AZZ | CALVERT

Isolated Phase Bus

Receiving, Storage, Installation and Preventative Maintenance Manual

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Foreword

Calvert custom designs and manufactures the Isolated Phase Bus (IPB) to project specific requirements and conditions. Therefore, each Isolated Phase Bus System will differ somewhat and will require the installation personnel to have access to the project design drawings and bills of materials (BOM) for each phase of the installation. This O&M manual is intended as a guide to aid the receiving, storage, installation and preventative maintenance personnel through each phase of the process.

The Calvert design drawings offer exact project design, location and installation requirements. The actual site installation requirements may differ slightly from the O&M manual depending on actual specified design requirements. Installation personnel should verify that what is stated in this O&M Manual concurs with the specific project design drawings prior to proceeding with installation. However, note that the concept for all receiving, handling, storing, installation and preventative maintenance remains the same for all projects.

NOTE: A Calvert Installation Services (CIS) Site Representative can help you through the installation process. From replacement parts to turnkey installation, Calvert can supply your needs. Contact CIS at the number or address listed later in this manual.

The Calvert Project Operational Manual (POM) is a complete data, design, installation and testing manual. The POM contains:

- All project specific technical design data
- Design drawings
- Drawing lists
- Specified test reports
- MSDS documents
- Component data
- Component catalog cut sheets
- Component test reports
- Operational data and test reports of subcontracted equipment or parts
- Support structure load data
- Special operational data and procedures, and
- Any specified special safety or environmental concerns.

Please confirm that all drawings contained within the POM are the latest revision. Revisions in design are sometimes made after the POM has been submitted as final. The Drawing List will show all latest revision numbers applicable to the design drawings. If any design drawings are found with a later revision, all POM's should be updated with the latest revision of the design drawing(s). Contact Calvert's Project Management Department for assistance.

To insure all design drawings are of the latest revision please request a drawing list from Calvert's Project Management Department.

The Bill of Material (submitted with the final design drawings) and Packing List (submitted with the shipment) are useful to both the receiver and installer to identify equipment by item or drawing number, unit number, bus run number and by crate number. The BOM references all part numbers, design drawing numbers, descriptions, quantities, unit and run numbers and

whether the specific equipment is factory attached or shipped loose. The BOM and Packing List designations as to how equipment is shipped are as follows:

"**A**" - refers to factory attached
"**D**" - refers to Shipped Direct (drop-shipped from a sub-supplier)
"**X**" - is a special designation (instructions will be noted on the BOM and Packing List)

NOTE: No designation in the block means the item(s) is/are shipped loose

Keep in mind that an item that is factory attached will be attached to another BOM item. Examples of shipped attached items are seal-off bushings, heaters, flanges, etc. The Packing List is basically identical in structure to the BOM. However, the packing list also identifies the crate number that each specific piece of equipment is packed. The bill of lading contains the weights and dimensions of each crate.

Prior to beginning any installation, Contact Calvert's Project Management Department to verify that you have the latest revision of the design drawings. Any revisions can be sent directly to the project site, via e-mail, if there are no restrictions against this action.

NOTE: All receiving and installation personnel must be fully trained in all site safety and handling requirements. Calvert assumes no responsibility for personnel injury for violations in safety related issues or for damage to equipment from improper storage, handling or installation.

If you have questions concerning receiving and storage, installation or preventative maintenance of any Calvert supplied product contact:

Calvert's Project Management
(601) 939-9191 Ext. 2203
(601) 939-9191 Ext. 2204
(601) 939-9191 Ext. 2211

Calvert Installation Services (CIS)
Emergency Service (601) 939-9191 Ext. 2501
Parts (601) 939-9191 Ext. 2505

The Calvert Company
120 Aztec Drive
Richland, Mississippi 39218 (United States)
Phone: 601-939-9191
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Email: Calvert@azz.com

Table of Contents

Equipment Description

Calvert's Isolated Phase Bus (IPB) is a bus system in which each phase (pole) conductor is both supported and enclosed within it's own enclosure. The conductor and enclosure are circular in shape and are manufactured from high conductivity aluminum. The conductors are generally non-insulated and manufactured from extruded tube 6101 alloy (12" and less in diameter) or rolled plate1100 alloy (greater than 12" in diameter). The IPB system is of a fully welded construction. All elbows and taps are factory welded. Field welding consists of splice joints at shipping splits, bonding plates and expansion joints. See final design drawings for additional job specific welding. All joints and parts to be field welded are factory beveled and/or weld prepped and have been masked during the factory painting process.

Conductors and the interior of enclosures are painted with a high temperature rated flat black finish for heat dissipation. The exterior of the enclosures are finished with the specified color and thickness of paint.

The conductor is supported within the enclosure by porcelain insulators (or epoxy if specified) mounted to castings that are welded to the enclosure. Depending on the design of your system there may be 1, 2, 3 or 4 insulators per location. Each insulator assembly is fully removable as one assembly simply by removing the six bolts that fasten the insulator mounting casting to the enclosure casting.

The IPB system is a very strong structure so centerline distances between steel supporting structures may be greater than shipping splits. However, since the system is manufactured from aluminum, it is very easy to lift and handle. (Refer to the IPB cross section drawings for the actual weight and dimensions of your particular bus system) Although Calvert puts forth every effort to supply a bus system that provides the lowest "total installed cost", the IPB system and steel support structures are designed with the system in a fully installed/operational state in mind, not necessarily with ease of installation.

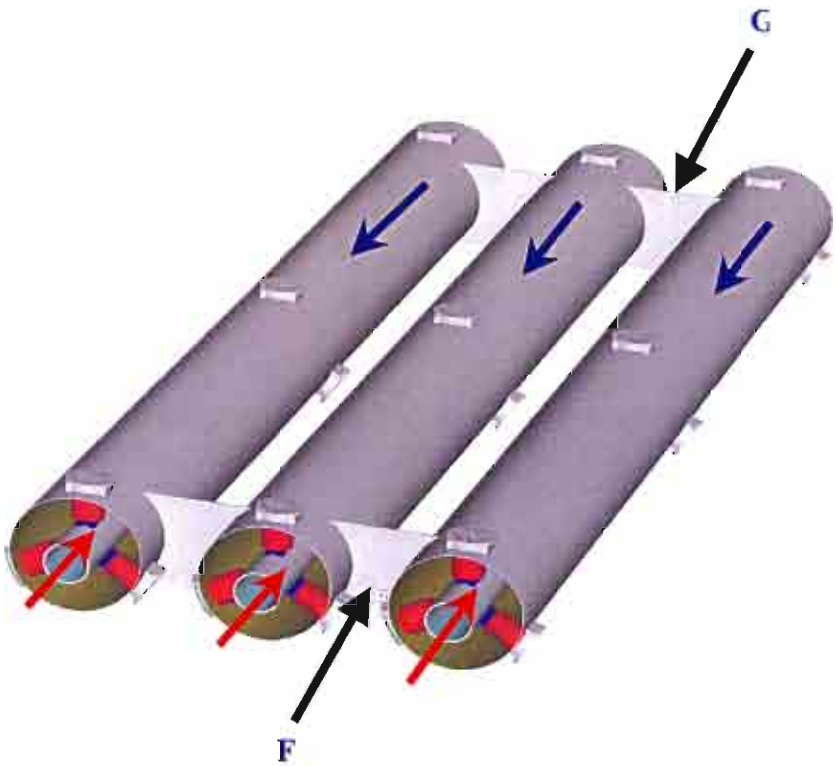
Refer to the installation section for techniques that will help save time and effort during the installation process.

Calvert's IPB system is a totally sealed system, unless otherwise specified, once installation has been completed. All conductor and enclosure splice joints are welded and terminal interfaces have insulating bellows clamped in place to prevent intrusion of moisture or other contaminants. Every effort is placed on cleanliness at the factory prior to sealing the ends of each section so that field cleaning is kept to a minimum.

Calvert's IPB system is both isolated and insulated from all ground points such as supporting steel, wall penetrations and terminal interface points with other equipment. The design also ensures that no mechanical or thermal loads are applied to interfacing equipment by utilizing the conductor flexible connectors and enclosure bellows assemblies.

Theory of Operation

Calvert's IPB system is a "no-flux" or "continuous" enclosure design. The continuous enclosure was chosen by The Calvert Company to insure that inductive heating is reduced to a minimum and that enclosure voltage relative to ground is limited to the IR drop. The direction of current in the enclosures will be opposite and equal in value to the conductor currents as indicated by the appropriate arrows on the enclosures. These enclosure currents will flow because of the completed circuit formed by either the bonding plates or bonding bars (Item F and G.



In this practical bus, the enclosure does have resistance so that some flux must escape in order to drive current through the enclosures. Laboratory and field tests have shown the external flux to be approximately 5% of that which would exist if the enclosures were absent. The fact that no insulation is required with the "no-flux" bus assures that voltages generated in the enclosure and appearing between enclosure and ground will be low; in fact they are very near zero. The voltage drop along the enclosure will mainly be the "IR" drop which, because of the low resistance of the enclosure, will also be low.

NOTE: Calvert's IPB system is designed to be a single point grounded system. Please refer to the grounding section of this manual for details concerning grounding the IPB system.

Receiving and Storage of Equipment

On Site Inspection

NOTE: The Calvert Company will not be responsible for shortages or damage if not notified within fourteen (14) days after receipt of the shipment.

1. Receiving Inspection:

    a. Receiving starts when the items arrive at a storage facility or construction site before unloading or unpacking from shipping vehicle.
    b. Preliminary visual inspection or examination shall be performed prior to unloading to determine if any damage occurred during shipping.
    c. If any damage has occurred during shipment contact the factory immediately.

