Table of Contents

Numerous Additional Connection Options Are Available.
Contact Customer Service
or
View the BURNDY Substation Catalog for Additional Information

Introduction and Design Criteria

EHV Substation Connectors Introduction

Connectors for use in EHV Substations must meet essentially the same electrical and mechanical requirements as those for other power connectors. However, operations at extra high voltages imposes an important additional requirement. They must not produce corona discharges that interfere with radio reception and cause energy loss.

Corona forms when the voltage gradient at the surface of a conducting material exceeds a critical value and ionizes the surrounding air. For conductors, the four basic factors that determine surface voltage gradient are distance from ground, conductor diameter, phase spacing and voltage.

In A.C. circuits, there are two basic kinds of corona. Negative corona forms during the negative half cycle, and positive corona during the positive half cycle. Negative corona generally appears as a glow on conventional conductors at about 20 kV rms/cm. Its amplitude is relatively low and cause no significant radio interference. Positive corona appears as a plume at above 30 kV rms/cm. Its amplitude is about 50 times higher than that for negative corona and is the major cause of radio interference.

BURNDY® EHV connectors are designed so that under fair weather operation conditions the voltage gradient at the connector surface will be at a level that will not cause corona and the resultant radio interference (RIV).

BURNDY® Design Criteria

Cable Connectors

For reasons of economy, EHV systems using stranded conductor are generally designed to operate at voltage gradients close to the negative corona onset level. It is essential, therefore, that connectors provide corona-free performance superior to that of the cable. So our design criterion calls for the voltage which corona extinguishes from the connector to be higher than the voltage at which it extinguishes from the cable. This criterion is met by eliminating all protusions and by providing smooth contours on all surfaces. On compression elements, the ends are especially critical. Carefully designed tapers are provided to keep the voltage gradient at a level lower than that on the conductor. Of course, it is still necessary during installation to smooth crimped elements.

On accessories, like spacers for bundled lines, the critical areas are those at the edges of the bundle. The bundle itself generally shields those parts that fall within it. Many protrusions that would cause corona on a single conductor line are quiet when they fall within the shielding influence of a bundle. However, those parts that fall at the edges are carefully finished at the factory to assure corona-free operation.

Tubular Bus Connectors

Station designers choose tubular bus sizes on the basis of mechanical rather than electrical requirements. For instance, stations that only need 4" IPS to meet electrical and corona requirements often have 6" IPS as main buses. The resultant voltage gradient on these buses is very low, perhaps only 10 kV rms/cm, well below the corona onset level.

It is impractical therefore, to require that connectors operate quieter than the bus regardless of the voltage. Under some circumstances, it might be impossible to meet such criteria. In most cases, it would be prohibitively expensive to do so.

Of course, theoretically optimum connectors could be designed for each application, based on the design voltage gradient for individual stations. However, in most cases even differences as great as that between 345 and 500 kV don't have a meaningful impact on connector costs. So, from a practical point of view, it is feasible to design most connectors for 500 kV operation. This makes it more convenient for the station designers to select and order connectors.

Bus connectors are designed to provide corona-free performance under conditions of actual operation. This is done by calculating the voltage gradient on the surface of the bus at 500 kV, using the phase spacing and ground distance typical for this voltage. Connectors are then designed to operate corona free when the voltage gradient on the bus is 10% above this value.

The exceptions to this rule are the flexible expansion connectors. Those designed for 345 kV are self-shielding. Those for 500 kV have separate shielding rings. Experimental work on self-shielding 500 kV expansion connectors indicates that the margin of safety is too small to justify recommending them for this voltage.

Controlling Corona

Since corona is caused when the voltage gradient at the surface of a conducting material reaches a level that causes the surrounding air to break down, then obviously, the way to prevent corona is to keep the gradient below this critical level.

From this point of view the connector designer, this can be accomplished in three ways:

1. By providing generous radii on all outside surfaces to keep the voltage stresses to a minimum.
2. By providing shielding rings.
3. By placing the connector within the shielding influences of some part of the bus structure.

