AZZ | CALVERT™

Your Single Source Worldwide

ISOLATED PHASE BUS SYSTEMS

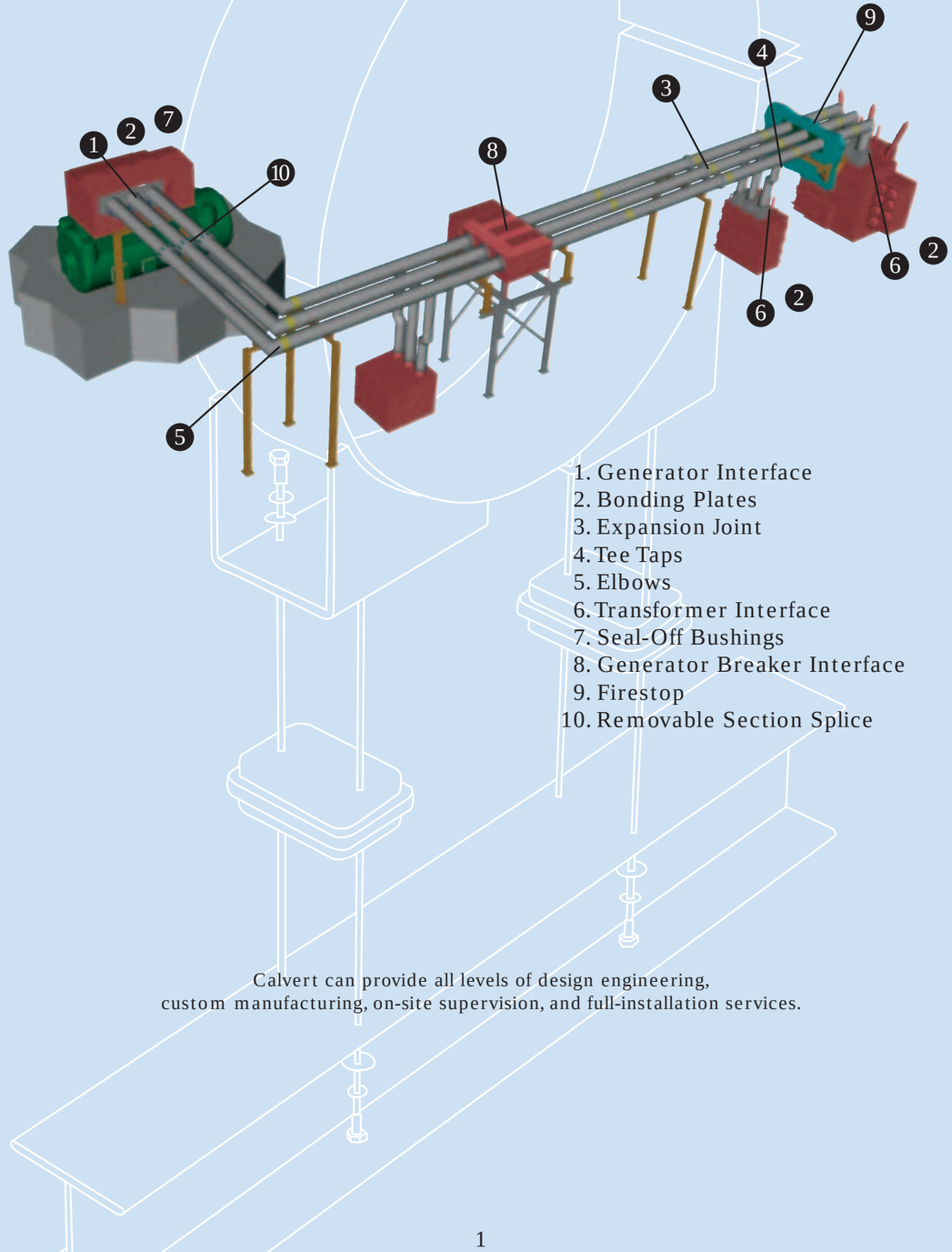
Table of Contents

THE CALVERT COMPANY

“ACHIEVING CUSTOMER SATISFACTION THROUGH CONTINUOUS IMPROVEMENT”

ISO 9001 CERTIFIED

ISOLATED PHASE BUS SYSTEM COMPONENTS



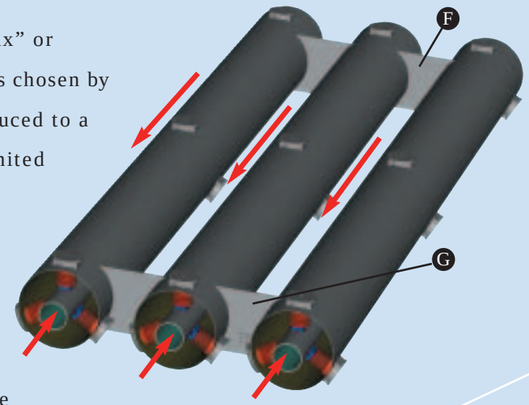
1. Generator Interface
2. Bonding Plates
3. Expansion Joint
4. Tee Taps
5. Elbows
6. Transformer Interface
7. Seal-Off Bushings
8. Generator Breaker Interface
9. Firestop
10. Removable Section Splice

Calvert can provide all levels of design engineering,
custom manufacturing, on-site supervision, and full-installation services.

THEORY OF OPERATION

The Calvert Company Isolated Phase Bus 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.

CONTINUOUS ENCLOSURE DESIGN



At a given instant, the direction of current flow is as shown by the arrows. 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 the bonding plates F and G.

In the 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% or less 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: A Sample Isolated Phase Bus Layout Drawing is located on page 21.

1. IPB Primary Design Features

1A. The Isolated Phase Bus is designed to the specifications shown on the Technical Data Sheets. All known bus parameters and calculated results are fully detailed on the data sheets. (Please see page 19 for a complete sample data sheet.) All of Calvert’s Iso-Phase bus designs are of the electrically continuous type with bonding plates between phase enclosures at each terminating point of the duct to provide a path for the enclosure current. Ground pads are provided on the bonding plates for connection to station ground. Calvert recommends grounding the Iso-Phase bus (IPB) system at one point only to prevent any induced currents from outside sources or current loops within the ground circuit. All Calvert IPB designs incorporate grade 304 stainless steel hardware for all fasteners which are used on the exterior portions of the duct and Grade 5 Zinc Dichromate Steel fasteners which are used on the duct interior and all conductor joints. Calvert uses, as a standard, specific pre-loaded stainless steel conical washers for all bolted conductor joints. Calvert can supply any hardware to meet your specific application.

Calvert factory-welds all IPB equipment and components per AWS D.1.2 Welding Specifications. Calvert recommends all field welding follow AWS D.1.2 guidelines.

1A.1 Enclosure/Conductor Current Ratio: As a general rule, the enclosure will carry approximately 95% as much current as the conductor in an electrically continuous Iso-Phase bus system. For this reason, it is standard practice to use a 95% value when calculating the load capability, temperature rise and loss as shown on the Technical Data Sheets. However, if specified that the enclosure capability be based upon full conductor current, then this value is changed to 100% and the factor used in the calculation will be 1.0. (Reference Technical Data Sheet line A.8, page 19.)

1A.2 Conductor/Enclosure Emissivity Factor: It is Calvert’s standard policy to paint the exterior surface of the conductor and the interior surface of the enclosure with a flat black high-temperature paint to aid in the dissipation of heat. The emissivity factor for unpainted aluminum has been established to be .35, where aluminum painted with the flat black paint has been established to be .90. Unless otherwise requested, Calvert has used the .90 emissivity factor for the conductor in all calculations represented on the Technical Data Sheets. (Reference Technical Data Sheet lines C.4 and D.2.)

1A.3 Conductor Resistivity: The International Standard for the resistivity of annealed copper equal to 100% conductivity at 20 degrees Celsius equals 00.017241 ohms-meter/sq. mm. Converting, this equals 8.1454 microhms/sq. in./ft. Using these values, Calvert computes the resistivity of a conductor as follows:

(1) Metric: R = .017241/IACS (2) English: R = 8.145/IACS (3) Where: R = Resistivity, IACS = Conductivity

1A.4 Recommended Phase-to-Phase Spacing: Calvert’s recommended phase-to-phase center distance is based upon a factor of 1.5x the enclosure diameter. This allows ample clearance between enclosures for air circulation for the dissipation of heat. Also, the greater the phase-to-phase distance, the less force is exerted during a short-circuit condition. Reference Technical Data Sheet lines A.5, D.12, and F.12. Calvert recommends a phase-to-phase spacing that will allow no less than 4.00" between enclosure outside diameters.

STANDARD CROSS SECTIONS – 125kv B.I.L.