2. The Bill of Material supplied with the project is to be used for incoming inspection. The Bill of Material will show the following:

    a. Item number
    b. Reference drawing description number
    c. IPB Section (number and/or letter)
    d. P.O. number
    e. Quantities and description of all associated materials for the stated run

3. All IPB sections will be marked as shown on the Bill of Material (i.e. M3A/CD). These end markings correspond to the housing splice and bus end numbers found on the layout drawings. See layout drawings for specific section markings.

4. Crate Markings will always include Calvert's Job Number and sling markings. At the Customer's request, the following information can also be included:

    a. Crate number
    b. Purchase Order number
    c. Weights and Dimensions

Proper Handling of Equipment

Calvert ships the IPB on flat bed trucks and packages the IPB and related equipment on wooden crates. The crates are generally 8' wide x 8' high and vary in length from 20' to 40' and have an average weight of less than 15,000 lbs. per crate (Note that steel support structure crates may weigh up to 20,000 lbs. each). The Bill of Lading will detail the actual weights and dimensions of each crate on your project.

Calvert factory-seals each IPB shipping section end with heavy mil sealant that is banded to the enclosure ends. In addition to the end seals the conductor is supported at each enclosure end with internal bracing.

Note: Due to possible damage to internal components, the end seals or the internal bracing **shall not** be removed until the IPB shipping section has been lifted and fitted into its designed location.

The recommended method of unloading the crates from trucks or moving the crates around the project site is by overhead lifting with nylon slings. Spreader bars may be required between slings if equipment exceeds 20 feet in length. Fork trucks are not recommended for moving bus duct due to the damage that could be caused to the IPB. Fork trucks or other small portable lifting equipment can be used to lift and move small loose parts, small crates (crates with a maximum dimension of 6 feet or less) and unassembled steel support structures.

Preferred lifting method

Standard Storage for Bus Duct and Accessories

1. General

   1.1 These storage procedures are predicated upon a moderate environment without corrosives in the atmosphere such as salt spray or chemical by-products and which is not subject to high humidity or extreme temperature variations during a 24-hour period.

2. Storage Environment

   2.1 Some bus duct components are sensitive to environmental conditions such as the effects of temperature extremes, humidity, corrosives, airborne & chemical contamination and physical damage. These items require indoor storage.

3. Indoor Storage

   3.1 The following equipment is recommended for indoor storage. The storage site must be weather-tight and well ventilated. Precautions should be taken to prevent vandalism. The storage area should be situated and/or constructed to prevent flooding. The floor shall be well drained and all items should be placed on pallets or shoring to permit air circulation. The site should provide uniform heat and temperature controls to prevent wide temperature variations and condensation.

   3.1.1 Bus duct sections
   3.1.2 Material boxes

3.1.3 Neutral grounding cubicles
3.1.4 Surge protection & potential transformer compartments
3.1.5 Disconnect switches and switch compartments
3.1.6 Current transformers
3.1.7 Lightning arrestors
3.1.8 Capacitors
3.1.9 Grounding transformers
3.1.10 Resistors
3.1.11 All rigid and flexible connectors – see paragraph 6 for special maintenance procedures applicable to silver-plated connectors.
3.1.12 Hardware and other small items
3.1.13 Instrumentation such as thermometers, flow meters and other wired devices.
3.1.14 Installation items such as greases, paints, tapes and gaskets
3.1.15 Structural steel
3.1.16 Primed structural steel – The first field coat of paint is to be applied within a reasonable period after receipt, and in any event before the weathering (and required touch-up of the shop coat) becomes excessive. This is usually within 3 to 7 months for a single shop coat under normal atmospheric conditions
3.1.17 Main transformer compartments when insulation is part of the compartment assembly
3.1.18 Main transformer compartment insulation
3.1.19 Seal-off bushings
3.1.20 When shipping container or packing list is marked "Indoor Storage Required", all equipment in the container must remain indoors.

4. Outdoor Storage (Less than 6 months)

Although outdoor storage is not recommended, in the event that the equipment cannot be stored indoor, the following will apply:

4.1 Bus duct equipment may be stored outdoors in an area designated and marked for storage purposes. This area is to be well drained and gravel covered or paved. The storage area should be reasonable removed from the actual construction site and traffic to minimize the possibility from construction damage. Equipment shall be stored on pallets or shoring to allow air circulation and water drainage.
4.2 A weatherproof covering is recommended for all equipment in outdoor storage. It must be a flame resistant material or tarpaulin. The covering should be placed to provide adequate drainage and allow air circulation to minimize condensation. The covering shall be tied down to secure it during inclement weather. Holes should be punched in the shipping plastic at the lowest points to allow condensation to drain.
4.3 Items stored outdoors shall be positioned and covered to avoid trapping water in pockets. For example, ninety-degree covers should be positioned so that water does not form a pool inside welded joint.
4.4 When coverings are secured to the bus sections, metal strapping must not be used.

5. Outdoor Storage (Greater than 6 months)

5.1 If it is known upon receipt of equipment that the storage period will exceed six (6) months, then it is recommended that bus or components having silver-plating be stored initially as described below:

5.1.1 The equipment shall be stored within a weather-tight and well-ventilated building. Precautions should be taken to prevent vandalism. The storage area should be situated and/or constructed to prevent flooding. The floor shall be well drained and all items should be placed on pallets or shoring to permit air circulation.

6. Silver-Plated Connectors

6.1 Special care is required to protect silver-plated contact surfaces. All silvered surfaces are coated with a layer of VpCI-316 or a protective grease for protection.

6.1.1 Each piece of equipment must be inspected upon arrival. Any silver-plated connections found to be exposed must be coated with VpCI-316 or a protective grease.

6.1.2 If the equipment is stored indoors, the silver-plated surfaces will require maintenance at least once per year as follows:

A. Uncover silver-plated connections (if required).
B. Remove existing VpCI-316 or protective grease and clean the silvered surfaces with a clean cloth.
C. Reapply new VpCI-316 or protective grease.
D. Recover connections.
E. After completion of steps A thru D, cover the bus sections as originally done. Be sure that the enclosure end is completely sealed and taped. Punch holes at the lowest point of the plastic wrap to allow condensation to drain.

Note: If silver-plated bus must be stored outdoors for more than six (6) months, follow the maintenance steps outlined in paragraphs 6 thru 6.1.2 (A –E) with the exception that the maintenance shall be performed every six months.

7. Welded Flexible Connectors

7.1 Bus duct assemblies or conductor assemblies with welded flexible connections are extremely sensitive to physical damage. Special precautions should be taken to ensure that they are not damaged while in storage.

8. Galvanized Structural Steel

8.1 During normal outdoor service, galvanized steel/zinc builds up a natural patina, which ensures long service. Under poor storage conditions, severe damage can occur in a matter of weeks. The resultant corrosion is known as "wet storage stain". It is a white crusty deposit made up of zinc oxide and zinc carbonate. Such corrosion is common when galvanized equipment is stacked together. When moisture is present between galvanized equipment, a galvanic cell is created, which breaks down the protective zinc coating and hastens corrosion.

8.2 Upon receipt of galvanized steel, the following precautions should be taken.

8.2.1 Protect the equipment from rain and water spray.
8.2.2 Never place the steel on the ground. Allow at least one foot of space.
8.2.3 It is preferred that all galvanized steel be stored indoors as outlined in section 3. If outdoor storage is necessary, the following guidelines should be followed.

A. Water must be allowed to drain freely. Store materials in such a way that rainwater cannot pool.
B. Steel should be stacked so that air can circulate. It is recommended that spacers be placed between layers to minimize contact between equipment.
C. If wood is used, it should not be overly resinous. Do not use uncured or untreated lumber.

9. Equipment Inspection

9.1 Indoor Inspection

9.1.1 Equipment stored indoors is to be inspected on a BI-monthly basis for physical damage and cleanliness. Ensure that all identification markings and tags are intact. Clean up any dirt, oil residue, metal chips or other contaminants found on or near the equipment. Check all packing and sealing plastic to ensure that it is not torn or missing. Replace packaging as required.

9.2 Outdoor Inspection

9.2.1 Equipment stored outdoors is to be inspected on a monthly basis for physical damage and cleanliness. Ensure that all identification markings and tags are intact. Clean up any dirt, oil residue, metal chips or other contaminants found on or near the equipment. Check coverings to ensure that they are not ripped or damaged. Verify that the covering is placed so that drainage is adequate and water does not pool. Ensure that all tie-downs are fastened properly. Check all packing and sealing plastic to ensure that it is not torn or missing. Replace packaging as required.

10. Warranty Limitations

10.1 In no case will the following of these procedures by the purchaser obligate The Calvert Company beyond the contractual warranty period.

10.1.1 Buyer assumes all risk of loss and damage during storage.
10.1.2 Under no circumstances should the field attempt to repair or dismantle the bus duct unless authorized by The Calvert Company. Failure to comply with the requirement may cause loss of warranty.
10.1.3 All cost associated with the preparation for and storage of the isolated phase bus shall be to the account of the buyer unless expressly stated provisions for storage preparation have been contracted for on the purchase order.

Pre-Installation Checks

Preparation for Installation

Planning the proper installation sequence can save you time, money, rework and scheduling problems. Calvert's Site Representative can help you plan the best solution for each particular site. If a Calvert Site Representative has not been requested, a representative can usually be arranged and arrive at your project location within 48 hours for visits up to three days. If extended site supervision is required (more than 3 days), please inform Calvert of the required timeframe you prefer and a site representative will be scheduled for your particular needs. Please allow 4 weeks lead-time for extended stays.

Location of Equipment on Shipping Crates

All Calvert supplied equipment can be located by crate number. The crate number is stenciled on the box, on a wooden area of the crate, or, for international shipments, on a placard attached to the crate. A packing list is also attached to each individual crate. The equipment and the associated crate number are shown on the packing list.