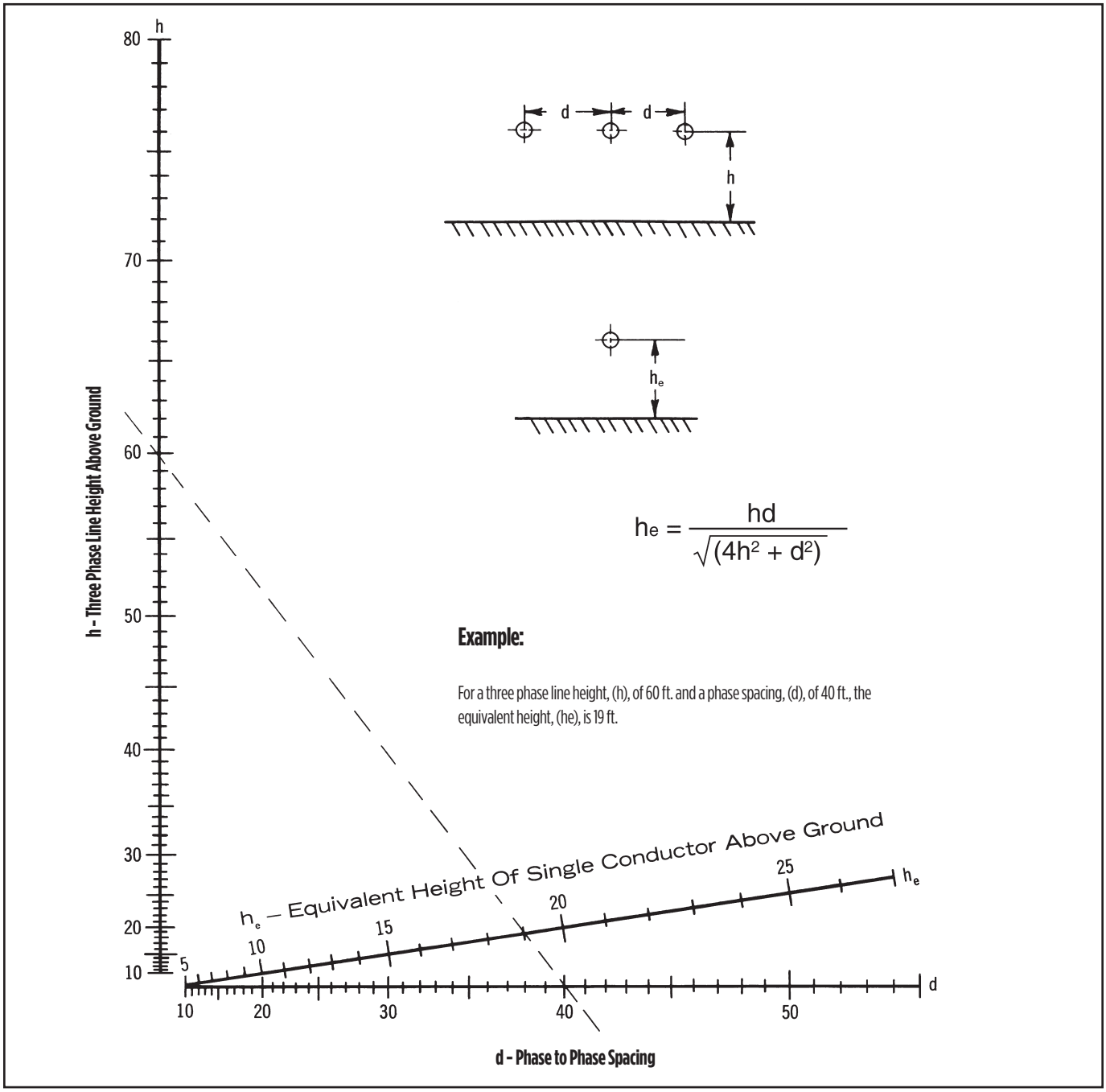
Since it is impossible for the connector designer to know the exact configuration of every bus system where the connectors might be used, the third approach is not practical. So, for the purposes of developing a standard line, we concentrate on the first two.

Whenever possible, connectors are designed to be self-shielding. This approach leads to less costly and less obstrusive designs. BURNDY® EHV designs only use corona rings in complicated connector configurations. Examples of such applications are disconnectable equipment taps, expansion couplers and equipment terminals which often have configurations that preclude the use of self-shielding designs.

Design Criteria - Nomogram for Determining the Equivalent Height

Nomogram for Determining the Equivalent Height

HEIGHT (he) OF A THREE PHASE LINE



Nomogram for determining the equivalent height of a single conductor line having the same average voltage of gradient as the CENTER conductor of a horizontally spaced three phase line, with the same line to ground voltage and the same conductor size. All dimensions measured in the same units.

Design Criteria - Gradient Calibrator

The use of the laboratory is based on the fact that it is the surface voltage gradient that causes corona. Although most systems consist of 3 phase conductors and a ground plane, it is a rather simple matter to duplicate in the laboratory the conductor surface voltage gradient as it exists on any of these phase conductors with a single conductor and a ground plane.

The formulas and nomograms give this three phase to single phase equivalency. Because this conversion is possible, all EHV testing is done single phase; and there is no necessity for 3 phase testing with its high cost in terms of equipment and space.

Since voltage gradient is the signifcant factor, the single phase test does not have to be done at the full voltage of an operation system. By setting up the test closer to the ground plane, the operation voltage gradient can be obtained with a lower test voltage. There is a limit, however, below which the height cannot be lowered lest corona onset and flashover occur simultaneously. Generally, the minimum test height should be about 10 times the diameter of the test conductor.

Gradient Calibrator

Normally the conductor surface voltage gradient at the extinction of corona in the laboratory is calculated using the accompanying equations. However, for test setups involving unusual conductor configurations, the conductor gradient cannot be readily calculated. In these cases, a gradient calibrator may be used. This is a small sphere mounted on the conductor. It has previously been calibrated for each conductor size to establish the surface voltage gradient that starts positive corona on the sphere. With it tests can be duplicated in any number of laboratories. The applied voltages and ground distances could all be different. But the voltage gradient on the surface of the conductor when the corona occurs on the sphere will always be the same. The calibratory provides a convenient bench mark for measuring the corona performance of connectors.