Ampere Rating (A)	*Enclosure Inch*	*Diameter Mm*	*Recommended phase spacing center line Inch*	*Mm*
3500	*22*	*562*	*33*	*838*
4000	*24*	*613*	*36*	*610*
5000	*24*	*613*	*36*	*610*
6000	*26*	*664*	*39*	*660*
7000	*26*	*664*	*39*	*660*
8000	*28*	*714*	*42*	*711*
9000	*30*	*765*	*45*	*1143*
10000	*30*	*765*	*45*	*1143*
11000	*34*	*870*	*51*	*1295*
12000	*34*	*870*	*51*	*1295*
13000	*37*	*946*	*56*	*1422*
14000	*37*	*946*	*56*	*1422*
15000	*39*	*997*	*59*	*1499*
16000	*40*	*1022*	*60*	*1524*
17000	*42*	*1073*	*63*	*1600*
18000	*43*	*1099*	*65*	*1651*
19000	*46*	*1175*	*69*	*1753*
20000	*48*	*1226*	*72*	*1829*
20000-up	*Forced-air cooled or self-cooled special design available from Calvert.*			

Note: The cross sections shown above are rated at 40 degrees Celsius with a 65 degree Celsius rise.

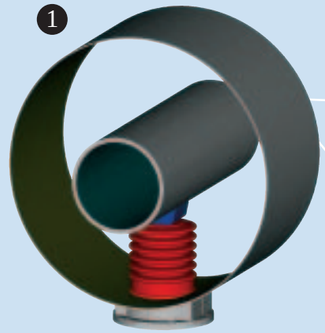
No compensation is made for solar gain, limited rise, or high ambients.

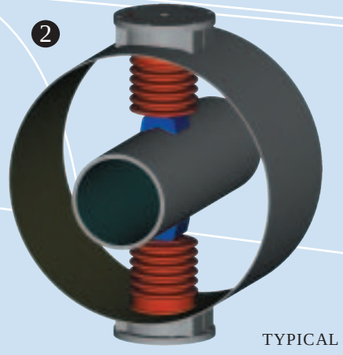
1B. Conductor: The bus conductor will be either a round extruded aluminum tube, 6101-T6 alloy for conductor sizes 12.00" or less in diameter (59.5% conductivity) or rolled from aluminum plate, 1100-H14 alloy for conductor sizes greater than 12.00" in diameter (57% conductivity).

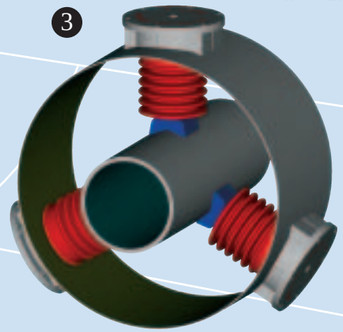
Project specific electrical characteristics are shown on the Technical Data Sheets supplied with each Calvert Proposal. Factory-welded conductor sections are fitted with backing rings and ends beveled to attain 100% weld penetration and weld reinforcement which exceeds AWS requirements. All conductor ends for field welding are factory weld prepared. Backing rings are also included with the splice assembly for extruded tube size conductors. Two-piece splice sleeves are supplied for rolled conductors (see section 2G for details).

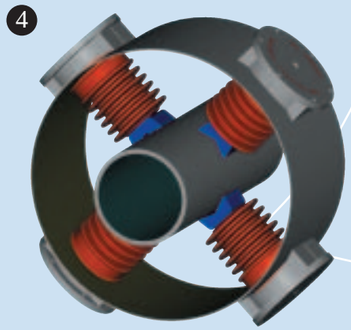
1C. Enclosure: The bus enclosure is rolled from 1100-H14 aluminum sheet or plate. Each longitudinal seam is fully factory welded. The enclosure is designed for all field splicing to be performed by welding to assure a continuous current path, a weather-and dust-tight seal, and also to maintain structural integrity. The enclosure is fitted with factory-welded castings for bolt-in installation and removal of each insulator assembly. The insulator casting is gasketed for positive sealing of the enclosure. As a standard, filter type drain plugs are factory installed on the enclosure at low points for drainage of condensation.

1D. Insulators: The insulators are of the wet process porcelain type. Calvert supplies, as a standard, 36kv/150kv B.I.L.-rated insulators, for any voltage requirement up to 36kv rated systems. The insulators are rigidly fastened to aluminum castings and, welded to the bus enclosure, to provide the required strength for short-circuit bracing. The insulators are provided in one, two, three, or four insulator designs per location and spaced to provide both short-circuit bracing and required conductor support. This specific information can be found on the Technical Data Sheets. Calvert's specially designed insulator assembly accomplishes the required loads without being rigidly fastened or welded to the conductor (except the single insulator design). This feature allows the entire insulator assembly to be removed and reinstalled in a one-piece assembly allowing unlimited conductor movement due to thermal expansion without placing lateral stress on the insulator. The number of support insulators is determined by size and weight of the conductor and the rated short-circuit value of the bus system.









TYPICAL
One, Two, Three, & Four
INSULATOR DESIGNS

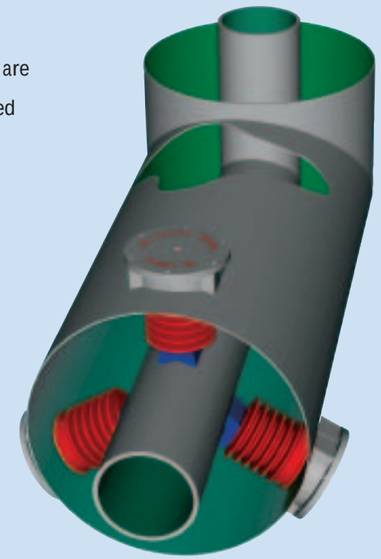
1E. Finish (Standard): Calvert supplies all Iso-Phase bus systems and accessories with a minimum of 2 mils dry-finish coat. There is no additional charge for standard finish. The standard paint type is Sherwin Williams KEM400 Series Enamel. The standard colors are ANSI-61 (indoor) and ANSI-70 (outdoor).

1F. Finish (Custom): Calvert can supply custom finishes, if specified. Please make sure that your specification addresses coatings for aluminum equipment.

2. Bus Duct Fittings

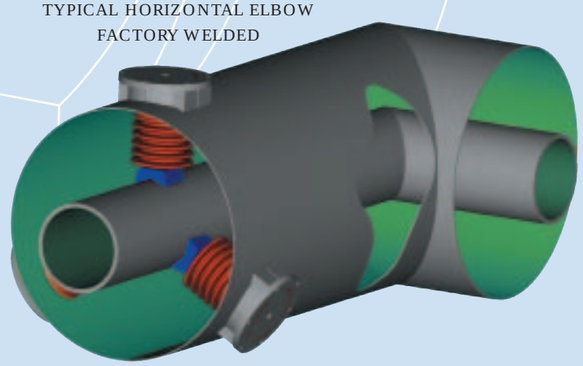
2A. Elbows: Calvert can supply elbows designed at any angle of offset. All elbows are CNC plasma cut from flat plates, rolled and welded together to form a mitered joint. All elbows are factory welded to a longer section of bus to complete a shipping section. This feature reduces the amount of on-site weld time.

Elbows are designed to accommodate the placement of insulators and custom layout designs. Note that bus length is determined by conductor center-line dimensions.



TYPICAL VERTICAL ELBOW
FACTORY WELDED

TYPICAL HORIZONTAL ELBOW
FACTORY WELDED



2B. Tee Taps: Calvert can supply tee taps at any location and with any rating required. The design and construction are typical to elbows. Also all tee taps are fully factory assembled to reduce on-site weld time.

Electrical taps in the bus are used to connect components such as auxiliary transformers, excitation transformers, neutral grounding cubicles, and so forth. In most cases, the current rating of the tap bus is irrelevant. The tap bus design and size is mainly determined by rated momentary current rating of the system.

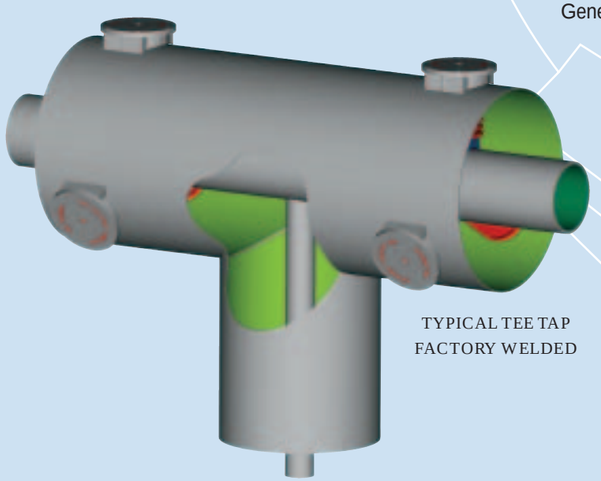
Calvert's standard tap bus is rated up to 3500 amps continuous.