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SHIPPING MEMO / PACKING LIST

120 Aztec Drive
Richland, MS 39218
Phone: 601-939-9191
Fax: 601-420-8334

JOB NUMBER 3-8528 BOM 231 & BOM Spare Parts — SHIPPING MEMO NO.: 22659

P.O. NUMBER ABC12345 — CRATE NO.: 1

SHIP TO:
ABC Warehouse
987 Lakeland Drive
Chicago, IL 99098

SOLD TO:
ABC Electrical
P. O. Box 568
Chicago, IL 99099

SHIP DATE 5/5/2005 — SHIP VIA Holmes Trucking

QTY REQ'D	QTY SHIP	UM	GT NO	REV NO	DWG/PART NO	ASSY REQ'D	ITEM NO	DESCRIPTION	PART SIZE or DESCRIPTION
								BOM 231	
1	1	EA	72		E-6462-127-A2		A.06	BUS SECTION M231CB-M231CC	KKS No. 23BAA21GA101
1	1	EA	72		E-6462-127-A1		A.07	BUS SECTION M231AC-M231AD	KKS No. 23BAA21GA101
								SPARE PARTS Box #1	
6	6	EA	72		3100705R		A.01	INSULATOR, IPB, POST	36KV, 150KV BIL
6	6	EA	72		3100719		A.02	GASKET, ENCLOSURE	IPD
6	6	EA	72		3100740I		A.03	COVER PLATE	10 3/8" O.D.

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Typical Packing List

Proper Handling of Crates from Storage to Installation Area
Once the proper crate has been located, the crate will need to be moved to the installation area. The recommended method of lifting the crates at the job site is by overhead lifting with nylon slings. Spreader bars may be required between slings if equipment exceeds 20 feet in length. Fork trucks are not recommended for moving crated equipment (unless fork truck is rated for the lift and has fork lengths that exceed 100") due to the damage that could be caused. See proper lifting technique illustrations in the Receiving and Storage section of this manual.

Note: The end users (or on-site) lifting and handling procedures take precedence over this manual's instructions.

The crates should be moved to the installation area by means of an open bed transport vehicle. Each crate should be strapped to the vehicle as shown below.

Relocating Bus Duct from storage to job site

Cleaning Equipment Prior to Installation
Once the equipment has been removed from the receiving or storage area a full visual inspection should be performed to insure no damage was done during the transit of equipment to the installation area.

After the equipment has been delivered to the installation area, an inspection of end seals and lifting damage should be performed. **Factory end seals and factory conductor end bracing should have arrived at the installation area without damage or removal.** A visual inspection should be performed for lifting damage such as gashes, cuts, dents and paint damage. Any damage to factory end sealing, shipping bracing or lifting damage should be immediately documented.

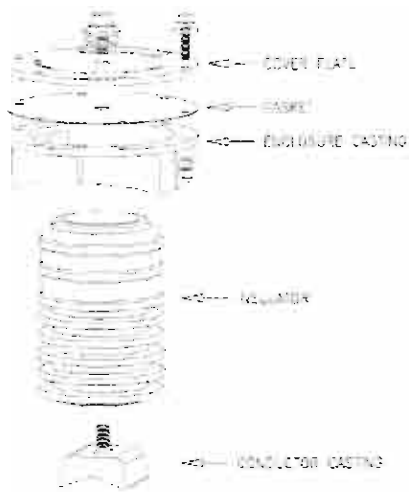
Note: Calvert's Project Management Department should be notified of any damage and copied on any damage reports immediately (regardless of time of occurrence) to insure that the Calvert factory warranty is not compromised.

If the factory end seals have been damaged or removed, a complete internal (enclosure) inspection must be performed on the items found to be to be compromised. If dust, dirt, debris

or water has accumulated inside the enclosure or on the conductor, the entire area(s) affected must be thoroughly cleaned and dried prior to installation.

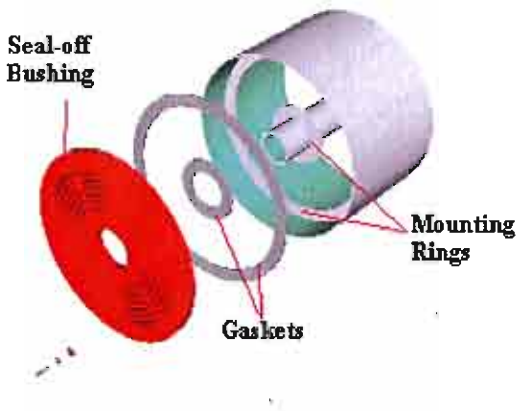
Warning: If the conductor end bracing shows signs of damage or has been removed, each porcelain insulator within that shipping section must be inspected for damage due to the cantilever force applied to the insulator from the conductor being out of center of the enclosure.

If the insulator and castings show no visual signs of damage, more than likely there will be no need to replace the insulator(s) and/or the casting assemblies. However, it is recommended that either the insulator(s) be Hi-Pot tested prior to re-installation and/or the insulator(s) location should be documented so that during the final testing phase (after installation is complete), if a problem arises, the insulator(s) that may be causing test failure can be quickly identified and replaced, if necessary.



Insulator Assembly

If the IPB section has seal-off bushings factory installed, and the end bracing has been removed or damaged, the factory seal of the seal-off bushing assembly may have been compromised. Also, if end bracing has been removed or damaged, verify that the cantilever force placed on the seal-off bushing mounting rings has not caused the rings to bend in a manner to where the seal-off bushing is no longer perpendicular to the enclosure.



Seal-off bushing

Cleaning the IPB for Dust, Dirt or Debris

If the IPB has been subjected to dry dusty environments, a general interior cleaning may be required prior to installation. Generally only water-wet rags are required to remove dust, dirt and debris. However, keep in mind that some IPB sections may be as long as 40 feet. Temporary cleaning poles 20 feet or longer may be required to adequately reach areas towards the center of the IPB section. Particular attention should be placed on the conductor supporting insulators. Do not damage the insulators during cleaning. The insulators can be quickly removed and re-installed if required for cleaning.

Cleaning the IPB for Water/Moisture

If the interior of the IPB enclosure is found to have accumulations of water, all water must be removed prior to installation. The IPB system must remain completely free of moisture during the installation process. The preferred way to remove moisture from the IPB is to first elevate one end of a shipping section to drain out excessive moisture and then place a heater fan at the lowest end to provide airflow until internally dry. The insulator castings will tend to hold water so the IPB section will need to be rotated to a position that will allow the moisture to escape the insulator castings. Once the section(s) is completely dry the IPB section(s) ends should be temporarily re-sealed to prevent moisture and contaminants from re-entering the section until the section(s) is ready for installation.

Potential Transformer (PT)/Surge Arrester (SA) Cubicles

PT/SA Cubicles are used together to provide a metering and relaying cabinet along with the ability to provide protection for the generator using capacitors and surge arresters.

Voltage (Potential) Transformers are used to transform primary voltage to a nominal safe value, usually 120 V. The primary rating normally is that of the system voltage, though slightly higher ratings may be used, that is, a 14,400 V rating on a 13,800 V nominal system. These transformers are used to isolate the primary voltages from the instrumentation, metering, and relaying systems, yet provide replica scale values of the primary voltage. All ratings, such as impulse, dielectric, etc, should be adequate for the purpose.

Potential transformers provide a secondary voltage compatible to the rating of the instrument's potential coil. Switches are provided in the secondary circuit of the voltage transformer to disconnect the instrument for testing. The connected load should not exceed the VA rating of the transformer if accuracy is to be maintained. For safety, the secondary winding of a voltage transformer is grounded.

The surge arresters and capacitors in the back of the cubicles are used for limiting surge voltages on the generator by diverting surge current and returning the device to its original status.

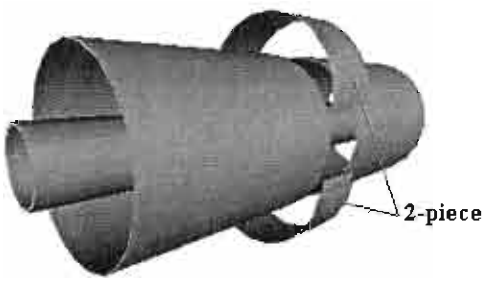
Equipment Installation

General Installation Recommendations

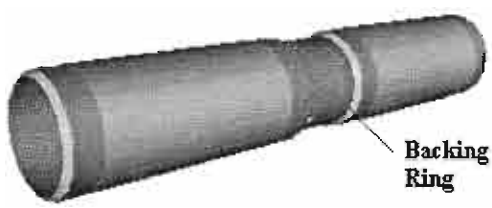
Calvert recommends that the IPB system be loose fit installed from one point to another to insure that once final welding is complete, no rework will be required. Calvert recommends that you begin installation from a mid-fixed point location such as a building wall or generator circuit breaker (otherwise from one terminating point or endpoint). This will allow the installer to utilize all of the built-in adjustability of Calvert's IPB system. If your system has no mid-point equipment, Calvert recommends that installation begin at the main bus terminal interface point (generator or GSU transformer) and proceed by installing IPB shipping sections from that point to all other interface points. Care should be taken in either case to insure that the IPB system from one point to others will fit up properly. The first section(s) installed should be verified that the end points, support points and terminal interface points all match the design drawing locations.

Warning: **DO NOT** begin welding until all bus sections (at shipping splits and all terminal interface points) have been confirmed to fit-up properly at the point of interface.