In use, the sphere is mounted on the conductor in a connector test setup. The voltage is raised until there is a corona on the sphere. We already know from previous calibration what the voltage gradient on the surface of the conductor is at this point.

Design Criteria - Formula to Determine Voltage Gradient

Formula for Determining Voltage Gradient

The sphere is removed and the voltage raised until there is a corona on the connector. Snce the voltage gradient increases directly with increases in applied voltage, the gradient on the conductor at this point can be readily calculated.

It is important to note that the significant parameter is the voltage gradient on the surface of the conductor. It is not necessary to know the gradient on the connector. The conductor gradient in any given substation is controlled by its design parameters and may be calculated using the following formulae and nomograms. Once the gradient is known, it is unnecessary to have any other information to design connectors. As long as connectors are corona-free at a conductor voltage gradient higher than that planned for the conductor, the connector will be corona-free under fair weather operating conditions.

There may be on occasion be unusual situations where choice of conductor, station geometry or clearance problems cause the need for connectors of special design. Where this is the case, BURNDY is prepared to design corona-free devices to operation under such conditions.

Formula for Determining the Voltage Gradient - Notations Used

h = line to ground distance (cm)
r = radius of the individual conductor (cm)
s = conductor spacing in the bundle (cm)
d - phase to phase spacing of the line (cm)
V = line to ground voltage (kV)
Ea = average gradient at the surface of the conductor (kV/cm)
Em = maximum gradient on the surface of a single conductor **he** = equivalent single phase line to ground distance (cm)
re = equivalent single conductor radius (cm) of bundled conductors
n = number of conductors in the bundle

$$E_a = \frac{V}{r \ln \frac{2h}{r}} \qquad E_m = \frac{h}{h - r} E_a$$

The maximum gradient (E_m) occurs on the side facing the ground plane.

The center conductor has a gradient about 5% higher than the outside conductors. The gradient on the center phase may be calculated using the formula for the single conductor.

Single phase system and substituting (h_e) from the following formula or attached nomograms for the height about the ground (h). For the center phase:

$$E_a = \frac{V}{r \ln \frac{2h}{r}} \qquad h_e = \frac{hd}{\sqrt{(4h^2 + d^2)}}$$

It should be noted that h_e is somewhat smaller than $\frac{d}{2}$

$$E_a = \frac{V}{n\, r \ln \frac{2h}{r_e}} \qquad \text{in which } r_e = r\left(\ell \frac{s}{r}\right)^{\frac{n-1}{n}}$$

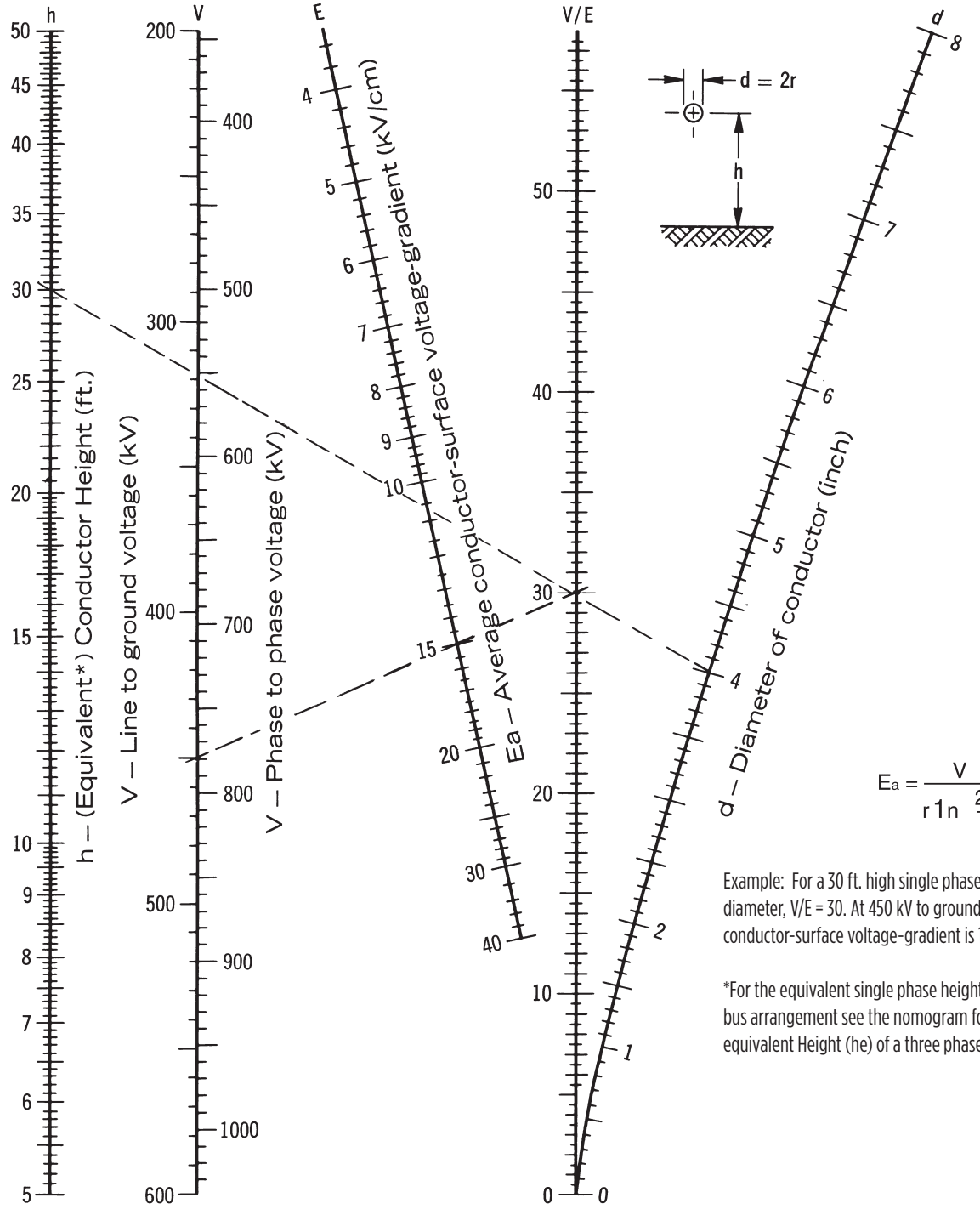
The value of " ℓ " is unity for 1-, 2-, and 3- conductor bundles and 1.12 for 4- conductor bundles.