Tee taps have various designs based on interfacing equipment. Calvert will design tap bus configuration to match main bus phase centers and the interfacing equipment phase centers.

2C. Delta Bus Transitions: Are used when three single-phase main step-up transformers are connected to the main generator bus duct run. The typical design of the transition sections would incorporate dual delta taps from the same main bus location. The transition sections are fully factory assembled to save on-site fit up and welding time.

2D. Phase Transpositions: Calvert can supply a fully factory-fabricated, three-phase transposition to accommodate proper equipment phase requirements. A typical phase transposition reverses the phasing on the outer two bus phases.

2E. Solar Shields: Are used when the bus system is required to be solar derated. Generally, if the bus system has a smaller portion of outdoor bus in comparison with the portion of indoor bus, it is more cost effective to place solar shields on the outdoor sections in lieu of derating the entire bus system for the effects of solar radiation. Calvert designs the solar shields to be fully factory fabricated. The shields are field installed to prevent damage during shipment and installation.



TYPICAL TEE TAP
FACTORY WELDED

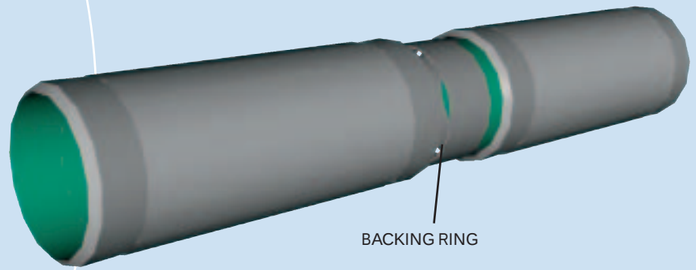
2F. Solar Derating: When the monthly maximum normal temperature is shown on the Technical Data Sheets (Line B.6) as "NO," then there has been no consideration made for solar radiation heat gain to the bus enclosure. If "YES," and the temperature appears as a value, then solar heat gain has been considered and will show calculated results in section E.1.

There are two recognized methods with which to compensate for this additional heat gain. First, the use of heat shields (see Item 2E) to protect the bus enclosure from sun exposure, thereby causing no heat gain to the bus system. Secondly, the enclosure and/or the conductor cross-sectional area may be increased to allow the enclosure to absorb the additional heat from the sun's rays without exceeding the specified maximum temperature rise on the enclosure or conductor. The derating application may be a more cost-effective solution if there is a larger majority of the bus system exposed to the sun. However, if solar radiation has been considered, the Technical Data Sheet will indicate the method used by Calvert to compensate for heat gain. Reference Technical Data Sheet line B.7.

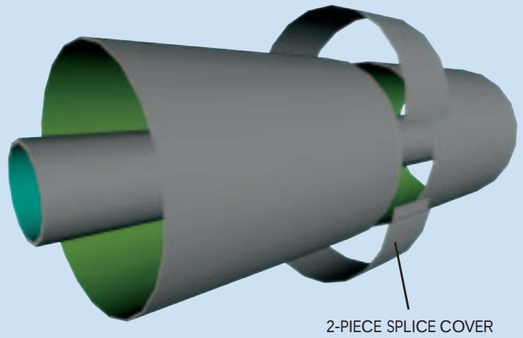
2G. Splice Joint, Welded, Conductor/Enclosure: The splice joint assembly contains all fittings necessary for the installer to join two bus sections. Included in the assembly are two split-enclosure splice covers with backing strips factory welded, and pre-fitted conductor backing rings for extruded tube size conductors or two-piece splice sleeves for rolled conductors.

All components are factory weld-prepared for field-welding.

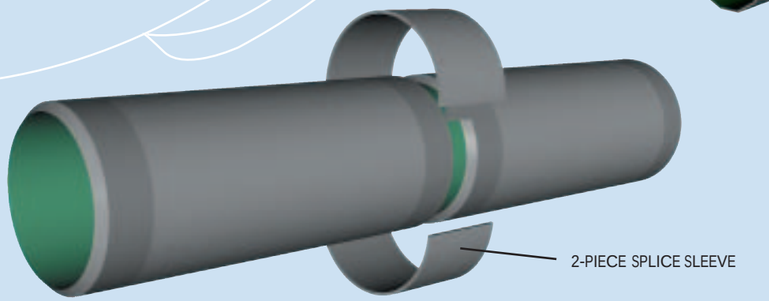
FIELD-WELDED SPLICE JOINT
EXTRUDED TUBE CONDUCTORS

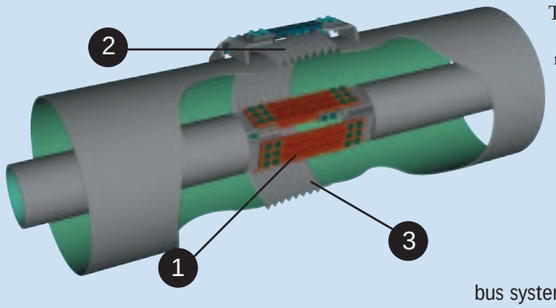


FIELD-WELDED SPLICE JOINT
ENCLOSURES



FIELD-WELDED SPLICE JOINT
ROLLED PLATE CONDUCTORS





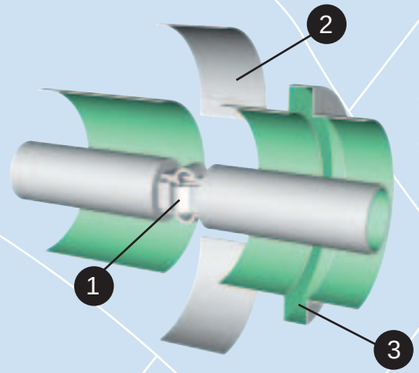
TYPICAL VIBRATION/EARTHQUAKE/EXPANSION JOINT

1. FLEXIBLE CONDUCTOR CONNECTORS
2. FLEXIBLE ENCLOSURE CONNECTORS
3. INSULATING FLEXIBLE ENCLOSURE BELLOWS

2H. Splice Joint, Vibration/Earthquake/Expansion, Conductor/Enclosure: This type of joint can be used for numerous applications. Its main functions are to provide a flexible joint when the bus system is to be installed in a seismic region that is rated above Zone 2 per Uniform Building Code. It can be used alone as a thermal expansion joint in a seismic area.

Or depending on the bus system routing, the joint can be used for a combination of earthquake and expansion at the same location. Each joint of this type contains factory-welded conductor studs for bolting the supplied flexible connectors. The enclosure joint is made up of a bellows assembly, which attaches to factory-welded bellows collars, and an enclosure jumper assembly which consists of factory-welded studs for supplied flexible enclosure connections. This type of splice joint may also be used as a removable joint when certain sections, typically in generator or transformer areas, are required to be removable without cutting or welding of the enclosure and conductor to allow for equipment removal or servicing.

TYPICAL THERMAL EXPANSION JOINT

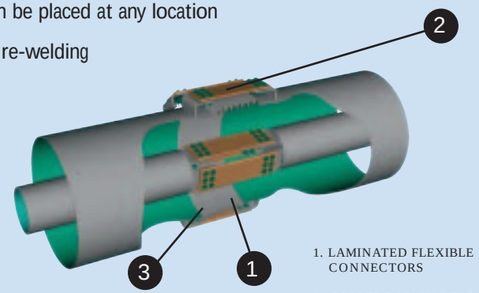


1. LAMINATED FLEXIBLE CONNECTORS
2. (2)-PIECE SPLICE COVER ASSEMBLY
3. FACTORY-WELDED ENCLOSURE EXPANSION RING

2I. Splice Joint, Expansion, Conductor/Enclosure: This type of joint is used only for thermal expansion of the conductor and enclosure. The joint assembly consists of a fully factory-welded enclosure expansion ring and a factory-assembled laminated flexible connector joint for the conductor. The conductor expansion assembly is welded in place typically at a section split which is offset from the enclosure expansion ring. The expansion ring is factory located and welded within a bus section.

A laminated flex assembly is provided to compensate for thermal expansion of the conductor. The location will be selected at the time manufacturing drawings are prepared. The conductor joint is factory assembled for field welding to the weld-prepared conductor ends. Calvert, as a standard practice, does not factory-weld the flex joint to one conductor end due to the possibility of damage during installation.

2J. Splice Joint, Removable, Conductor/Enclosure: This type of joint can be placed at any location along the bus routing for a bus section to be removed without cutting and re-welding the bus conductor and enclosure. The removable joint is used typically in areas where periodic access to other equipment is required. The removable section is typical in design to the Vibration/Earthquake/ Joint, 2H. The only change made to the removable section is the enclosure jumpers are typically rigid bar.