All sections should have only the conductor joints tack welded together until all interfacing points of the bus run and conductor joints have been verified to fit correctly. The enclosure splice joints are adjustable in a linear fashion to allow the enclosure length to grow or shrink, and the conductor splice joints are adjustable for conductor diameters over 12". Confirm the conductor/enclosure splice design on the supplied project drawings. Examples of both enclosure/conductor splice joints are shown below. Where the enclosure interfaces with other equipment, the enclosure bellows is designed to allow up to one inch of misalignment in any direction.



Enclosure splice joint



Extruded conductor splice joint

However, the enclosure and conductor should be loose fit in as near a perfect (per design) position as possible to insure there are no phase to ground potentials. See the Electrical Clearances Section for recommended and minimum electrical clearances. All IPB systems are installed in a single-phase manner. The single-phase terminal compartments, flanges, flexible connectors, adapter bars, expansion/removable/earthquake joints, non-factory attached interfacing equipment, etc. should be verified to fit up properly in a single phase manner as shown on the design drawings. In other words, one phase should be completely installed in a loose fit fashion prior to installation of the other phases. If there are problems found with the

first phase installation, necessary modifications to design and equipment can be made quickly so that the installation schedule sees little or no impact.

If discrepancies are found between the site conditions and the design drawings, please inform the Calvert Site Representative immediately. If a Calvert Site Representative is not present, please contact Calvert's Project Management Department.

Prior to welding any joint, both the enclosure and conductor welded joints and bolted joints, at **all** interface points, should be verified for proper fit up. Flexible connectors and adapter bars should be temporarily installed to verify that all conductor joints fit properly. Phase to phase centers should be confirmed to match design drawings to verify that bonding plates will fit up properly. All bus section lengths can be verified on the ground prior to lifting into place. Please verify section lengths by utilizing the layout drawings, splice drawings and terminal drawings. Bonding plates should be set into position to verify proper fit up. Both the enclosure and conductor should be checked for proper fit. The proper elevation and dimensional gaps, shown on the project design drawings, must be confirmed prior to full welding and/or final fit up of equipment.

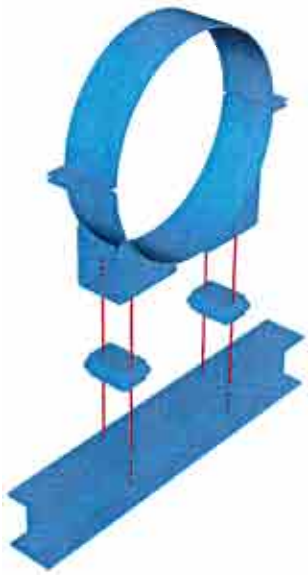
Steel Supports

To expedite the steel support structure erection, the Calvert supplied steel support base plate drill pattern should be checked against the foundation anchor locations and elevation of the foundations prior to support column installation. The steel support design drawings can be utilized to verify that the anchor locations and support base plates drill patterns match. If the support base plates do not match the foundation anchor locations verify that the foundation and anchor locations are per customer design drawings and the foundation and anchor locations match the Calvert design drawings for location and base plate design. If the foundation or anchors do not match the customer-supplied designs contact the responsible personnel on site for further instruction. If the foundation elevations and anchor locations are per design, but the support base plate does not match, contact the Calvert Site Representative immediately. If a Calvert Site Representative is not present please contact Calvert's Project Management Department.

Most steel support structures can be fully assembled on the ground and then lifted into position if preferred. Steel structures can sometimes warp slightly during the hot dip galvanizing process so loosening of the fasting hardware may be required to set the steel properly onto the foundation anchor bolts. Care should be taken to avoid injury or damage to the support structure if supports are ground assembled. Project site rules and procedures for lifting structures must be followed and supercede any Calvert lifting instructions.

Saddle Support Assembly and Steel Support Erection

To save time and prevent work from an elevated position the saddle support assemblies (whether bolted or welded type) can be pre-installed onto the steel support beams prior to erecting the steel support structures. Locate the desired cross member support beam and install the insulators and then the bottom saddle clamp as shown below. Confirm that your project design drawings reflect the same saddle design prior to any installation of insulators and saddles. Some projects require special support applications in some areas.



Saddle Support

Wall/Floor Penetration Location, Verification, and Erection

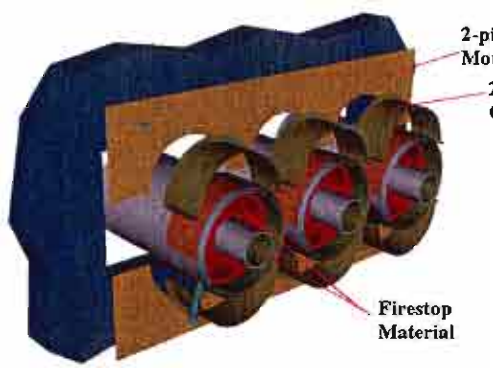
To save time and possible project delays, prior to lifting bus sections into a wall or floor penetration, the wall or floor-opening location should be verified. Confirm the correct location by first verifying that both the Calvert design drawing location and the customer design drawing location match. Elevation, distance from column lines (or reference points), opening size and wall or floor thickness should be confirmed as correct prior to lifting IPB sections into place.

See the Calvert specific project design drawings of the wall or floor penetration for detailed installation instruction and possible site-specific installation and/or design variations prior to installation.

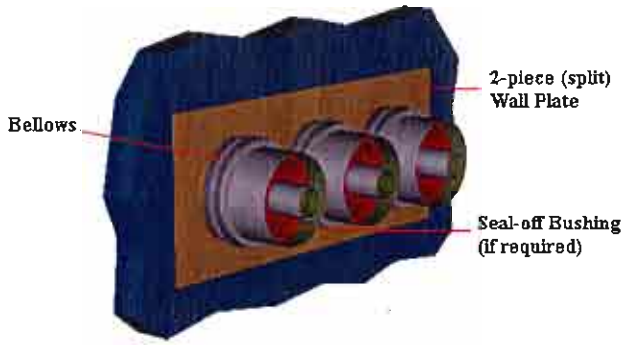
Firestops and Wall/Floor Seals

Prior to installation of wall/floor seal assembly or firestop bus section the seal off bushing or firestop should be verified to be clean, dry and free of dust and/or dirt. The bushing or firestop should be completely wiped down with a water dampened lint free cloth to remove all dust and debris that may have settled on the bushing surface. Care should be taken to completely clean all of the machined grooves of the bushing or firestop.

The wall/floor seal or firestop assembly is fully factory fabricated and ready for installation. The internal seal off bushing or firestop (if supplied) is factory mounted to the enclosure and the conductor. The external enclosure wall plate assembly is a two-piece plate split across the phases. The wall plate assembly will be installed as detailed on the project specific design drawings to either bolt to a framed opening or anchored to an opening that the plate overlaps.



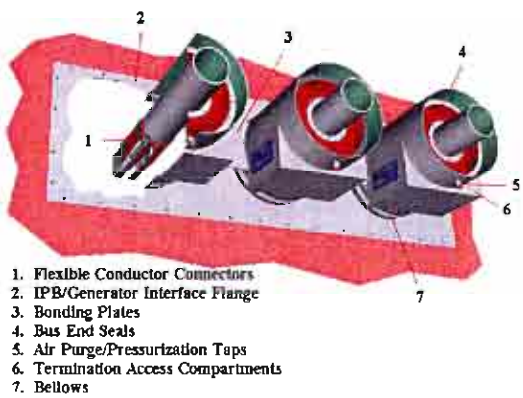
Typical Firestop

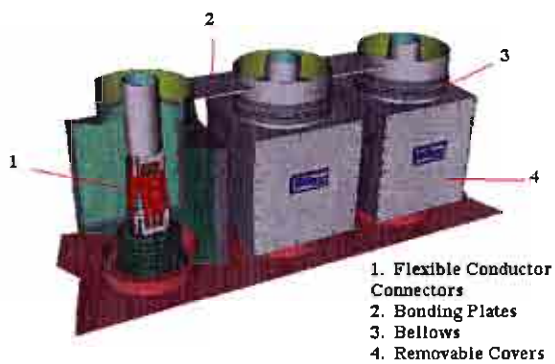


Typical Wall/Floor Seal Assembly

Terminal Compartments

Calvert supplies all required fastening hardware and gasketing material to completely install all interfacing terminal equipment. The design drawings will indicate all required installation parts required for assembly of interfacing equipment. The installer must review all interfacing equipment drawings prior to installation of the terminal compartments. Depending on the design of the interfacing equipment, the installer must understand whether or not the compartment can be installed prior to or after the IPB sections have been installed. Generally, the interfacing equipment will follow one of the two scenarios shown below:





Typical Terminal Compartments

Lifting Bus Sections into Place

The bus should be lifted by overhead means when ever possible. All slings should be nylon or equivalent to prevent damage to the bus enclosure. In no case are metal straps or chains approved as an alternative. A spreader bar should be used along with nylon slings to distribute the weight of the bus when the equipment length exceeds 20 foot or multiple sections are being lifted at the same time. Slings should be long enough to position onto the bus section to minimize deflection. Tag lines should be utilized as necessary to safely guide the bus into position.

Note: All shippers cribbing and packing must remain in place until the equipment and/or bus is placed in its final position. A protective covering must be used until the final enclosure covering is installed.

Preferred method of lifting and guiding bus duct into place

Proper Location Verification

The layout drawings provided by Calvert should be followed closely to identify equipment orientation. Some items that should be checked are equipment overall length, elbow orientation, insulator orientation and tee tap orientation.

If Questions arise concerning stencil identification of bus end pieces, consult with your Calvert Installation Services on site representative or contact your Calvert Project Manager.

Temporary Bus Fit-Up

Warning: DO NOT begin full penetration welding until all bus sections (at shipping splits and all terminal interface points) have been confirmed to fit-up properly at the point of interface. Calvert recommends that the IPB system be loose fit installed from one point to another to insure that, when final welding is complete, no rework will be required. Prior to full penetration welding of any welded joint, both the enclosure and conductor welded joints and bolted joints at **all** interface points should be verified for proper fit up.