Bundled Conductor - Three Phase

This case may be reduced to the single bundled conductor case by replacing h with he in the equation. The definition of he is identical to that given for the single conductor — three phase situation.

Design Criteria

Nomogram for finding the average conductor-surface voltage-gradient from line dimensions and voltage



Example: For a 30 ft. high single phase bus* of 4" diameter, V/E = 30. At 450 kV to ground the average conductor-surface voltage-gradient is 15 kV RMS/CM.

*For the equivalent single phase height (he) of a 3 phase bus arrangement see the nomogram for determing the equivalent Height (he) of a three phase line.

Radio Interference Voltage

There is serious question as to whether measurement of RIV on connectors makes a meaningful contribution to quieter station operation.

Under test conditions, there is generally no significant indication on the radio noise meter until the onset of visible positive corona. At this point, the RIV reading goes into the hundreds of thousands of microvolts. The effect of this phenomenon is to provide a visibly discernable point at which RIV will be excessive. It eliminates the necessity to make, record and plot RIV measurements. Where there is no corona, there is no RIV. So our test criterion calling for no visible corona assures that there will be no radio interference generated by the connector under operating conditions.

Effect of Conductor Size on Testing

Conductor diameter has a significant effect on potential corona problems. The larger the diameter, the lower the surface voltage gradient for a given test voltage. This means that smaller conductors produce corona at lower voltages than larger ones.

Many connector designs have the same basic configuration for various conductor sizes. The only difference being the size of the attaching elements. This is particularly true for many of the welded type connectors. Where this is the case, it is often sufficient to test the connector only on the smallest conductor, since it yields the lowest corona extinction voltage. When there is any doubt, each size is tested.

Contamination

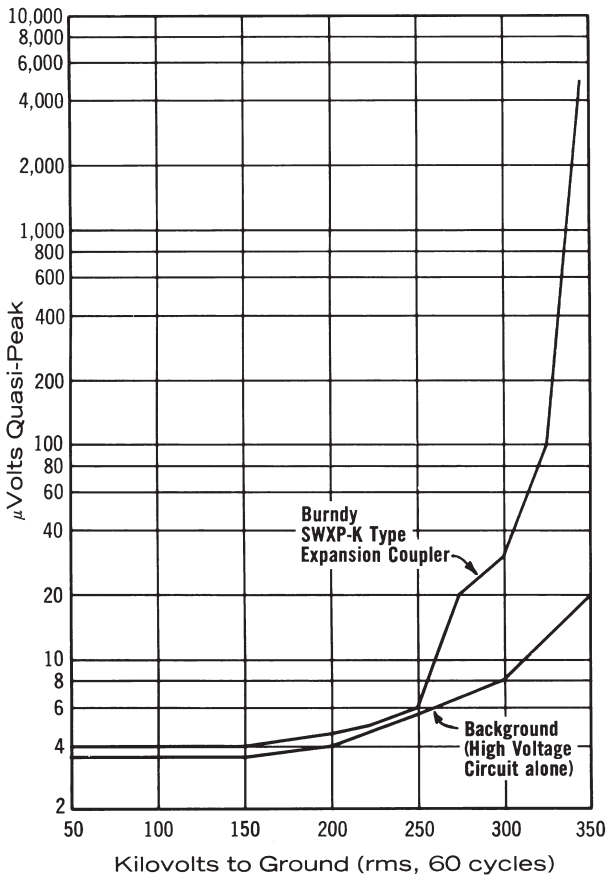
Much work has been done to establish the relationship between the corona onset voltage for contaminated as compared to clean hardware. Experiments with contaminated hardware in the BURNDY laboratory indicate that corona onset can be reduced to half of the voltage for clean hardware. However, the relationship varies with the kind of contamination, atmospheric condition and type of connector.

There have been a number of attempts to produce artificial contamination and atmospheres in laboratories. However, there is as yet no clearly established relationship between the corona performance of hardware contaminated in the laboratory. Until such a relationship is established, the only testing that provides comparable data is on clean hardware under fair weather conditions.

