in place, then install the next layer of firestop blocks around and above the cables.
4. Fill remaining voids and perimeter gaps using trimmed pieces from the same firestop blocks.
5. Compress the firestop blocks tightly to eliminate gaps and maintain passive fire pressure.

The provided engineering sketch shows installation of firestop blocks inside a cable bus housing for information only.

Figure 13 Firestop Block Assembly - Cross Section View



a. Firestop Block(s)
b. Cable(s)
c. Wall

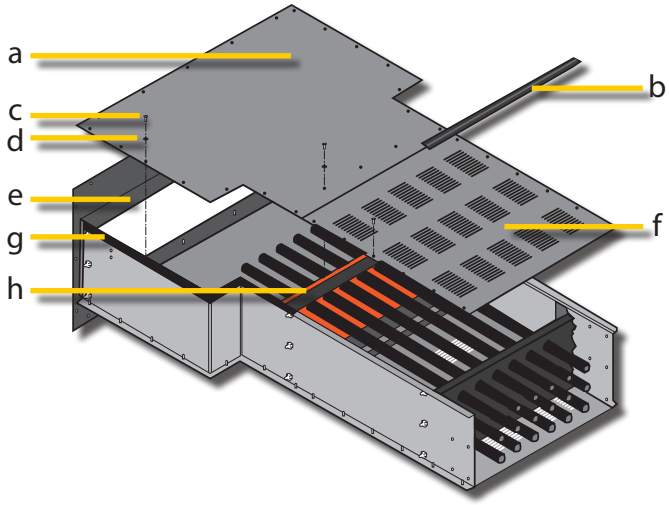
Proper procedures help ensure a trouble free installation and a long service life. All sections containing firestop barriers must have sufficient clearance from walls and ceilings to provide easy access, both for original installation and for maintenance, including the possible removal of a section.

Alternative fire rated penetrations are available with Multi Cable Transit (MCT) kits and frames. Please refer to the instructions provided by the MCT kit manufacturer for installation of those systems.

P. 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 should be installed first; shorter covers can be cut down to size as needed.

Figure 14 Top Cover Assembly on Outdoor Bus End Section



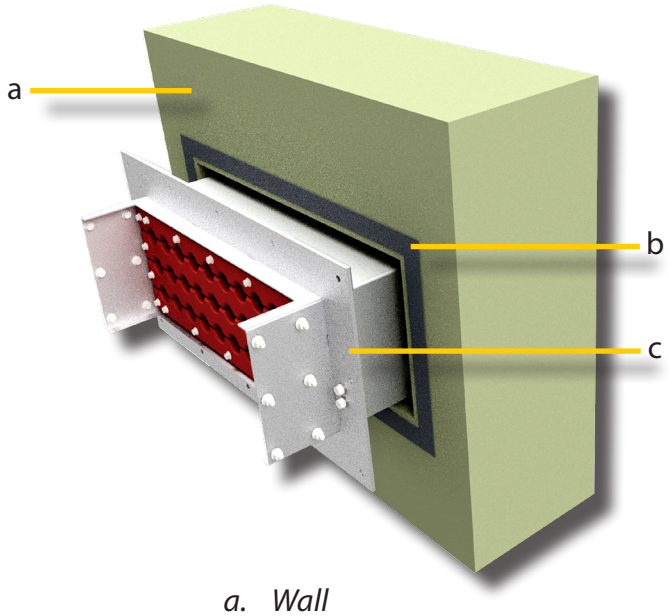
a. Solid Top Cover
b. Joiner Strip
c. TEK Screw
d. Seal Washer
e. Bus End Flange
f. Vented Top Cover
g. Gasketting
h. Vapor Barrier

Every top cover should be positioned and clamped in place before all TEK screws (which are self drilling and tapping) are applied to fasten the cover to the side rail following the drilling pattern from the cover. The joiner strips should 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.

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 14* above 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 15*.