TYPICAL REMOVABLE SECTION JOINT

1. LAMINATED FLEXIBLE CONNECTORS
2. COPPER BAR JUMPERS
3. INSULATING FLEXIBLE BELLOWS

3. Termination Compartments

All of Calvert's Termination Compartments are custom designed and manufactured to fit each application. Each compartment is fully fabricated from aluminum sheet or plate and members, with removable covers to provide access to the conductor termination. All compartment exteriors are painted to match bus finish specification (high temperature flat black interiors) and come complete with 3/8" stainless steel fastening hardware and gasketing material to bolt to the interfacing equipment flange. All compartments are supplied with grounding provisions and are manufactured from material of adequate thickness to prevent hotspots.

The transition requirement from the generator bushing terminations to the isolated phase bus connection varies by generator manufacturer and whether the machine type is combustion or steam turbine driven. The generator manufacturer determines the isolated phase bus starting point. Calvert designs the terminal interface and line/neutral compartments to suit your specific application.

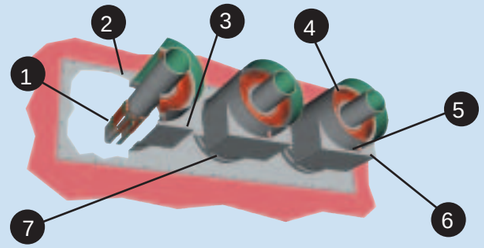
Fiberglass or aluminum barriers are provided to separate phases internally. Ground pads are provided on the end of the enclosure.

If the generator manufacturer supplies the terminal compartment, Calvert will supply all necessary components to complete the generator/bus duct interface.

Bus bonding plates are provided at the generator exit interface. The bonding plates provide the same cross-sectional area as the isolated phase bus enclosure to insure that the circulating currents will flow equally in both directions. Suitable ground pads are provided at both the generator and transformer ends. Calvert recommends grounding at a single point. Bonding plates are supplied at each terminal interface to equipment connections (i.e., auxiliary transformers, generator breakers, PT Cubicles, etc.).

The isolated phase bus connection to the main power transformer is made by terminating the phase bus to a transformer termination enclosure. Each termination enclosure is sized to contain bushing blades, adapter bars, and flexible main-bus-to-adapter-bar connectors. Each enclosure has a removable cover to permit connection of the flexible connectors.

TYPICAL GENERATOR TERMINATION



1. FLEXIBLE CONDUCTOR CONNECTORS
2. IPB/GENERATOR INTERFACE FLANGE
3. BONDING PLATES
4. BUS END SEALS
5. AIR PURGE/ PRESSURIZATION TAPS
6. TERMINATION ACCESS COMPARTMENTS (3E)
7. INSULATING FLEXIBLE ENCLOSURE BELLOWS

3A. Compartment, Non-Segregated – Three Phase, Auxiliary Equipment: This compartment is generally used when the connecting terminals on the interfacing equipment are too close, phase-to-phase, to allow for single-phase or segregated-phase compartments to be used. Please note that seal-off bushings will be required for this compartment application to prevent ionization of the air between phases.

3B. Compartment, Segregated – Three Phase, Generator, Transformer, Auxiliary Equipment: This compartment is used when the connecting terminals on the interfacing equipment are spaced sufficiently, phase-to-phase, to allow for a phase segregation of either GPO3 fiberglass or aluminum.

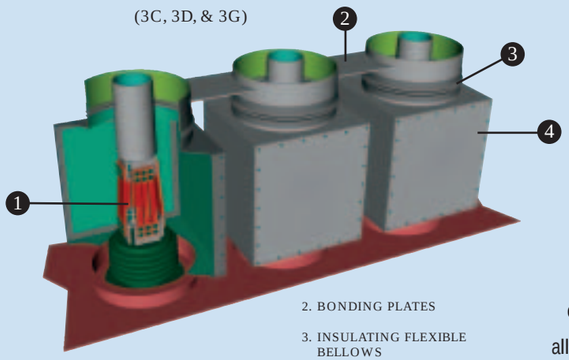
3C. Compartment, (Standard) Single Phase – Generator, Transformer, Auxiliary Equipment: These compartments are used to enclose each phase individually. The single-phase compartment assembly includes electrical bonding accessories to tie all phases together to prevent circulating currents.

3D. Compartment, (Custom) Single Phase – Generator, Transformer: These compartments are typical to the single-phase "standard" compartments, however custom designed to fit unusual design parameters. This design typically is required when there is a close strike arc distance between the H.V. and L.V. transformer bushings or when there are piping or other obstructions that cause a special design. This type of compartment is also recommended when the terminal point is used as a "removable" disconnect between the IPB and the interfacing equipment for equipment removal without cutting the bus system. For example, when a transformer bushing needs to be removed or the entire transformer needs to be replaced, the compartment can be removed to allow clearance for the transformer to be moved without cutting and re-welding the IPB.

3E. Compartment, Access (Standard) Single Phase – Generator, Transformer, Auxiliary Equipment: These compartments are built into the IPB enclosure. The access compartments provide access to the terminal point of interface by means of a fully welded access panel with a removable cover. This type of termination compartment is a more cost-effective alternative to the independent type compartments described above, where only limited access is required to the terminal point. However, they may restrict equipment removal.

3F. Compartment, Generator Neutral – Three Phase: This compartment provides enclosed protection for either the generator line side bushings or the neutral tie. This type of compartment is typically required on Steam Turbine Generators. All features of a segregated phase compartment are included.

SINGLE-PHASE COMPARTMENTS
(3C, 3D, & 3G)



1. FLEXIBLE CONDUCTOR CONNECTORS
2. BONDING PLATES
3. INSULATING FLEXIBLE BELLOWS
4. REMOVABLE COVERS

3G. Compartment, In-Line Current Transformer – Single Phase: This compartment is designed to provide support and access to current transformers per your specification. Each compartment will contain single ratio current transformers fully mounted to non-magnetic material (GPO3 fiberglass) frames. The compartment will also contain a conductor-bolted connection which will allow the CTs to be removed. Each CT compartment will include a NEMA 4 externally mounted terminal box with short-circuiting type terminal blocks. The CTs are factory-wired to the terminal blocks.

3H. Compartment, Disconnect w/Switch Segregated Phase: This compartment fully encloses a disconnect or grounding switch which you have specified. This compartment can be mounted in various positions and includes viewing windows mounted on the removable covers. This compartment is fully isolated from the IPB enclosure with the switch assembly fully factory-installed. Each complete unit is operated to insure alignment and is high-potential tested prior to shipment. Typically, this type of compartment is factory-welded to the main bus enclosure. Calvert can supply a stand-alone switch compartment which will utilize a tap bus for connection to the switch compartment location.

3I. Compartment, Disconnect w/Switch Single Phase: This compartment is typical in all respects to the segregated-phase compartment except that each switch is individually enclosed. All switch operational linkages are provided. Typically this type compartment is factory welded to the main bus enclosure. Calvert can supply a stand-alone switch compartment which will utilize a tap bus for connection to the switch compartment location.

3J. Compartment, Phase Reversal Four-Pole Switch: These compartments are used when your system is designed to reverse phasing between the generator and the transformer by means of remote operation. These compartments are fully factory-assembled with switching units except for phase-to-phase linkages which are field installed. All phase reversal compartments are completely bonded to the IPB to insure a continuous type of bus system. All compartment features are typical to the segregated phase disconnect switch compartments (3H).

3K. Compartment, Surge Protection Single Phase: This compartment contains lightning arresters, surge capacitors, and other surge protection equipment per your specification. Each compartment is bolted or welded and gasketed to the bottom of each phase enclosure at a specified location. The compartment is supplied with a connection stud which is factory welded to the main bus conductor. All primary and secondary wiring is factory installed. A NEMA 4 terminal box is provided with each phase compartment for external connection.

3L. Flange, Three Phase, or Single Phase: The flange is typically used to connect the bus enclosure bellows to the interfacing equipment flange. The flange would be required for applications where access compartments are used (3E).

3M. Compartment, Generator Line, and Neutral Six Phase: This enclosure provides protection for both the line and neutral generator leads and termination to IPB. The compartment is ventilated as a standard but can be provided as non-ventilated. Please verify whether the compartment is to be ventilated or non-ventilated because it will affect the design of the conductor termination to the generator. This type of compartment is typically used on Steam Turbine Generators. All features of a segregated-phase compartment are included.

4. Conductor/Enclosure Terminations

4A. Termination Assembly (Standard), Conductor/Enclosure Single Phase – Generator, Transformer, Auxiliary Equipment: This termination assembly includes all necessary components to complete equipment interface between the IPB and equipment supplied by others.