Conclusion

For more than 90 years, BURNDY has been designing connectors for the industry's most critical applications. Connectors for EHV are an outgrowth of this tradition. Whether your need is for catalog items or special designs, you can count on electrical, mechanical and corona-free performance, commensurate with the application.

TYPICAL CURVE

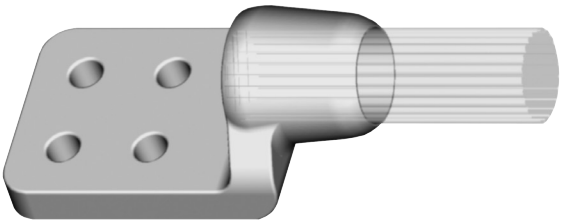


Welded Terminal Connector Type SWA-R-N

Welded Terminal Connector, Type SWA-R-N for Cable to Two or Four Hole Pad (offset terminal)

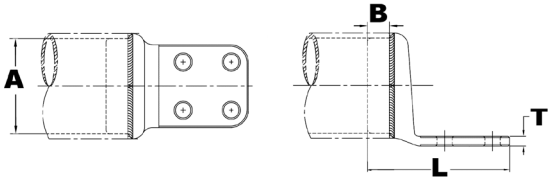
Material: **Cast 365 Aluminum Alloy**

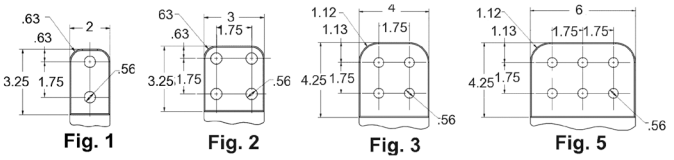
EHV Rated: **up to 550 kV (with shielding caps)**



NOTES:

1. *Dimensions in brackets [ ] are in millimeters.*
2. ***DOES NOT INCLUDE SHIELDING CAPS.*** *For EHV applications, shielding caps are required.*
3. *Shielding caps may be ordered separately or add suffix '-STS' to catalog number (example: SWA54R-44NSTS), includes one Type STS shielding cap.*
4. *One surface of pad finished. For finished pad on both sides add suffix '-Q' to the catalog number (example: SWA22A-44NQ).*
5. *For 45 or 90 degree angle add suffix '-45' or '-90' to catalog number (example: SWA54R-44N90).*





Catalog Number	Accommodates "A" Dia.		Str.	Min. Dia.	Max. Dia.	Fig. No.	B	L	T
	Alum. Cable	ACSR Cable							
SWA58R44N	1700 kcmil thru 1900 kcmil	1510.5 kcmil thru 1780 kcmil	54-49 54-19	1.471 [37]	1.605 [41]	3	2.50 [64]	7.25 [184]	0.69 [18]
SWA444A44N	900 kcmil thru 1100 kmcil	795 kcmil thru 954 kcmil	54-7	1.086 [28]	1.210 [31]	3	1.75 [44]	6.56 [167]	0.50 [13]
SWA486A44N	2300 kcmil thru 2500 kcmil	2156 kcmil thru 2300 kcmil	84-19 96-19	1.741 [44]	1.875 [48]	3	2.62 [67]	7.50 [191]	1.12 [28]

Welded Terminal Connector Type SW2A

Welded Terminal Connector, Type SW2A for Two Cables to Two or Four Hole Pad (offset terminal)

Material: **Aluminum Alloy**

EHV Rated: **up to 550 kV (with shielding caps)**

Aluminum alloy weld type terminal for joining a range aluminum cables to pad. Drilling in pad confirms to NEMA standards. PENETROX™ joint compound recommended on pad contact surfaces.

NOTES:

1. *Welding to be done by customer*
2. *Before welding scratch brush connector and conductor contact surface dry, then apply an oxide inhibitor.*
3. *Please contact factory for availability of sizes.*

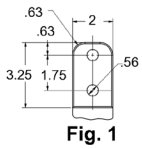


Fig. 1

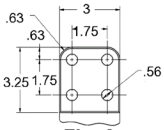


Fig. 2

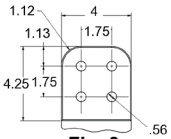
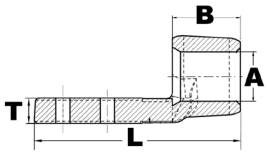
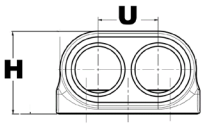


Fig. 3





Catalog Number	Fig. #	A-Aluminum Stranded	A-Aluminum ACSR	B	U	L	H	T
SW2A444A44N90	3	900 kcmil-1000 kcmil	795 (54/7) Condor kcmil-954 (45/7) Rail kcmil	1.75	1.62	6.40	1.85	14/25
SW2A486A44N	3	2300 kcmil-2500 kcmil	2156 (64/119) kcmil-2312 (76/19) Thrasher kcmil	2.67	2.50	7.42	3.32	1
SW2A486A44N90	3		2156 (64/119) kcmil-2167 (72/7) Kiwi kcmil	2.67	2.50	7.97	2.77	1
SW2A486A66N90	–			2.67	2.50	8.62	2.77	1
SW2A48A44N	3	2000 kcmil-2250 kcmil	2167 (72/7) Kiwi kcmil	2.62	2.25	7.42	3.32	1
SW2A58R44N	3	1700 kcmil-1900 kcmil	1510.5 (45/7) Nuthatch kcmil-1780 (54/19) kcmil	2.50	2.10	7.25	2.75	3/4