After setting the equipment into the proper location verify that it is level, plumb, and at the correct elevation per the Calvert installation drawings. Also, insulator castings must maintain

correct orientation. This orientation can be found on the cross section drawing. Bus fit-up should be started at any fixed point and movement or adjustment must be along the bus to the next fixed point. All sections should have only the conductor joints tack welded together until all interfacing points of the bus run and conductor joints have been verified to fit correctly. When the first section(s) are installed it must be verified that the end points, support points, and terminal interface points all match the design drawing locations.

Note: Periodic checks should be made using the dimensions on installation drawings to assure that the bus does not "grow" or "shrink". The difference, if any, should be distributed among the adjacent sections, while positioning, to prevent cumulative build up (plus or minus lengths) going to the last section. If the duct system is rigidly connected to a steel support by design, where no adjustment can be made once supporting members are in place, the support members should also remain loose fit until final fit-up is made to the equipment.
Where the enclosure interfaces with other equipment, the enclosure bellows is designed to allow up to a maximum cumulative total of one inch of misalignment in all directions. The enclosure must not be less than one inch from any equipment flange.

Flexible connectors and adapter bars should be temporarily installed to verify that all conductor joints fit properly. Phase to phase centers should be confirmed to match design drawings to verify that bonding plates will fit properly. All bus section lengths can be verified on the ground prior to lifting into place. Verify section lengths by utilizing the layout drawings, splice drawings and termination drawings. Bonding plates should be set into position to verify proper fit. Both the enclosure and conductor should be checked for proper fit. The proper elevation and dimensional gaps, shown on the project design drawings, must be confirmed prior to full welding and / or final fit up of equipment.

Consult your on site Calvert Installation Services representative or Calvert Project Manager if problems arise.

Conductor and Enclosure Splice Welding

Temporarily weld all conductors in place by tack welding bottom, top and both sides of each conductor splice point. After conductors are tack welded and placement of all bus sections are verified, weld out each conductor by placing two root welds and a cap weld around the circumference of the conductor to completion of the weld. Begin at the bottom, go up both sides, and finish at the top of the conductor for best weld penetration. To prevent overheating and drawing a section of conductor, care should be used to alternate locations until all four sides of the conductor are fully welded.

After welding the conductor, a visual inspection of the inside of the enclosure should be made. Remove all metal shavings, dust, dirt, welding splatter or other debris from the enclosure, conductor or insulators. Paint the welded area and touch-up any bare sections of the conductor or inside the enclosure, with high temperature flat black paint provided for that purpose.

Prior to installation of splice covers, visual inspection must verify that all cribbing, shipping materials, packaging, and tools have been removed.

When the conductor is completely welded and painted, place the two piece splice enclosure over the enclosure opening. Center the enclosure over the opening making sure the ends butt together for a tight fit. Temporarily secure the enclosure in place with ratchet straps, or other suitable means, and tack weld the enclosure in several locations around the circumference and at the butt sections to secure it in place.

Remove any temporary straps and supports. Weld out all surfaces, including the end sections, of the splice cover to the enclosure. Start at the bottom, go up both sides, and finish at the top of the conductor for best weld penetration. Take care to alternate areas being welded to prevent overheating and drawing or warping sections of the enclosure.

After welding is complete, clean up welds and remove all weld splatter from the exterior of the enclosure. Paint the welded area and touch up any bare sections of the enclosure with the appropriate color and type of paint provided for that purpose

Recommended Cleaning and Welding Procedures

The bus duct is normally shipped with a Bill of Materials clarifying which additions to sections of the field erection is needed. There are connections made at the generator and transformer ends of the three-phase runs, with splice sections in-between. Some of these items are mechanically joined, whereas field welds support much of the erection.

Calvert requires that field welding is to be accomplished by the employment of certified welders, to a company standard traceable to AWS D1.1, the Structural Welding Code for Steel and AWS D1.2, the Structural Welding Code for Aluminum. The Procedure and Performance Qualifications of the Welders and Procedures to AWS B2.1 2000 is used as well.

To obtain a proper weld, the following cleaning procedures should be adhered to:

Weld Cleaning Procedures

The work metal surface should be cleaned of contaminants. Dirt can be removed easily by washing and scrubbing with a detergent solution. An effective drying procedure is necessary to ensure that no moisture is present on the surfaces to be welded. Removal of grease and oil can be accomplished by swabbing with solvent-soaked cloths. Suitable solvents include butyl alcohol, naphtha or acetone, and must be used with care because they are flammable.

Warning: Because Carbon tetrachloride and trichlorethylene compose and produce toxic fumes when contacted by the arc, they must be used only with effective ventilation and well *away* from the welding area.

Heavy oxide layers should be mechanically removed with a wire brush, stainless steel wool, mil file, portable milling tool or a scraper. The use of abrasive paper or grinding discs alone is not recommended, because particles of the abrasive paper or grinding discs may become embedded in the aluminum and, unless subsequently removed, can cause inclusions in the weld. Wire brushes should have sharp bristles and should be kept free of oil and other material. Bristles preferable should be 0.012 to 0.016 inches in diameter and of stainless steel, to minimize iron oxide pick-up.

Motor driven wire brushes should be used carefully. If excessive pressure is applied, a brushing

action in which the oxide is rolled into the freshly exposed surface will result and the weld may be of poorer quality than one made without wire brushing. However, enough pressure has to be used to cause the sharp bristles to break the oxide from the surface of the aluminum alloy.

It is preferable that degreasing and chemical cleaning be done before the parts are assembled for welding. Cleaning after assembly can result in retention of foreign material and solutions between abutting edges and lapped areas of the joint, and porosity and dross entrapment in the weld are likely to result. Freshly machined and freshly filed surfaces are the cleanest and are often specified when the ultimate in weld quality is demanded.

Defects such as porosity, incomplete fusion, or cracks shall be removed before repair welding is to be done. The use of dye penetrant or a magnifier will aid in the detection of these defects. The use of the aluminum grinding wheels, carbide cutting and milling tools or nylon wheels may be used to remove any defects. Care should be taken to escavate the defects, leaving the *area* smooth and free of defects prior to welding.

After removal of defects by mechanical means, a re-cleaning of the area as described above must be done prior to welding.

Welding equipment
The equipment used, the welding application, and installation is dictated by specific guidelines. Below is the basic guideline:

1. Suggested power sources
   a. Lincoln CV300 Pro/CV350 or equivalent – These are constant voltage units rated at 350 Amps, 34 Volts
   b. Lincoln Electric Vantage 300 or equivalent – Fossil fuel powered source, rated at 300 Amps,32 Volts, capable of producing a constant voltage

2. Filler metals
   a. ER 4043 should be the filler metal for aluminum welding applications
   b. ER 70xx-xx series should be filler metal for steel welding applications

3. Shielding gas
   a. Aluminum - 99% Argon is recommended
   b. Steel – Carbon Dioxide is recommended

Safety issues should be adhered to per AWS D1.2 and AWS D1.1. No operator should be allowed to work the product without proper outer covering, masks, and headwear. Body straps are to be employed when height becomes an issue.

Special Considerations – Welding of Copper Bus Bars
On special projects, Calvert has had a need for copper bus bar to be field welded. The bus bars used are normally oxygen free. This welding shall be done in accordance with ASME Sections III and IX with the following considerations:

1. Joint design
   Weld-joint designs for copper have larger groove angles than those for steel. The larger groove angles are required to provide adequate fusion and penetration for copper, which has high thermal conductivity.
2. Surface preparation
   Cleanliness is of major importance in welding copper regardless of the welding process. Weld joint faces and adjacent surfaces should be free of grease, oxides and oil prior to welding. A chemical or abrasive method is more suitable for cleaning over wire brushing, as copper develops heavy surface oxide. The place of weldment should be made promptly after removal of the oxide film.

3. Preheating
   Achieving fusion and weld penetration is very difficult in that copper has a high thermal conductivity. There is considerable heat loss from the welded area. The use of "Cool Heat" paste or putty can be used to minimize loss of heat from the welded area. Preheat may be applied by flame, induction or resistance blankets. Preheat temperature should be measured with an infrared thermometer.

4. Bus bar support
   It is imperative that the bus bar is uniformly supported in order to eliminate droop or sag.

5. Welding parameters

   a. The shielding gas should be 100% helium or 75% He, 25% Argon (in some cases, the shielding gas may have an even greater percentage of Argon, up to 60%).
   b. The filler metal should be Alloy DE OX, size .045, per AWS A5.7
   c. Preheat temperature should be at least 600 degree F.
   d. The amperage range is 300-375 amps

6. Post-weld surface finish

The welded joint must be sanded smooth with the original bus bar diameter. The entire area must be highly polished and shall have a surface finish equal to or greater than the adjacent existing bus bar diameter.

The welding applications in all cases will be guided by Calvert supplied fabrication prints. The prints are supplied with proper symbols for location of and application of weldments. Certified welders are aware of and must adhere to the placement of weldment as per the prints issued with prior proper fit-up and cleaning of the members to be joined. Removal of excess weld may be done through peening or other mechanical means. In the case of weld repair, engineering support and/or guidelines per AWS D1.1 and AWS D1.2 are to be followed.