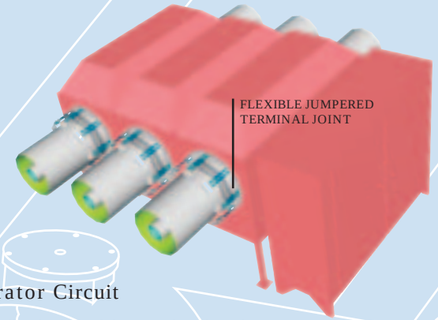
The conductor portion of the assembly includes flexible connectors, factory-welded bolting stud on IPB, and fastening

hardware. The flexible connectors are a rope lay braid type which is flexible in 360 degrees and has silver-plated ferrules and tin-plated braid. The flexible connectors are designed to allow for a fully rated B.I.L. gap when removed for testing, and they are designed 1.00" longer than required for misalignment. Also included is a conductor extension of up to 18.00".

The enclosure portion of the termination assembly includes Hypalon bellows, bellows clamps, RTV sealant, bonding plates or bars, and grounding provisions. The bellows assembly provides a 3.5kv potential clearance between the IPB enclosure and the interfacing equipment and flexibility for minor misalignments, vibration, and seismic conditions. The bonding plates or bars are provided for a return current loop in the enclosures and are factory-weld-prepped and include grounding provisions. All of Calvert's termination designs provide a terminal interface which applies no loads to the connecting equipment and provides for +/- 1.00" misalignment in any direction.

4B. Termination Assembly (Custom), Conductor/Enclosure Single Phase – Generator, Transformer, Auxiliary Equipment: This termination assembly contains all of the components stated above for the standard termination assembly. However, this assembly allows for extra materials, labor, and design for termination features which require a non-standard design. Generally this occurs when there are differences in equipment phase centers. Adapter bars or tubes with special fittings and/or supports, conductor elbows, offsets and extensions greater than 18.00" are items which are typically included in the custom package.

TYPICAL GCB TERMINATION ASSEMBLY



4C. Termination Assembly (General Electric), Conductor/Enclosure Three Phase – Generator: This termination is specifically designed for connection to the G.E. Frame 7 and Frame 9 Generator Terminal Enclosures. The termination is supplied with all components listed for the standard termination assembly.

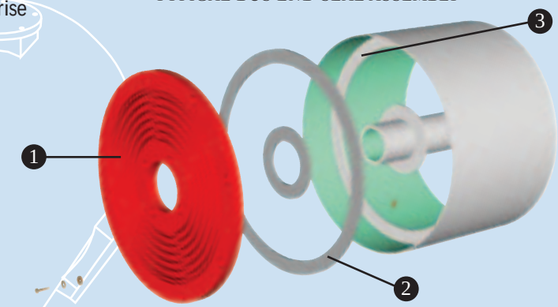
4D. Termination Assembly, Conductor/Enclosure Single Phase – Generator Circuit Breaker (SF_6 Continuous Design): This termination assembly is specifically designed for gas insulated type circuit breakers which allow the IPB enclosure currents to continue through the circuit breaker enclosure to provide a continuous current path through the circuit breaker enclosure. This design creates a continuous current path for the entire length of the bus system. Specifically designed enclosure flanges are supplied for welding to the GCB enclosure. The IPB conductor bolting stud is designed to match the conductor configuration of the circuit breaker. Flexible connectors and all fastening hardware are supplied to join the conductors and enclosures. The enclosure bellows, used for misalignment and to prevent damage to the IPB and GCB when GCB is operated, are jumpered with flexible connectors to allow for a current path through the GCB enclosure. The flexible connectors are fastened to factory-welded jumper brackets installed on both the IPB enclosure and Calvert-supplied interface flange to the GCB.

Gas insulated circuit breakers are rated for 90 degrees Celsius and 105 degrees Celsius maximum operating temperature. The IPB can be rated for both 90 degrees Celsius and 105 degrees Celsius maximum operating temperature. The obvious problem to be avoided is to prevent the heat transfer to the circuit breaker. Calvert recommends one of the following solutions:

(a) Oversize/Derate the IPB to reduce the resulting temperature rise to a maximum of 90 degrees Celsius.
(b) Specify 105 degrees Celsius operating temperature for the circuit breaker.

Please consult the factory for project-specific options which are the most cost effective for your application.

TYPICAL BUS END SEAL ASSEMBLY



1. SEAL-OFF BUSHING
2. CONDUCTOR & ENCLOSURE GASKETS
3. CONDUCTOR & ENCLOSURE MOUNTING RINGS

Note: This type of termination will require single-point grounding of the bus system. The breaker should not be grounded to prevent a current loop within the ground system. Calvert recommends that the GCB manufacturer be consulted to coordinate the grounding design between the IPB and GCB.

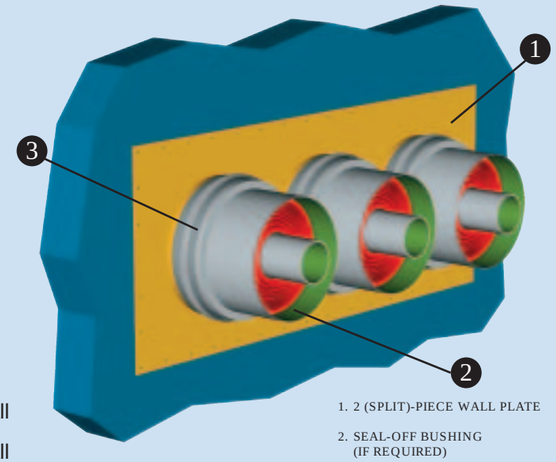
4E. Termination Assembly, Conductor/Enclosure Single Phase – Generator Circuit Breaker (SF_6 Non-Continuous Design): This termination assembly, which is typically more cost effective, includes all components supplied with the SF_6 type of termination, except this termination does not allow current to flow from the IPB enclosure into the circuit breaker enclosure (i.e., for a non-continuous type breaker). The enclosure splice covers are replaced with insulating bellows, and bonding plates or bars are supplied to create a current loop for the IPB enclosure.

Note: This type termination of will require the bus enclosure be grounded on each side of the breaker and the breaker enclosure itself. Calvert recommends that the GCB manufacturer be consulted to coordinate the grounding design between the IPB and GCB.

5. Seal Assemblies/Firestops

5A. Seal Assembly, Bus End, Single Phase: This type of seal assembly is used at any terminal point where it is desired to restrict the exchange of air between equipment. The bus end seal also provides a positive seal for pressurized or forced-air cooled bus systems and a seal for hydrogen leakage. The seal-off bushing is machined from 2.00" thick GPO3 fiberglass to provide creep rings for voltage potential, is solidly mounted with fasteners, gasketed to a fully factory-welded conductor and enclosure mounting rings, and is fully epoxy coated.

TYPICAL WALL/FLOOR SEAL ASSEMBLY



1. 2 (SPLIT)-PIECE WALL PLATE
2. SEAL-OFF BUSHING (IF REQUIRED)
3. INSULATING FLEXIBLE ENCLOSURE BELLOWS

5B. Seal Assembly, Wall/Floor, Three Phase: This type of seal assembly is used to seal any bus duct penetration through a wall or floor that is non-fire-rated. The seal assembly incorporates all

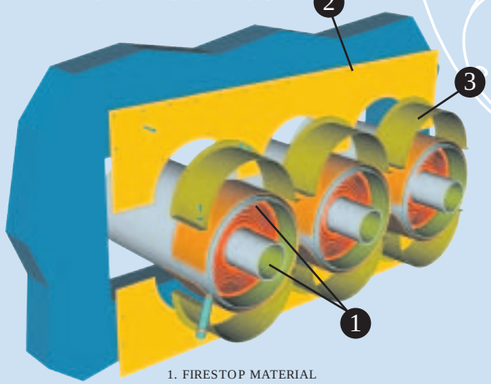
components of the bus end seal assembly, 5A, to seal the interior of the duct. A two-piece (split horizontally across phases), three-phase aluminum wall/floor plate seals the wall/floor opening. All required fasteners and gasketing materials are supplied. The design of the seal assembly, by utilizing an insulating flexible bellows, allows the enclosure to pass through the wall/floor penetration ungrounded to provide a continuous current path in the enclosure. The bellows also allow for misalignment through the wall penetration.

The wall or floor seal assembly provides a convenient, pre-engineered assembly that simplifies the bus penetration. The two-piece wall plate is fabricated from aluminum. IPB systems generally need no internal seal at a building wall/floor penetration because the IPB system is totally sealed. If you do not require an internal seal for a penetration, Calvert can supply only the external plate to seal the opening surrounding the bus enclosures.

Note: If your system is fitted with filtered breathers for condensation control, seal-off bushings may be required at the wall penetration.