Welded Terminal Connector Type SWA-A-N

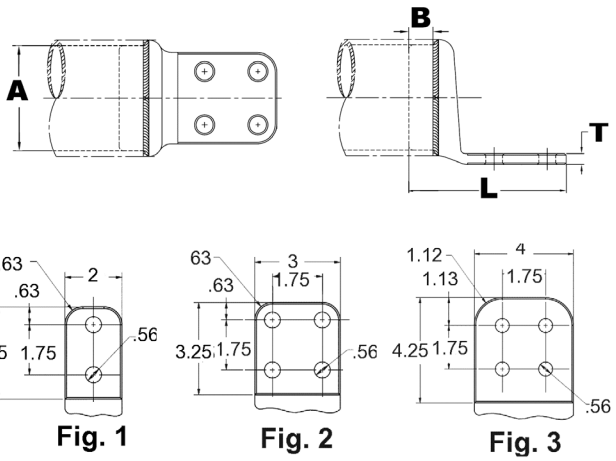
Welded Terminal Connector, Type SWA-A-N for Bus to Two or Four Hole Pad (offset terminal)

Material: **Cast 365 Aluminum Alloy**

EHV Rated: **up to 550 kV (with shielding caps)**

NOTES:

1. *Dimensions in brackets [ ] are in millimeters.*
2. ***DOES NOT INCLUDE SHIELDING CAPS**. For EHV applications, shielding caps are required.*
3. *Shielding caps may be ordered separately or add suffix '-STS' to catalog number (example: SWA22A44NSTS), includes one Type STS shielding cap.*
4. *One surface of pad finished. For finished pad on both sides add suffix '-Q' to the catalog number (example: SWA22A-44NQ).*
5. *For 45 or 90 degree angle add suffix '-45' or '-90' to catalog number (example: SWA22A-44N90).*
6. *For six hole NEMA pad contact factory.*



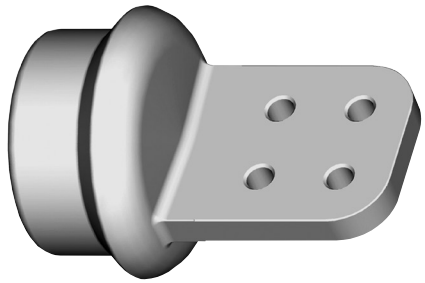
Catalog Number		Accommodates "A" Dia. Alum. Tube	Fig.	B	L	T
IPS (Sch. 40)	EHPS (Sch. 80)					
SWA18A34N	—	2" (2.375 Dia.)	2	1.25 [32]	5.88 [149]	0.50 [13]
SWA18A44N	—	2" (2.375 Dia.)	3	1.25 [32]	6.95 [177]	0.50 [13]
SWA19A34N	—	2-1/2" (2.875 Dia.)	2	1.50 [38]	6.36 [162]	0.56 [14]
SWA19A44N	—	2-1/2" (2.875 Dia.)	3	1.50 [38]	7.40 [188]	0.56 [14]
SWA20A2N	—	3" (3.500 Dia.)	1	1.75 [44]	6.41 [163]	0.62 [16]
SWA20A34N	—	3" (3.500 Dia.)	2	1.75 [44]	6.41 [163]	0.62 [16]
SWA20A44N	**SWA90A44N**	3" (3.500 Dia.)	3	1.75 [44]	7.46 [189]	0.62 [16]
SWA21A44N	—	3-1/2" (4.000 Dia.)	3	1.75 [44]	7.47 [190]	0.62 [16]
SWA22A44N	**SWA92A44N**	4" (4.500 Dia.)	3	2.00 [51]	7.51 [191]	0.75 [19]
SWA23A44N	—	4-1/2" (5.000 Dia.)	3	2.00 [51]	7.77 [197]	0.75 [19]
SWA24A44N	—	5" (5.563 Dia.)	3	2.00 [51]	7.82 [199]	0.75 [19]
SWA86A44N	—	6" (6.625 Dia.)	3	2.50 [64]	7.90 [201]	1.00 [25]

Welded Terminal Connector Type SWAC-A-N

Welded Terminal Connector, Type SWAC-A-N for Bus to Two or Four Hole Pad (center formed)

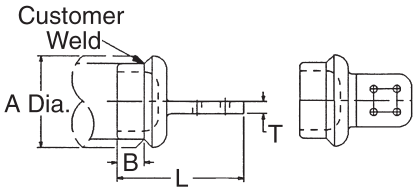
Material: **Cast 365 Aluminum Alloy**

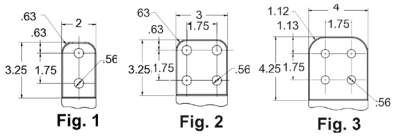
EHV Rated: **up to 550 kV (with shielding caps)**