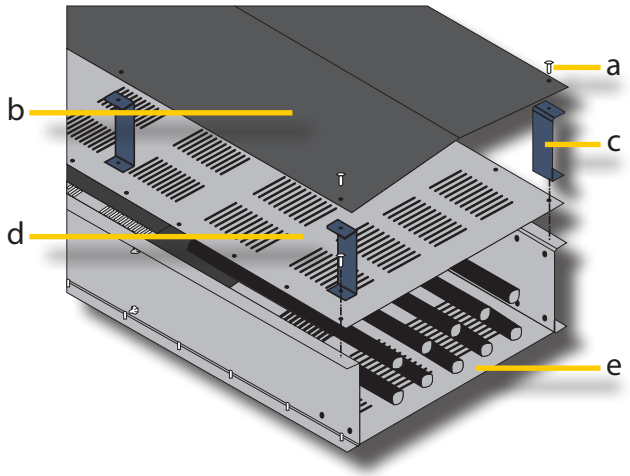
Figure 15 Typical Metal-Enclosed Cable Bus Wall Assembly



a. Wall
b. Gasket
c. Wall Kit Assembly

Solar shields (sun shields) are used in case of direct sun exposure by customer request only and are normally attached along with the top cover in outdoor sections only. Sun shield installation is shown on *Figure 16*.

Figure 16 Solar Shield Assembly



a. TEK Screw
b. Solar Shield
c. Solar Shield Bracket
d. Top Cover
e. Bottom Cover

Q. 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 can not be assumed by Powell.

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.

A continuous insulated or bare cable for neutral use or grounding is also an available option. When specified in the Powell Bill of Material, UL listed bonding clamps may be included to connect grounding cables along the cable bus housing. When provided, bonding clamps should be installed every 60 feet. Field drilled mounting holes may be required and should match the bolting hardware of the bonding clamp.

For Catalog Orders, grounding and bonding clamps shall be ordered separately. A list of commercially available conductor clamps that are approved for use in Powell Cable Bus is available

R. Checks Before Energizing

Before energizing the metal-enclosed cable bus for the first time, several checks shall be performed. To perform these checks, the cables must be isolated from the remainder of the electrical system. If disconnect switches or circuit breakers are available to isolate the metal-enclosed cable bus, open these devices. If there are no disconnecting devices available, unbolt the last connecting link at the end of the metal-enclosed cable bus.

Check the phasing of the metal-enclosed cable bus from end to end to insure that the connected apparatus is properly phased. This phasing check can be made with a bell set, a buzzer, or an ohmmeter. Check each phase for continuity, and to be sure it is not connected to any other phase or to ground.

Perform an insulation resistance test. Use an insulation resistance tester rated at least 500V. Check each phase by connecting the other two phases to the grounded enclosure and measuring between the phase under test and the enclosure.

Insulation resistance is a function of the length of a metal-enclosed cable bus, the number of bus supports, the number of conductors per phase, and other factors, preclude determination of a fixed value of insulation resistance. For a new, dry installation, any resistance less than one megohm per kV of rated voltage should be questioned. Record the values obtained from this test for future use in the maintenance of the bus. See *Ch 5 Maintenance* for further information.

In case of shielded power cable, the use of high voltage DC hipot testing is standard for checking cable reliability. The field test voltages are directly proportional to the cable insulation thickness. The test voltage should not exceed 75% of the 60Hz hipot voltage given in *Table B Cable DC & AC Hipot Field Test Voltage* for the class of bus being tested. If it is desired to perform a power frequency withstand test (AC "hipot") on the bus conductors, the test voltage should not exceed 75% of the hipot voltage given in Table A for the class of metal-enclosed cable bus being tested.

Once these checks have been made successfully, reconnect and reinsulate any connections that were disconnected for the checks, and replace any covers removed. The metal-enclosed cable bus should now be ready for energizing.

S. Energizing the Metal-Enclosed Cable Bus

⚠ WARNING

The metal-enclosed cable bus is a component of a high power electrical system. Operation of electrical power systems should be done only by experienced personnel qualified in the operation of such systems. Failure to do so could result in death or serious injury.

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

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.

There should be no load on the metal-enclosed cable bus when it is energized. Since the assembly typically extends between two pieces of electrical apparatus, care should be taken to see that all devices fed from the metal-enclosed cable bus are switched to the "OFF" position before energizing the metal-enclosed cable bus.

Confirm that overcurrent protective devices on the source side of the bus are in place and operating properly before energizing the metal-enclosed cable bus.