5C. Seal Assembly, Firestop, Three-Hour Rated, Three Phase: This type of seal assembly is used when there is a requirement for fire protection. The firestop design and components are typical to the wall/floor seal assembly except a Dow Corning material, Sylgard 170, is poured on the fire side of the seal-off bushing. The two-piece wall plate is fabricated from 304 grade stainless steel. The wall plate is designed to mount directly to a building's is steel framing or concrete wall, therefore the firestop is not supplied with a wall frame.

TYPICAL FIRESTOP DESIGN



1. FIRESTOP MATERIAL
2. 2-PIECE S.S. MOUNTING PLATES
3. 2-PIECE S.S. COLLARS

Calvert can supply the firestop with or without the internal fire seal components depending on your specific requirements. The firestop plate-to-seal wall opening would be supplied in either case.

5D. Seal Assembly, Firestop, Two-Hour Rated, Three Phase: This type of seal is typical in design in all respects to the three-hour rated firestop but rated for two hours.

6. Steel Support Structures

Calvert can design and manufacture bus duct support structures to meet any code requirement or application. Calvert has many "standard" support structures in the single-column, two-column, three-column, four-column, knee-brace-trapeze, and bridge-type designs. Support placement is generally required at 20' to 30' intervals. All supports are hot-dipped galvanized per ASTM A-123 unless otherwise specified. All supports are furnished with grounding provisions. All support materials are ASTM A-36 and all fasteners are per ASTM A-325 and hot-dipped galvanized. Anchor bolts are assumed "by others" unless otherwise specified.

6A. Duct Support, Single Column, Single Phase: This type of support is used primarily to support a single phase of a three-phase bus system where there is limited support space for foundations or columns of a two-column support. This support has a center column fabricated from a wide flange beam or square tubing.

6B. Duct Support, Single Column, Three Phase: This type of support is typical to the single-column, single-phase support except designed to support all three phases at one location.

6C. Duct Support, Two Column, Three Phase: This type of support is the most widely used for outdoor duct support applications. This support is supplied with two main supporting columns which are connected to a single horizontal cross member.

6D. Duct Support, Two Column w/Auxiliary Bus Brace: This support is typical to the two-column support (6C) but includes a secondary horizontal beam to support a three-phase auxiliary bus tap. Normally this support will be required if the auxiliary bus tap length is greater than 12' in length.

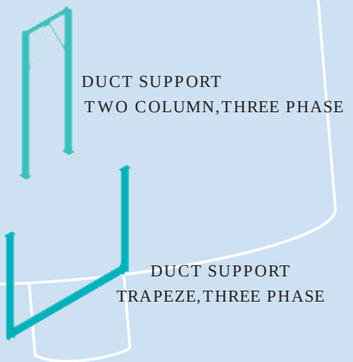
6E. Duct Support, Four Column, Three Phase: This type of support is designed to support a three-phase duct at a horizontal elbow. The support provides full support under the entire elbow area. Design is typical to the two-column supports.

6F. Duct Support, Knee Brace, Three Phase: This support is designed to support the duct from an existing wall or other structure. The support is generally used around main step-up transformer areas, mounted to a firewall, where support foundation areas are limited.

6G. Duct Support, Trapeze, Three Phase: This support is designed to support the duct from overhead. The design is simply an inverted two-column support which is anchored or welded to existing building steel or concrete structures. This support is for indoor use where wind loading is not a factor.

6H. Duct Support, Three Column, Three Phase: This type of support is typical in design to the four-column support and is typically used in elbow areas.

6I. Duct Support, Saddle Assembly, Single Phase (Field Welded): The saddle assembly is designed to fasten the IPB to the steel support structure and keep this entire bus system isolated from the steel and ground. This lower cost assembly contains a set of two aluminum support brackets which are field-welded to the bus enclosure once the duct is in its proper location. A set of two 5kv insulators are supplied that connect the support brackets to the steel support structure. All associated stainless steel fastening hardware is provided to complete the assembly.

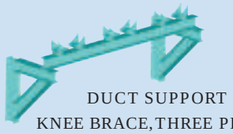


DUCT SUPPORT
TWO COLUMN, THREE PHASE

DUCT SUPPORT
TRAPEZE, THREE PHASE

DUCT SUPPORT
FOUR COLUMN, THREE PHASE

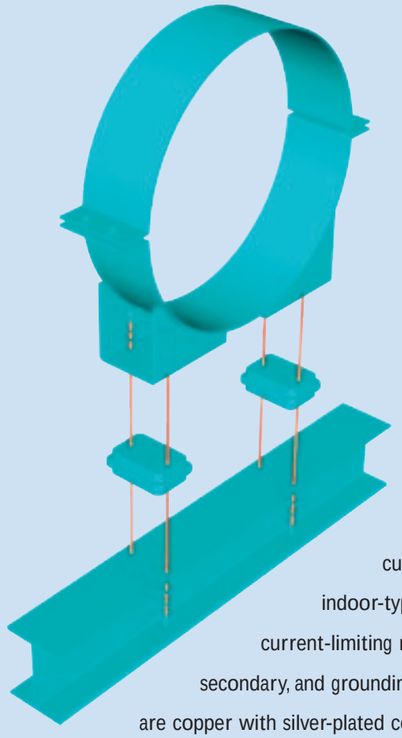
DUCT SUPPORT
THREE COLUMN, THREE PHASE



DUCT SUPPORT
KNEE BRACE, THREE PHASE

FIELD-WELDED
SADDLE ASSEMBLY

CLAMP TYPE SADDLE ASSEMBLY
FACTORY WELDED



6J. Duct Support, Saddle Assembly, Single Phase, Clamp Type (Factory Welded): This saddle assembly is designed to function the same as the field-welded assembly, (6I), however, totally factory-welded to reduce on-site welding time. Although the “clamp type” saddle assembly initially costs more, you are insured of total installed-cost savings many times over. The “clamp type” assembly needs only be bolted to the supporting steel and clamped around the bus enclosure. A set of two 5kv insulators are supplied that connect the clamp type support brackets to the steel support structure. All associated stainless steel fastening hardware is provided to complete the assembly.

7. Cubicles, P.T./Surge Protection

Calvert’s standard, free-standing, single-phase cubicle can be fitted with many different types of components to meet your specification. The standard cubicle includes: (2) draw-out, keyed-lock type potential transformer drawers, (2) indoor-type potential transformers with fuses, (1) lightning arrester, (1) surge capacitor, (1) current-limiting resistor, IPB connection and primary bus bar, all P.T., S.C., and L.A. primary, secondary, and grounding wiring factory-installed and continuous ground bus system. All bus bar and wiring are copper with silver-plated contact surfaces. The rear compartment has bolted removable covers for access to the cabinet interior. The cabinet and framing is fabricated from steel or aluminum and can be supplied for either indoor or outdoor applications. Each set of three single-phase cubicles is supplied with a NEMA 4 secondary wiring terminal box with all fittings to interconnect the cubicles.

8. Condensation Control

8A. Heaters, Insulator: If your specification requires heaters, Calvert will supply, as a standard, 240V, 500W ring-type heaters at each insulator location. The heaters will be operated at 120V to increase the life of the heater. Calvert supplies the heaters factory-wired with an isolated (insulated) “T” rigid conduit fitting for connection to wiring conduit supplied by others. Heaters are supplied for each insulator below the centerline elevation of the IPB.

8B. Control Panel, Heater, Three Phase: Calvert’s standard heater control panel includes all necessary components to meet any supplied voltage requirement. The control panel includes a differential thermostat which senses both ambient and internal bus temperatures to insure the duct interior remains above the dewpoint. Also included is a step-down voltage transformer, if required, and all relays for proper heater operation. A separate NEMA 4 control box is supplied for each three-phase system. All interconnection components for phase-to-phase heater circuit control panel wiring are supplied. Interconnecting conduits and wiring between locations are not supplied unless specified.

8C. Dry Air Systems: Calvert can supply a complete dry air system to pressurize the IPB. Or if you prefer provisions for connection to a dry air system supplied by others can be provided. Calvert recommends that the input air pressure not exceed .5 PSI. Calvert can also supply pressure relief valves and other air handling components if specified. The complete dry air system is an enclosed panel-mounted unit designed to operate on dry instrument air supply at an inlet air pressure of approximately 120 PSIG. It is divided into individual sections, each section controlling pressurization of one, 3-phase bus system. Pressure regulators are provided to allow two stages of pressure regulation in order to assure reliable flow control and added over-pressure protection. Flow gauges will be provided to allow flow monitoring and flow-rate adjustment. Calvert has two standard models. However, almost any component can be supplied for a fully customized unit.

8D. Forced-Air Cooled Systems: Calvert can supply complete forced-air cooled bus system for any system which is rated over 18,000 amps continuous current. If your system has requirements for forced-air cooling, Calvert will include a separate package in the proposal concerning the cooling system.

Please note that forced-air cooled systems are generally rated self-cooled at 60% of the forced cooled rating. Special designed elbows which aid in air movement will be included. This feature must be coordinated with the bus system layout. Forced-air systems are typically used when the physical size of the IPB must be reduced due to plant space.