NOTES:

1. *Dimensions in brackets [ ] are in millimeters.*
2. *Conductor smaller than 3 inch bus size not recommended for 550 kV*
3. **DOES NOT INCLUDE SHIELDING CAPS**. *For EHV applications, shielding caps are required.*
4. *Shielding caps may be ordered separately or add suffix '-STS' to catalog number (example: SWAC22A44NSTS), includes one Type STS shielding cap.*
5. *Pad surface finished on both sides of tongue.*
6. *For six hole NEMA pad contact factory.*





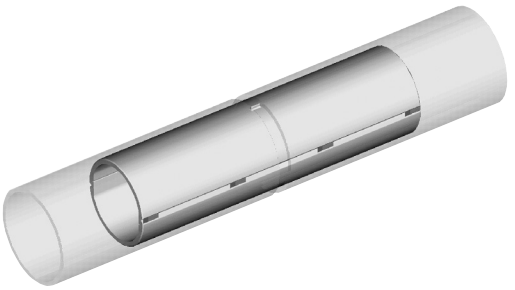
Catalog Number		Conductor		Fig. No.	Dimensions In.		
IPS (Sch. 40)	EHPS (Sch. 80)	IPS	A		B	L	T
SWAC18A2N	—	2"	2.38 [60]	1	1.25 [32]	5.80 [147]	0.50 [13]
SWAC18A34N	—			2	1.25 [32]	5.80 [147]	0.50 [13]
SWAC18A44N	—			3	1.25 [32]	6.86 [174]	0.50 [13]
SWAC19A2N	—	2-1/2"	2.88 [73]	1	1.50 [38]	6.23 [158]	0.56 [14]
SWAC19A34N	—			2	1.50 [38]	6.23 [158]	0.56 [14]
SWAC19A44N	—			3	1.50 [38]	7.29 [185]	0.56 [14]
SWAC20A34N	—	3"	3.50 [89]	2	1.75 [44]	6.30 [160]	0.62 [16]
SWAC20A44N	—			3	1.75 [44]	7.36 [187]	0.62 [16]
SWAC21A34N	—	3-1/2"	4.00 [102]	2	1.75 [44]	6.30 [160]	0.62 [16]
SWAC21A44N	—			3	1.75 [44]	7.36 [187]	0.62 [16]
SWAC22A44N	SWAC92A44N	4"	4.50 [114]	3	2.00 [51]	7.40 [188]	0.75 [19]
SWAC23A34N	—	4-1/2"	5.00 [127]	2	2.00 [51]	6.23 [158]	0.56 [19]
SWAC24A44N	SWAC94A44N	5"	5.56 [141]	3	2.00 [51]	7.72 [196]	0.75 [19]
SWAC86A44N	SWAC96A44N	6"	6.62 [168]	3	2.50 [64]	7.75 [197]	1.00 [25]

Welded Rigid Coupler Type WS-A

Welded Rigid Coupler, Type WS-A Bus to Bus Coupler

Material: **Cast 356 Aluminum Alloy**

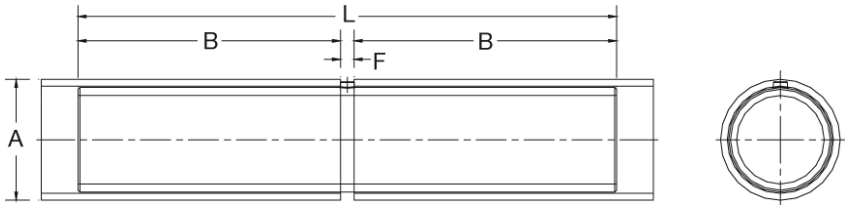
EHV Rated: **Self-Shielding up to 550 kV**



NOTES:

1. Dimensions in brackets [ ] are in millimeters.

2. Conductor smaller than 3 inch bus size not recommended for 550 kV.



Catalog Number	Conductor (IPS) "A" Schedule 40	Conductor (EHPS) "A" Schedule 80	Dimensions Inches		
			B	F	L
WS14A	3/4" (1.050 Dia.)	–	2.13 [54.1]	0.23 [5.8]	4.50 [114.3]
WS15A	1" (Dia.)	–	2.13 [54.1]	0.23 [5.8]	4.50 [114.3]
WS16A	1-1/4" (1.660 Dia.)	–	3.60 [91.4]	0.28 [7.1]	7.50 [190.5]
WS17A	1-1/2" (1.900 Dia.)	–	4.36 [110.7]	0.29 [7.4]	9.00 [228.6]
WS18A	2" (2.375 Dia.)	–	5.88 [149.4]	0.31 [7.9]	12.00 [304.8]
WS19A	2-1/2" (2.875 Dia.)	–	7.31 [185.7]	0.39 [9.9]	15.00 [381.0]
WS20A	3" (3.500 Dia.)	–	8.81 [223.8]	0.44 [11.2]	18.00 [457.2]
WS21A	3-1/2" (4.000 Dia.)	–	8.75 [222.3]	0.47 [11.9]	18.00 [457.2]
WS22A	4" (4.500 Dia.)	–	8.75 [222.3]	0.47 [11.9]	18.00 [457.2]
WS24A	5" (5.563 Dia.)	–	8.75 [222.3]	0.50 [12.7]	18.00 [457.2]
WS58A	6" (6.625 Dia.)	–	8.75 [222.3]	0.56 [14.2]	18.00 [457.2]
WS59A	–	2" (2.375 Dia.)	5.88 [149.4]	0.31 [7.9]	12.00 [304.8]
WS86A	–	2-1/2" (2.875 Dia.)	7.31 [185.7]	0.39 [9.9]	15.00 [381.0]
WS90A	–	3" (3.500 Dia.)	8.81 [223.8]	0.44 [11.2]	18.00 [457.2]
WS91A	–	3-1/2" (4.000 Dia.)	8.75 [222.3]	0.47 [11.9]	18.00 [457.2]
WS92A	–	4" (4.500 Dia.)	8.75 [222.3]	0.47 [11.9]	18.00 [457.2]
WS94A	–	5" (5.563 Dia.)	8.75 [222.3]	0.50 [12.7]	18.00 [457.2]
WS96A	–	6" (6.625 Dia.)	8.75 [222.3]	0.56 [14.2]	18.00 [457.2]