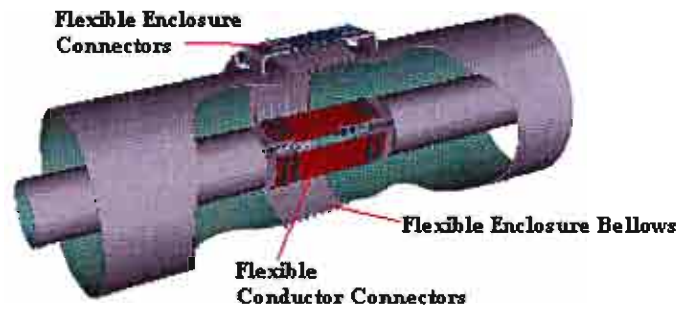
Visual inspection of finalized work shall be performed with the following parameters as a guide:

- AWS D1.1 Sections 6.3, 6.5, 6.6, 6.9, and Table 6.1
- AWS D1.2 Section 5.6
- API 1104 Pipe welding code
- AWS B1.11 Visual inspection of welds

Expansion, Earthquake and Removable Joint Assemblies
These joints generally contain factory weld studs or blades for bolting the rigid or flexible connectors. In some cases the conductor joint is factory assembled for field welding. In these cases a laminated flex assembly will be factory welded to one end of the conductor with the other end weld prepared for its mating section. All contact surfaces must be clean prior to installation of connectors. When aligning both the conductor and enclosure on these joints they should be held as close as possible to the design dimensions.

These terminations are designed to provide a terminal interface, which applies no load to either of the connecting equipment. The terminations are designed for a maximum connecting misalignment in any direction to an accumulated total of plus/minus one inch. Make sure that conductor connectors fit prior to making final welds to adjacent bus supports or splices.

Some joints incorporate a flexible insulating bellows in the design. These should be placed on the enclosure prior to making up the final conductor connection because most bellows are made in one continuous piece. If the installation requires any welding near the bellows, it should be protected from any welding sparks and/or heat. After all welding and touch-up painting have been complete, finish the bellows installation per the installation drawing provided. All tightening and torque of bolts should be done in accordance with the hardware fastening procedures in this manual. All welding must be done in accordance with the welding section of this manual.



Typical Vibration/Earthquake/Expansion Joint

Conductor Termination Assembly
The conductor termination assemblies at equipment generally consist of a factory welded bolting stud, flexible connectors, and bolting hardware. When aligning the conductor with the adjacent equipment, it should be held as close as possible to the design dimension tolerances. All contact surfaces must be clean prior to installation of connectors.

These terminations are designed to provide a terminal interface that applies no load to any of the connecting equipment. The terminations also allow misalignment in any direction to only a maximum accumulated total of plus or minus one inch.

Also it is recommended to fit test flexible connectors at each joint prior to doing any permanent welding on the bus or equipment.

Note: These connectors should not be installed permanently until a Hi-Pot test has been performed on the equipment.

During final installation of conductor connectors, the hardware fastening procedures in this manual must be adhered to. Refer to bus/equipment drawings for detailed information.

Enclosure Termination Assembly

The enclosure termination assembly generally includes a flexible insulating bellows for possible misalignment. This should be installed per the bellows installation drawing. The enclosure is designed to provide a maximum of accumulated misalignment to a total of plus or minus 1 inch.

The gap between the equipment flange and the bus enclosure should be the same or very close to the difference in the conductor gap. For example, if the conductor blades should have a 7-½ inch gap between them and you actually have 7 inches, then the gap in the enclosure should be ½ inch narrower. If this is not the case and the system is a multiple insulator system you should check the next enclosure splice gap at the other end of the section. If this gap is greater than the width of the enclosure splice cover, you may have to shift the enclosure back prior to welding. (Remember to loosely install the insulator bellows prior to making final conductor connectors).

Most all enclosure terminations incorporate a bonding plate in the design. These plates should be located per the equipment termination drawing. All welding is to be performed per the job specific drawings and this manual. Care should be taken to protect the flexible insulating bellows while welding from sparks and heat.

Note: Consult the factory if the air gap between the enclosure and the equipment flange is less than one inch. (The designed gap is usually two inches) The accumulated misalignment cannot exceed plus or minus one inch at these terminations.

Hardware Fastening Procedure

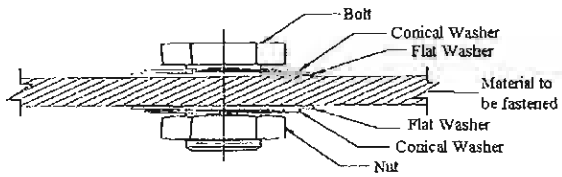
Conical washers

All current carrying and / or conductive fasteners shall be installed as shown below. Refer to detail drawing or bill of material for hardware type and quantity.

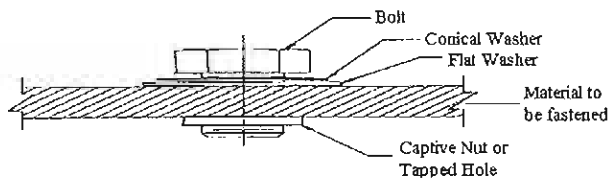
A conical washer and flat washer are to be placed between the bolt head and the material to be fastened, if the application is for use with captive nut or tapped hole.

A conical washer and flat washer are to be placed between the bolt head and the material and the nut and the material to be fastened, if the application is for use with a through bolt.

Note that each application shows the conical washer is to be installed so the bolt and nut will cause the conical washer to compress toward the material to be fastened.



Bolt and Nut Application



Bolt and Captive Nut Application

Torquing fasteners to a set value (e.g. ft/lbs.) is not required with use of conical washers. Extreme caution should be used to prevent over or under tightening of the conical washer.

If a joint is too loose, it could cause over heating beyond allowable specified temperatures. A joint, which is too tight could cause material to cold flow and eventually become a loose joint.

All personnel responsible for conductor-type joint fastening must be qualified and have working knowledge of conical washer applications.

CAUTION: The process for torquing must be followed in detail to provide a solid conductor connection.

All bolted connections must be made by hand. Pneumatic or electric tools cannot be used to properly set the conical washers.

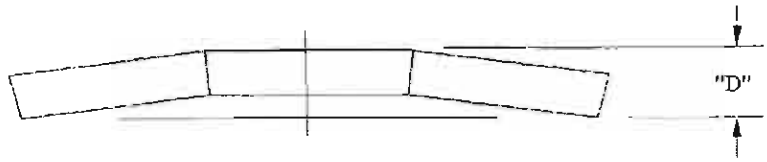
Use a ratchet-type tool with lever arm a minimum length of 14 inches.

Tighten the bolt (Bolt & Captive Nut application) or nut (Bolt & Nut application) until the conical washer is flattened.

NOTE: A sudden increase in pressure will be felt when the conical washer is flattened. The longer the tool lever arm is, the easier this pressure will be felt. **Do not tighten beyond a flattened configuration**.

If excessive torque is being applied, and conical washer is still not flattened, check the bolt and nut for thread damage. If you are having difficulty with all bolts consult factory.

Conical washers can be re-used, if the overall thickness of the washer meets or exceeds the values shown in the table below. Measurements of conical washers should be made by use of calipers.



Description	Clamping Force	Minimum Thickness "D"	Solon Category Number
3/8 Conical (S.S.)	1850 LBS	0.090	6-M-80301
½ Conical (S.S.)	5500 LBS	0.137	820125301
5/8 Conical (S.S.)	5200 LBS	0.140	10-M-112177
¾ Conical (S.S.)	6300 LBS	0.139	12-L112177

Flat washers or lock washers

The various conductor and other connection conductors will be either copper or aluminum. In either case, the contact surfaces will be silver surfaced or equivalent. Do not use non-plated copper or aluminum bars/conductors, except as ground bus. All field assembled joints in primary conductors, regardless of material, should be made as described below.

(1) Wipe contact surfaces with a clean, soft, dry, lint free cloth to remove dirt and grease. Do not use any abrasives such as sandpaper, emery cloth, or steel wool for this purpose. Avoid handling of the contact surfaces after cleaning.
(2) After all the hardware has been installed the bolts can be tightened to the correct torque per the below chart.

Bolt Size	Steel < Grade 5	Steel Grade 5	304 Stainless Steel	316 Stainless Steel	Galvanized
¼"	4.0	9	6.27	6.64	4.4
3/8"	12.0	31	19.9	20.65	15
½"	29.6	75	42.78	45	37
5/8"	59.2	150	92.2	96.6	74
¾"	96.0	265	127.6	132.02	120
1"	225.6	600	286.9	299.45	190

Recommended Torque Values – Unified (ft-lbs.)

Bolt Size	Steel < Grade 5	Steel Grade 5	304 Stainless Steel	316 Stainless Steel	Galvanized
¼"	5.42	12.2	8.5	9	6
3/8"	16.27	42.03	27	28	20
½"	40.13	101.69	58	61	50
5/8"	80.26	203.37	125	131	101
¾"	130.16	359.3	173	179	164
1"	305.9	813.5	389	406	260

Recommended Torque Values – Metric (n-m)

NOTES:
1) Torque value for anchor bolts will be identified on the project design drawings
2) The torque values above are not to be used for conductor joints. (See special instructions for conical washers)
3) All torque values listed are manufacturer specified and are maximum values.

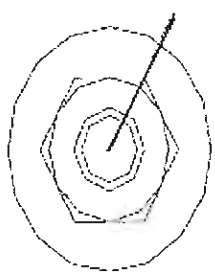
Torque Marking

- Torque marks shall be made by use of a red painting stick marker.

- Torque marks shall be placed across end of bolt, across top of nut, down side of nut, across washer and extend onto bolted material surface.

- All bolts that have been properly torqued are to be torque marked immediately by the person who torqued the assembly.

- If fasteners that have been previously torque marked are loosened, all previous torque marks must be removed. Tightening and marking procedures must be reapplied to the entire joint.



Torque Marking Detail

Maintenance of fasteners is by visually checking the torque marks. If the mark is aligned, the fastener remains at the proper setting to provide a good joint.