9. Crating/Shipping

9A. Standard Domestic Crating: For all domestic shipments, Calvert will provide all bus system shipments in open wooden crates. All bus section ends are sealed with a stretch-wrap material, and the conductor is braced at each section end to prevent damage during shipment. Each crate is provided with a wooden frame which covers the entire crate. All domestic shipments (except very small orders) are shipped via flat bed trailers and fully tarped prior to departure from Calvert’s plant.

The length of the bus sections is selected to accommodate the physical layout and the shipping requirements. Eighteen foot (18') lengths allow two sections to be shipped, end-to-end, in a 40' container. Containers are 8' high, thus side-by-side, and stacking is dependent on the diameter of the enclosure.

9B. Containerized Crating, Export Shipments: All shipments which are made by metal-enclosed containers will have crating typical to the standard domestic crating with the following additions: (a) stiffeners and additional bracing will be provided to insure that the crate will not move independently from the container, (b) desiccant will be provided to both the internal and external portions of the bus duct and within all boxed or separately packaged Bill of Material components.

9C. Export Crating, Export Shipments: For all export shipments that require export crating, Calvert will supply all components described within the containerized crating section except the bus duct crates will be totally enclosed with wooden framing and plywood sheeting. Calvert’s standard export crating procedure directly follows General Electric export crating specifications.

9D. Special Crate Markings/Special Shipping Documents: Calvert will supply special markings and/or special documentation you have specified. If any additional charges apply, they can be found in the Pricing Summary section of the proposal.

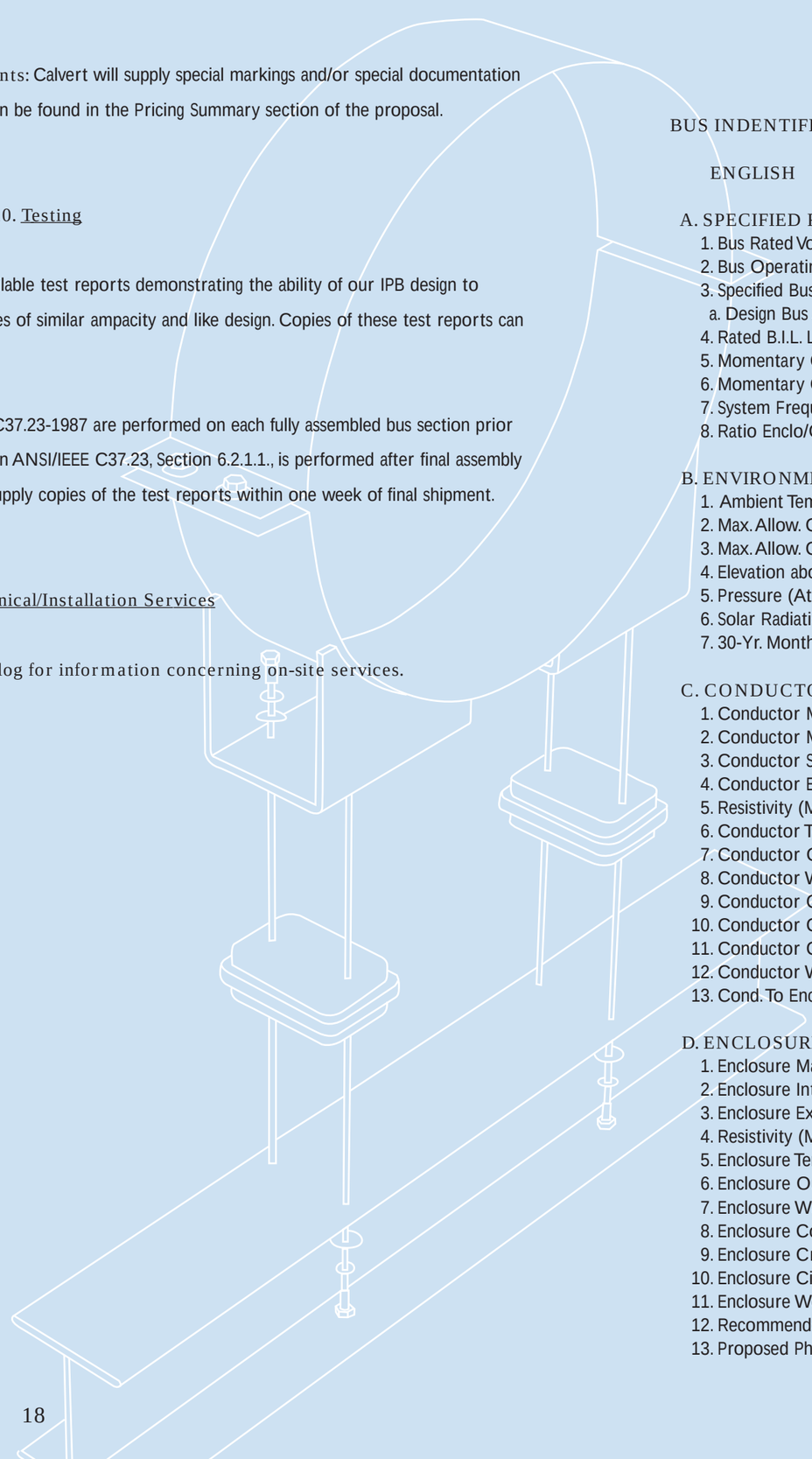
10. Testing

10A. Standard Equipment Design Tests: Calvert has available test reports demonstrating the ability of our IPB design to perform within ANSI standards. These tests are on buses of similar ampacity and like design. Copies of these test reports can be provided at no charge.

10B. Production Testing: Production tests, per ANSI/IEEE C37.23-1987 are performed on each fully assembled bus section prior to shipment. A Frequency Withstand Test, as described in ANSI/IEEE C37.23, Section 6.2.1.1., is performed after final assembly on each shipping section of the bus duct. Calvert will supply copies of the test reports within one week of final shipment.

11. On-Site Technical/Installation Services

Please refer to the Calvert Installation Services Catalog for information concerning on-site services.



TECHNICAL DATA SHEET

BUS INDENTIFICATION: MAIN BUS (EXAMPLE ONLY)

ENGLISH	METRIC VALUES	TECHNICAL VALUES	NOTES
A. SPECIFIED RATINGS:			
1. Bus Rated Voltage (KV)	29.5	29.5	
2. Bus Operating Voltage (KV)	18	18	
3. Specified Bus Ampacity (AMPS)	12000	12000	
a. Design Bus Ampacity (AMPS)	12727.92	12727.92	A.3.a.
4. Rated B.I.L. Level (KV)	125	125	
5. Momentary Current (KA 3-Ph rms Asymm)	275	275	
6. Momentary Current (KA Maximum Peak)	449	449	E.1.a.
7. System Frequenty (Hertz)	60	60	
8. Ratio Enclo/Cond Current	.95	.95	A.8.a.
B. ENVIRONMENTAL PARAMETERS:			
1. Ambient Temperature (Deg-C)	40	40	
2. Max. Allow. Cond.Temp. (Deg-C)	65	65	
3. Max. Allow. Cond. Oper. Temp. (Deg-C)	105	105	
4. Elevation above Sea Level (Feet-Meter)	100	30.48037	
5. Pressure (Atmospheres @ 100 Feet Elev.)	.9968755	.9968755	
6. Solar Radiation Compensation Specified	Yes	Yes	
7. 30-Yr. Monthly Normal Max Temp (DegF/C)	90.0/32.2		
C. CONDUCTOR DATA:			
1. Conductor Material	Aluminum	Aluminum	
2. Conductor Material Type	Rolled Sheet	Rolled Sheet	
3. Conductor Shape	Circular	Circular	
4. Conductor Emissivity Factor	.9	.9	C.4.a.
5. Resistivity (MocroOhms, Sq. In./Ft.-Sq.Cm/Cm)	14.2901	3.024742	C.5.a.
6. Conductor Temp. Coeff. Of Resistance	.004	.004	
7. Conductor Outside Diameter (Inches-mm)	19	482.6	
8. Conductor Wall Thickness (Inches-mm)	.375	9.524999	
9. Conductor Conductivity (%IACS)	.57	.57	
10. Conductor Cross Sectional Area (Sq. In-Sq.mm)	21.94206	14152.63	
11. Conductor Circumference (Feet-Meter)	4.974189	1.516151	
12. Conductor Weight (Lbs/Ft-Kg/M)	25.71171	38.2469	
13. Cond. To Encl. Clearance (Inches-mm)	8.875	225.425	
D. ENCLOSURE DATA:			
1. Enclosure Material	Aluminum		
2. Enclosure Internal Surface Emissivity Factor	.9	.9	D.2.a.
3. Enclosure External Surface Emissivity Factor	.8	.8	D.3.a.
4. Resistivity (Microhms, Sq. In./Ft-SqCm/Cm.)	14.2901	3.024742	D.4.a.
5. Enclosure Temp. Coeff. Of Resistance	.004	.004	
6. Enclosure Outside Diameter (Inches-mm)	37.25	946.1499	
7. Enclosure Wall Thickness (Inches-mm)	.25	6.35	
8. Enclosure Conductivity (%IACS)	.57	.57	
9. Enclosure Cross Sectional Area (Sq. In-Sq.mm)	29.05974	18748.18	
10. Enclosure Circumference (Feet-Meter)	9.752029	2.972454	
11. Enclosure Weight (Lbs/Ft.Kg/M)	34.0522	50.66967	
12. Recommended Phase-Phase Spacing (Inches-mm)	55.875	1419.225	D.12.a.
13. Proposed Phase-Phase Spacing (Inches-mm)	55	1397	D.12.a.