Energize the metal-enclosed cable bus by closing the switching device which feeds it. Check along the length of the metal-enclosed cable bus to be sure no abnormal operating conditions are evident. The metal-enclosed cable bus is now ready to be loaded by closing switching devices feeding loads through the metal-enclosed cable bus.

Table B Cable DC & AC Hipot Field Test Voltage

Rated Voltage (kV)	BIL Rating (kV)	AC Hipot Dry (1 min) (kV)	Cable Insulation [mills (%)]	DC Hipot (kV)
5	60	14	90 (100%)	21
			115 (133%)	26
8	95	27	115 (100%)	26
			140 (133%)	31
15	95	27	175 (100%)	40
			220 (133%)	48
15.5	110	37	175 (175%)	40
			220 (133%)	48
25	125	45	260 (100%)	59
			320 (133%)	72
35	150	60	345 (100%)	75
			420 (133%)	93

Note: *Hipot testing is typically not required for Cable Bus Systems rated <1000VAC.*

Ch 5 Maintenance

NOTICE

Before attempting any maintenance work, it is important to study and fully understand the safety practices outlined in Chapter 2 of this instruction bulletin. If there is any reason to believe there are any discrepancies in the descriptions contained in this instruction bulletin, or if they are deemed to be confusing and/or not fully understood, contact Powell immediately.

Inspect bus assemblies in normal service once a year or after any severe electrical fault. Bus assemblies operating in severe environments, such as excessive dust, salt spray, chemical vapors, etc., may require more frequent inspection. Bus assemblies operating in clean, dry, indoor locations may need inspection less frequently.

⚠ WARNING

Prior to removing any covers for service, deenergize the metal-enclosed cable bus, open switching devices at both ends of the metal-enclosed cable bus, and ground the source conductors. Failure to do so could result in death or serious injury.

Remove the covers from the metal-enclosed cable bus and examine the interior for any moisture or signs of previous wetness. Replace or thoroughly dry and clean any insulating material which is damp or wet or shows accumulation of deposited material from previous wetting. For indoor assemblies, eliminate the source of any dripping onto the metal-enclosed cable bus and any other source of moisture. For outdoor assemblies, seal off any cracks or openings which have allowed moisture to enter the metal-enclosed cable bus or its connection boxes.

Thoroughly clean any accumulation of dust and dirt by using a brush, vacuum cleaner, or clean lint-free rags.

Carefully inspect for signs of overheating at terminations or deterioration in insulating material. Check tightness of hardware in accordance with *Table A Bolt Torque Values for Bus Assemblies*. If joints or terminations appear to be badly discolored, corroded or pitted, or show evidence of having been subjected to high temperatures, the parts should be disassembled and replaced or cleaned.

Check the insulation resistance prior to reenergizing the metal-enclosed cable bus, using the insulation resistance test described in *Ch 4 Installation, R. Checks Before Energizing*. Keep a permanent record of resistance readings. If readings decrease appreciably with time, deterioration is taking place. If this occurs, find and correct the cause of the insulation deterioration before reenergizing the bus.

Replace the covers and secure them properly. Reenergize the metal-enclosed cable bus, observing the precautions given in *Ch 4 Installation, S. Energizing the Metal-Enclosed Cable Bus*.

Ch 6 Recommended Renewal Parts and Replacement Procedures

Metal-enclosed cable bus enclosures, conductors, and insulation systems do not include any parts that are normally subject to wear or that would normally require replacement during the useful life of the assembly. If routine maintenance reveals parts that require maintenance, they should be ordered at that time.

Order renewal parts from Powell at *powellind.com* or call 1.800.480.7273.

Order any necessary parts from Powell. Identify the metal-enclosed cable bus for which parts are required by the Powell work order on which it was furnished. The order must be accompanied by a full description of the part or parts needed. If possible, include a copy of the Powell drawing for the assembly with the required parts identified. If this is not possible, a sketch or photograph of the required part should accompany the order.

Powell recommends that only factory trained technicians perform maintenance on this equipment.

POWELL

01.4IB.81000
Metal-Enclosed Cable Bus

600V - 38kV, 800A - 6000A

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