Clearances (Structural and Electrical)

Structural Clearances

Although Calvert's IPB system is of a "no-flux" design, there is no reason not to avoid all potential induced heating problems. Magnetic items such as steel columns, beams and framework, conduits, etc. should be keep as far as possible away from the IPB enclosure. Calvert recommends that the following clearances be kept from the IPB enclosure.

- Steel structures and conduit installed perpendicular to the bus routing – 4.00" minimum air clearance

- Steel structures and conduit installed parallel to the bus routing – 8.00"

Electrical Clearances

System Rating	Recommended Phase to Ground Clearances	Minimum Phase to Ground Clearances
110kv BIL	7.38"	6.88"
125kv BIL	8.88"	8.38"
150kv BIL	10.38"	9.88"
Over 150kv BIL	Consult Factory	Consult Factory

Note: The clearances shown above are considered to be from one smooth surface to another. At least .50" should be added to the above minimum clearances if sharp corner clearances are being verified. (Example: From a corner of a flange to a corner of a flexible connector). If there are any concerns about electrical clearances please consult Calvert's Project Management Department.

Grounding of the Bus System

Grounding of Isolated Phase generally has two purposes. First, grounding is for personnel safety and secondly, it is to provide a path to ground for lightning impulses and short circuit conditions. Current flow in the conductor of isolated phase bus induces a voltage in the enclosure. If a path for current is provided, the induced voltage will push a current through the enclosure virtually equal to the current in the conductor. This current will flow in the opposite direction from that in the conductor, thus canceling the majority of the magnetic flux created by the current flow in the conductor. To create the path for the current flow, the enclosures of the three phases are joined together with bonding bars or bonding plates at every termination of the three-phase bus run. These bonding bars/plates provide loop circuits for the current to flow and consequently must have sufficient cross sectional area to carry the rated current of the bus.

Calvert's preferred method is to isolate the entire bus run from all grounds with exception of one. With this method, there is no circuit through the ground for current to flow. Where a second ground is supplied, stray currents from the grid may circulate through the bus. We accomplish single point grounding by inserting porcelain insulator pads underneath the bus supports and providing one grounding pad located on one of the bonding bars at one end of the bus run. A ground cable is then attached from the ground pad on the bonding bar to the system ground grid.

There are installations where generator circuit breakers are installed in the bus run between the generator and the step-up transformer. Where these circuit breakers are furnished as three single-phase breakers, they may be directly connected to the isolated phase bus and serve as a continuing path for current flow. However, these circuit breakers are sometimes bolted directly to the supporting steel and are not necessarily in the preferred arrangement for the isolated phase system. When this is the case, Calvert prefers to completely isolate the generator circuit breaker from the bus system all together. This is performed by installing bellows between the bus and the breaker in all three phases, before and after the breaker. When this is done, it is necessary to install bonding bars/plates prior to the bellows on both sides of the breaker. This in effect separates the bus into two circuits. Each of these two circuits then requires one ground each.

When the bus is isolated from transformer boxes with a bellows, and the transformer boxes are grounded to the transformer, a second ground must not be added to the box. If this is done, a current will flow through the ground and heating will occur.

Condensation Control Systems

There are many ways to fully control or partially control condensation, moisture, and other contaminants within the interior of an IPB system. Depending on the configuration and accessories purchased with the IPB system, it is possible to provide a basically maintenance free bus duct system. The categories below describe the required equipment that will provide a desired end result.

Calvert's Standard IPB Design

Calvert's standard design incorporates many factors to insure reliable operation for a specified duration or design life. All IPB designs include the following:

1) Phase to Ground Clearances – P-G clearances that exceed NEC minimum requirements by approximately 20%.
2) Standard Insulator – Calvert supplies as a standard 150kv B.I.L. wet process, high creep porcelain insulators. The insulators have passed dry impulse design testing at over 225kv B.I.L. The insulators also have passed wet power frequency flash test at over 90kv.
3) Other Standard Equipment – Calvert supplies as a standard on all IPB systems: manual drains, ½" NTP fittings for connection to dry air or purge systems and all materials to seal the external enclosures from the environment.

Calvert-designed Isolated Phase Bus Duct relies on air for insulation. Air cannot fail over time as with an insulated conductor, whether wet or dry. And with more than adequate electrical clearances the IPB system becomes an extremely stable operating unit even under the harshest environmental conditions.

Optional Environmental System Equipment

Calvert has numerous standard environmental control systems. Calvert can supply almost any custom designed system as well. The standard environmental systems are described below. The following section describes system applications in stand-alone scenarios as well as combination system applications.

1) Thermostatically Controlled Heaters – Calvert offers a 240V, 500W ring type heater that is mounted around the base of each insulator (bottom insulators only). The heater is operated at 120V to increase the life of the heater. A differential thermostat controls the heater operation. The thermostat has two sensors, one that senses the internal duct temperature and the other senses the external or ambient temperature. The thermostat operates the heater when the temperature variance, or differential, exceeds the parameters the thermostat is set for. The differential is pre-set to power on the heaters when the internal duct temperature approaches the dew point.

2) Dry Air Pressurization Systems – There are many ways to accomplish an internal positive pressure system, however, there are two main base systems. One is where the air is supplied by the existing plant instrument air system. The second is to supply a stand-alone pressurization system. The stand alone system being one or more generator IPB runs being supplied with a dry pressurized air supply from a compressor skid not related to any other plant function. Calvert' standard air pressurization system includes an air control panel. The

panel system includes an enclosure with HP and LP regulators, safety valve and a pressure gauge. Also supplied are a pressure gauge, safety valve and ball valve for the terminal point at the opposite end of the air source point. Calvert does not supply external piping, compressor skids or other items unless specified.

3) Bus End Seal-off Bushings – Seal-off bushings provide an airtight seal between the interior of the IPB and all interfacing equipment. Seal off bushings provide protection against airflow, hydrogen leakage and other environmental conditions. Sealing of bus ends is mandatory if air pressurized systems are to be utilized. Normally the GSU and auxiliary transformers do not require end seals because the transformer flanges are full welded to the transformer tanks. The following equipment typically may require that the IPB end be sealed to ensure pressurization and/or protection from hydrogen leakage:

   A. Generator Terminal Compartments
   B. Excitation Compartments (depending on manufacturer)
   C. PT/Surge Compartments (depending on manufacturer)
   D. Other equipment that requires a tap from the IPB system

4) Drain Plugs – Calvert supplies vented drain plugs (in non-pressured systems) to allow for removal of condensation that may have formed within the bus during shutdown. Non-vented drain plugs are supplied for pressurized systems during shutdowns.

Condensation and Environmental System Applications

The following items describe typical applications for each of the standard and optional environmental systems. Note that some systems can be used in a stand-alone fashion or in conjunction with other systems.

1) Base System – Calvert's IPB system is designed to operate without any additional condensation or environmental system in place. Calvert's standard electrical clearances combined with Calvert's high creep insulator provide adequate protection against corona and flashover provided that the IPB system is installed correctly. Note that the base system will require regular maintenance checks, during outages, to insure that a problem with condensation does not occur. The base system includes manual drains and dry air tap points at each terminal end of the IPB. Calvert recommends that in areas where the IPB has vertical drops to interfacing equipment that the interfacing equipment flanges have weep holes to provide a path for drainage of any condensation that may form during an outage.

2) Purge Air Systems – If preferred Calvert can design the base system to be purged with dry air during outages or prior to operation. If purging of the system is desired the system must be a "totally sealed" system. A totally sealed system requires that bus end seal off bushings be placed at all IPB terminal points that are not sealed. Typically, the IPB system would be purged by utilizing a portable dry air supply. To purge the system, the air supply would be connected to the generator end air tap point. At the GSU transformer the air tap plug would be removed to allow air to be freely exhausted. Drying of the IPB system varies in time from an hour to more than one day depending on internal moisture accumulation. If dry air purging is designed into the IPB system Calvert will supply purging instructions specific to the IPB system design supplied.
3) Dry Air Pressurization Systems – The pressurization system is the only fully reliable means to insure the IPB system consistently remains condensation and contaminant free.

Pressurizing the system will require that all terminal ends of the IPB are sealed. If desired, many optional items can be added to Calvert's base pressurization system such as flow meters and low-pressure alarms. The only purpose of a dry air pressurization system is to provide a positive pressure to the interior of the duct. Typically the total pressure would not exceed .145 PSI (4 in. W.C.), however this small amount of pressure is enough to ensure that no moisture or other contaminants can enter the IPB enclosure. For dry air pressurized systems, please note that over the past few years several, if not all, generator circuit breaker manufacturers have been providing breaker enclosures that are no longer airtight. This may require that bus end seal-off bushings be placed on each side of the breaker connections to insure a positive pressure within the IPB system.

4) Thermostatically Controlled Heater Systems – Calvert's standard "ring type" heaters are designed to provide only enough heat to prevent condensation from forming on the insulators.

Summary

Regardless of the systems controls included on an IPB system Calvert's design provides the best possible protection against environmental conditions. However, as with any system, Calvert recommends routine maintenance to insure the IPB system will operate to it's optimal "as designed" state.

Touch-Up Painting

All touch-up paint supplied by Calvert is premixed for spray use only.

Special Considerations

- All painting should be done under cover.

- All painting should be done by qualified personnel and in strict accordance with the specific written instructions supplied by the manufacturer, and in accordance with this procedure.

- All materials should be delivered to the paining site in the original unopened containers bearing the manufacturer's name, type designation, color and batch number.

Prepare Surface

1. Clean welds by wire brushing. Grind excess weld metal and weld spatter (per SSPC-SP-3) if required.

2. Clean surface by removing all oil, grease and other contaminants in accordance with Steel Structures Painting Council (SSPC-SP-Solvent Cleaning).