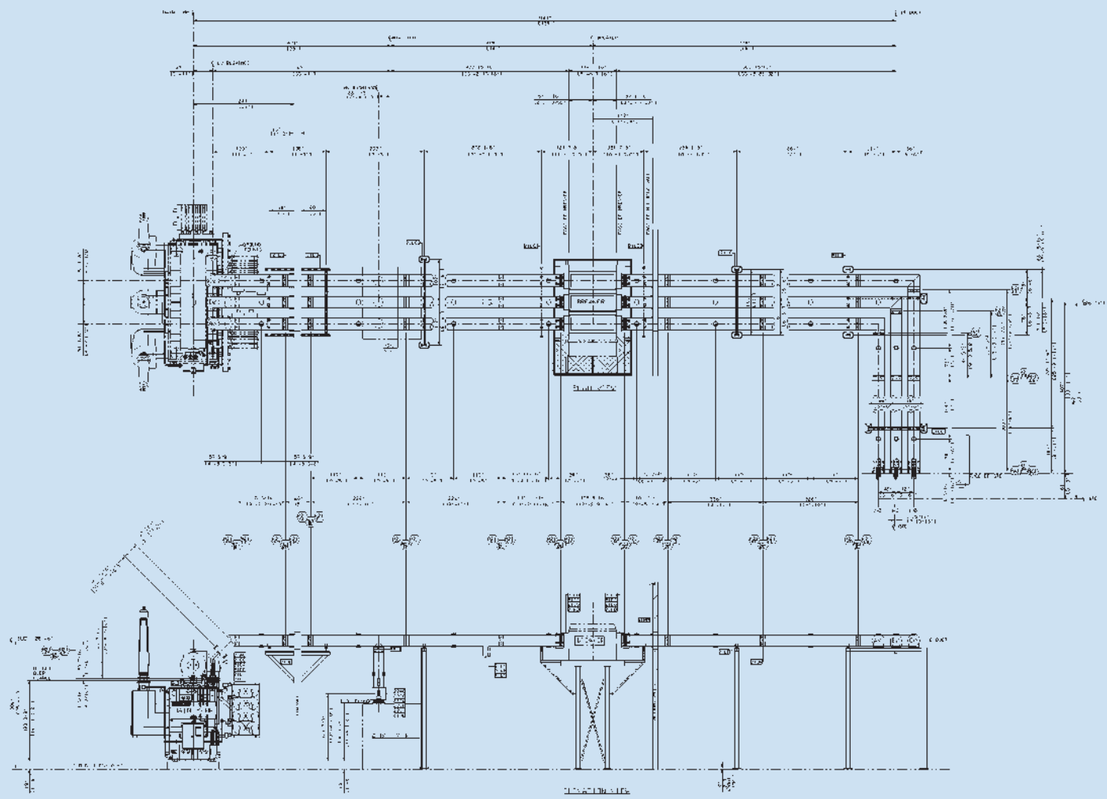
E. CALCULATED RESULTS:	ENGLISH VALUES		METRIC VALUES	
	CONDUCTOR	ENCLOSURE	CONDUCTOR	ENCLOSURE
1. Maximum Current @ 105 Deg-C (I)	13154.8	———	13154.8	———
2. Temp. of Air @ 13154.79 Amps (Q4)	———	86.74	———	86.74
3. Temperatures @ 13154.79 Amps (Deg-C)	105	74.42	105.00	74.42
4. DC Resistance @ 65 Rise (uohms/Ft-uohm/M	0.8475	0.5882	2.7806	1.9297
5. Skin Effect Factor	1.02405	1.00311	1.02405	1.00311
6. AC Resist. @ 95.33809 Deg-C (uohms/Ft-uohm/M)	0.8475	0.5882	2.7806	1.9297
7. Watts Loss/Single-Phase-(Foot-Meter)	125.0	76.7	410.0	251.6
8. Temp. of Air @ 12000 Amps (Deg-C) (Q6)	———	79.62	———	79.62
9. Actual Temp. Rise (Deg-C)	55.34	29.02	55.34	29.02
10. Actual Operating Temp (Deg-C)	95.34	69.02	95.34	69.02
11. Temp. After 1 sec Short Circuit@159KA-Symm	97.3	70.1	97.3	70.1
12. Linear Expan. (Ft/M), 0 Deg-C to Oper. Temp	.026313	.019049	.668358	.48385113
13. Inductance per (Foot-Meter) (Microhenries)	0.0410		0.1346	
a. Inductive Reactance per (Foot-Meter) (MicroOhms)	15.464		50.733	
14. Inductive Volt Drop per (Foot-Meter)	0.1857		0.6091	
15. Capacitance per (Foot-Meter) (MilliAmps)	25.67		84.21	
a. Charging Current per (Foot-Meter) (Picofarads)	164.924		541.082	
16. TOTAL LOSS (Watts/single phase foot-meter)	201.7		661.6	

E1. SOLAR HEAT GAIN:

2. CALCULATED RESULTS WITH SOLAR HEAT GAIN:				
a. Skin Effect Factor (S2)	1.023131	1.003022		
b. AC Resistance (microhms/ft) (R4)	.8832859	.5966433		
c. Watts Loss W/Solar Gain (Single-Phase-Ft) (W7)	127.1932	77.53976		
d. Temp. of Air @ 12727.92 Amps (Deg-C) (Q6)	———	84.09		
e. Temp Rise W/Solar Gain (Deg-C) (Q7-Q1)	61.39995	32.4133		
f. Operating Temp W/Solar Gain (Deg-C) (Q7)	101.4	72.4133		
g. Linear Expan. (Ft/M), 0 Deg-C to Oper. Temp.	.027986	.019986	.710854	.507646
h. TOTAL LOSS (Watts/single phase foot-meter)	204.7		671.17	

F. INSULATOR DATA:		
1. Insulator B.I.L. Rating (KV)	150	150
3. Creep Distance (In-MM)	18.5	469.9
3. Tortional Strength	N/A	N/A
4. Compressive Strength (LBS-KG)	44000	19958.4
5. Cantilever Strength (LBS-KG)	3500	1587.6
6. Tensil Strength (LBS-KG)	5950	2698.92
7. Power Frequency Withstand – Dry (KV)	80	80
8. Insulator Material	Porcelain	Porcelain
9. Insulator Weight (LBS-KG)	25	11.34
10. Insulator Assembly Weight (LBS-KG)	35	15.876
11. Short Circuit Calculations:		
a. Speci. Momen. Current (KA 3-Ph rms Asymm)	275	275
b. Calculated Momen. Current (KA-Peak)	449.0731	449.0731
c. Max. Resulting Force (Non-IPB) (LBS-KG)	1707.75	774.6354
d. Max. Resulting Force (IBP Scheme) (LBS-KG)	193.6269	87.82918
e. Insul. Failing Load/Allow.Load (LBD-KG)	8750/3500	3969/1587.6
f. Cond. Center to Insul. Bottom (IN-MM)	20.23405	513.945
g. Allow. Load at Cond. Center Line (LBS-KG)	2118.953	961.1569
h. Momentary Cantilever Load (LBS-KG)	83.25958	37.76655
i. Number Insulators per Set	3	3
j. Max. Allow. Insul. Spacing (Momentary) (FT-M)	25.44996	7.757147
k. Max. Allow. Insul. Spacing (Cond. Wt) (FT-M)	31.11423	9.483617
l. Proposed Max. Insul. Spacing (FT-M)	20	6.096

Sample Isolated Phase Bus Layout Drawing



TYPICAL GE 7FA ISOLATED PHASE BUS LAYOUT

Your Single Source , Worldwide, for Design, Manufacture, and Installation of Bus Systems.

AZZ | CALVERT

AZZ | ELECTRICAL PRODUCTS GROUP

AZZ | ELECTRICAL PRODUCTS GROUP

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