3. Apply Breakaway Metal Cleaner by mop or brush.

4. Dilute one (1) part Breakaway to three (3) parts water.

5. Rinse thoroughly after use.

6. Ensure all areas that do not require paint are taped off or covered with brown Kraft paper (or equivalent) to prevent over-spray from contaminating the area.

Apply Paint

1. Apply the Sherwin-Williams Washer Primer Catalyst Reducer to the surface.

Note: Surfaces that are painted with Hi-Temperature flat black do not have to be painted with the wash primer catalyst reducer.

2. Painting must be done within four (4) hours of surface preparation or before any rust or contamination occurs on the surface.

3. Paint must be evenly applied and the finish should be completely free of runs, drips, sags, dirt and other defects.

4. Each coat must be completely dry before the next coat is applied.

5. Any areas marred or otherwise damaged should be re-prepared and repainted as necessary. (For areas where a small amount of the paint may have been rubbed off, touch-up with spray cans is allowed).

Field Testing the Bus System

High Potential A-C Withstand Test (Field Procedure)

Warning: Only trained and qualified personnel will be allowed to perform high potential testing.
The operator must barricade off the test area and/or position safety personnel so as not to allow anyone in the testing area.

Before beginning the test

- **Bar and Isolated Phase Bus Duct**

The purpose of the Hi-Pot test is to check the insulator(s) and/or bushing(s) for cracks, phase to ground, and to ensure the insulation (Bar Bus only) is not damaged.

A. Attach wires from the Hi-Pot tester to the bus duct.

B. Jumper wires are attached to all but one phase and grounded to the housing.

C. The power line is connected to the one phase left open, not connected in series with the other wires.

D. Ground the machine to the housing and to an earth ground.

Note: Bar Bus requires that a phase to phase check be performed also. This can be done by testing each phase while the other 2 phases are jumpered to ground.

- **Cubicles**

A. Detach all capacitors, potential transformers, current limiting resistors, and arrestors from the bars in each phase. (The components that must be tested are the main bus conductors, which are connected to the insulators and bushings)

B. Ensure the Hi-Pot tester is grounded, then attach ground from the Hi-Pot tester to the housing,

C. Attach power line to bars in one phase. (Jumpers may be used, if needed)

Warning: All cubicles must be evaluated before testing to determine the equipment that must be disconnected prior to testing.

Begin Test

Warning: After all wires from the Hi-pot tester to the bus duct are attached, ensure all personnel are clear.

A. Insert "Safety" plug

B. Turn the tester "On" and increase the voltage by 5 kV increments until the desired test

voltage is reached. (Per ANSI Standard for the rated kV of the bus)

C. Hold for a minimum period of one (1) minute. This test will determine if there is adequate clearance from phase to phase and phase to ground.

D. Decrease the test voltage slowly to "0" volts. Turn the test set voltage "Off". Ground the tested phase by using an insulated tool (hot stick).

E. Remove "Safety" plug

F. Repeat all steps for each phase.

Note: If a short is found, each bar/conductor per phase is to be checked to determine which bar/conductor is at fault. This is accomplished by changing the series connections and power line connections as described previously.

When power frequency withstand voltage tests are made on ME (metal enclosure) bus after installation in the field, the test voltage shall not be greater that 75% of the test values of a test performed in a shop/plant atmosphere. The following test values have taken this rule into consideration and indicate the values required for an acceptable test.

Rated Maximum Voltage (kV rms)	**Power Frequency Withstand (kV rms)** Dry-1 minute	**BIL**
15.5 kV	37.0 kV	110 kV
24.5 kV	37.0 kV	110 kV
27.0 kV	45.0 kV	125 kV
29.5 kV	45.0 kV	125 kV
34.5 kV	60.0 kV	150 kV
38.0 kV	60.0 kV	150 kV

Preventative Maintenance

Maintenance on the Isolated Phase Bus System is minimal. It is recommended that maintenance be performed at every scheduled shut down or at approximately (18) eighteen-month intervals.

1. Bus Enclosure

A. Moisture or condensation checks

This problem may occur during shutdown when humidity levels are high.

Should your bus system design employ the use of drain plugs, located on the bottom of the enclosure, they should be removed and checked for moisture.

If your bus system does not employ drain plugs, moisture may be detected by removing an insulator assembly from a low point in the bus run.

Excessive moisture may mean a leak has developed in the enclosure. If this situation has occurred, consult the factory.

B. Dust, dirt and foreign material check

The bus system is designed to prevent dirt, foreign objects and/or pests from entering the enclosure.

If a small amount of dust is noticed on the internal surfaces of the bus system no service will be required. If a large amount of dust appears on internal components of the bus system it must be removed.

2. Conductor Joints

A. Bolted Joints

All bolted connections should be checked for torque at every outage.

Tightening and torquing of bolts should be done in accordance with procedures in this manual.

All plated surfaces should be checked for corrosion. Any problems with the plated surfaces should be directed to The Calvert Company's Engineering Department.

B. Welded Joints

If problems are detected at any welded joints, consult The Calvert Company's Engineering Department.

3. Insulators

Insulators should require no maintenance but should be inspected for the following:

Five (5%) percent of the total insulators in the bus systems should be removed to be properly inspected. Insulators should be removed from random locations.

Make sure to remove one (1) insulator per phase, per location, to check for dust, cracking and tracking.

If the insulators are found to be dirty, all insulators in the entire bus system must be checked for cleanliness.

If cracking of an insulator has occurred, replacement is mandatory.

If insulator shows signs of voltage tracking, the cause of tracking should be determined. If problem cannot be resolved, consult the factory.

4. Potential Transformers

Potential transformers require no maintenance but should be inspected.

If your bus system design employs the use of potential transformers they can be located per Installation Layout Drawings.

If dust or dirt is found, it must be removed.

Inspect all connections and mounting hardware that may have worked loose.

Any other problem with the potential transformers should be directed to The Calvert Company's Engineering Department.

5. Seal-off Bushings

Seal-off Bushings should require no maintenance, but should be checked for the following:

If your bus system design employs the use of seal-off bushings, they can be located per Installation Layout Drawings.

Inspect all seal-off bushings for cracks and dust. Remove dust if needed. If seal-off bushing is cracked it will need to be replaced.

Inspect for wetness. If the bushing is found to be damp, it can be dried by utilizing the heat from a hair drier or a flood light. To dry the back side of the bushing, remove the closest insulator and apply the heat as recommended above.

Inspect R.T.V. silicone to make sure the seal-off bushing is still sealed. If the seal has been broken, reapply silicone.

Inspect all internal mounting hardware for tightness.

Any other problems with seal-off bushings need to be directed to The Calvert Company's Design Department.

6. Current Transformers

Current transformers should require no maintenance, but should be checked for the following:

Inspect for dust and clean if dust is found.

Inspect all wiring to make sure connections are secure.

Contact the Calvert Company's Engineering Department with any problems.

7. Insulating Bellows

If your bus system employs the use of bellows, they will be located throughout the system. Refer to the Installation Layout Drawing for their location.

Inspect the silicone around each bellow to ensure the seal is watertight.

Inspect for holes, tears, dry rot, etc.

8. Equipment Grounds

All equipment grounds should be checked for loose connections and oxidation at the terminals.

9. Surge Arrestors

Should require no maintenance, but should be inspected for the following:

If your bus system design employs the use of surge arrestors, they can be located per Installation Layout drawings.

Inspect for dust and clean as needed.

Contact the Calvert Company's Engineering Department for any other problems with surge arrestors.

10. Surge Capacitors

Should require no maintenance, but should be inspected for the following:

If your bus system design employs the use of surge capacitors, they can be located per Installation Layout Drawings.

Inspect for dust and clean as needed.
Contact the Calvert Company's Engineering Department for any other problems with the surge capacitors.

11. Switches

Should require no maintenance, but should be inspected for the following:

Remove access covers and inspect for dust. Clean as needed.

Inspect all plated surfaces for corrosion.

Inspect all mounting hardware for tightness.

Contact the Calvert Company's Engineering Department with any other problems.

12. Gaskets and "O" Rings

All gasket, "O" rings, and sealing washers should be replaced when covers are removed for any reason.

13. Hardware

Most hardware that is used in the Calvert bus system is special. Contact the factory before replacing any hardware.

14. External Insulators and Supports

All support insulators should be cleaned where needed.

All support insulators should be checked for cracking. All cracked insulators must be replaced.

All hardware in the support steel should be checked for tightness.

Note: Any other maintenance on this bus system should be under the direction of The Calvert Company. If a field technician is desired, contact the factory at (601) 939-9191 ext. 501.

Spare Parts

During normal operation, replacement parts should not be required. However, it is recommended that miscellaneous items (i.e., hardware, gaskets, insulation, etc.) be available during all maintenance activity.
For pricing or to place an order for spare parts, contact Calvert Installation Services at (601) 939-9191 ext. 225.

The Calvert Company will not assume responsibility for the use of substitute replacement parts without its written authorization.

WARNING: Substitute replacement parts used without prior written authorization from The Calvert Company will void all warranties.

Spare Parts List

Heaters	Boots	Dry Air Modules
Insulators (Post)	Access Cover Plates	Gaskets
Bellows	Bellows Clamps	Backing Rings
Splices	Saddle Supports	Saddle Support Insulators
Bushings	Filters	Flexible Connectors
Adhesive	Paint	Primer
Hardware	Conduit	Piping (S. S.)
Air Compressors	Fire Stops	Thermostats
Wire	Junction Boxes	Expansion Joints
Ground Pads	Anchors	Steel Supports
Switches	Fuses	Potential Transformers
Surge Arrestors	Surge Capacitors	Current Transformers