Welded T Connector Type SWAB-A-N

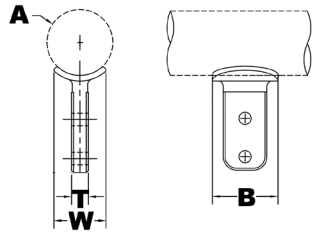
Welded T Connector, Type SWAB-A-N
Bus to Pad

Material: **Cast 356 Aluminum Alloy**

EHV Rated: **up to 550 kV (with shielding caps)**

NOTES:

1. *Dimensions in brackets [ ] are in millimeters.*
2. *Conductor smaller than 3 inch bus size not recommended for 550 kV*
3. ***DOES NOT INCLUDE SHIELDING CAPS**. For EHV applications, shielding caps are required.*
4. *Shielding caps may be ordered separately or add suffix '-STS' to catalog number (example: SWAC22A44NSTS), includes one Type STS shielding cap.*
5. *Pad surface finished on both sides of tongue.*
6. *For six hole NEMA pad contact factory.*



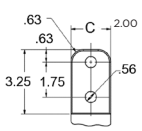


Fig. 1

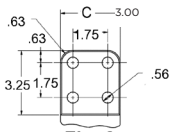


Fig. 2

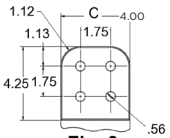


Fig. 3

Catalog Number	Complete Range Aluminum Tube	Fig. #	Dimensions - Inches					
			B	T	W	Aluminum IPS Pipe		
						Nominal	A	Y
SWAB19A2N	1" to 2-1/2"	1	3.00 [76]	0.38 [10]	1.32 [34]	1"	1.32 [34]	4.45 [113]
						1-1/4"	1.66 [42]	4.67 [119]
						1-1/2"	1.90 [48]	4.80 [122]
SWAB19A34N		2	4.00 [102]	0.50 [13]	1.32 [34]	2"	2.38 [60]	5.08 [129]
						2-1/2"	2.88 [73]	5.32 [135]
SWAB22A2N	2-1/2" to 4"	1	3.00 [76]	0.75 [19]	2.40 [61]	2-1/2"	2.88 [73]	5.25 [133]
						3"	3.50 [89]	5.62 [143]
SWAB22A34N		2	4.00 [102]	0.75 [19]	2.40 [61]	3-1/2"	4.00 [102]	5.92 [150]
SWAB22A44N		3	4.50 [114]	0.75 [19]	2.40 [61]	4"	4.50 [114]	6.21 [158]
SWAB86A34N	3" to 6"	2	4.00 [102]	1.00 [25]	2.62 [67]	5"	5.56 [141]	6.67 [169]
SWAB86A44N		3	4.50 [114]	1.00 [25]	2.62 [67]	6"	6.62 [168]	7.24 [184]

Welded T Connector Type SWT-A-A

Welded T Connector, Type SWT-A-A Bus to Bus T Connector

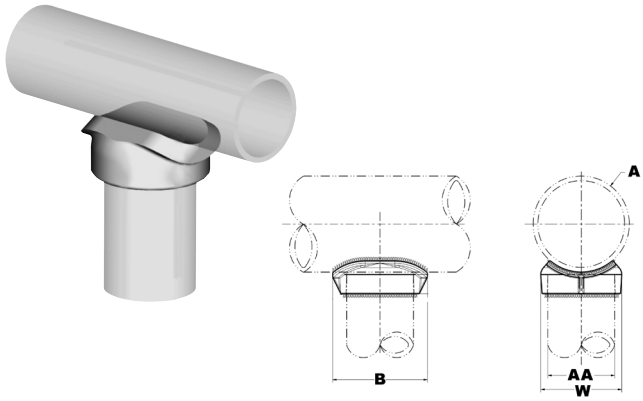
Material: **Cast 356 Aluminum Alloy**

EHV Rated: **Self Shielding up to 550 kV**

NOTES:

1. Dimensions in brackets [ ] are in millimeters.

2. Conductor smaller than 3 inch bus size not recommended for 550 kV.



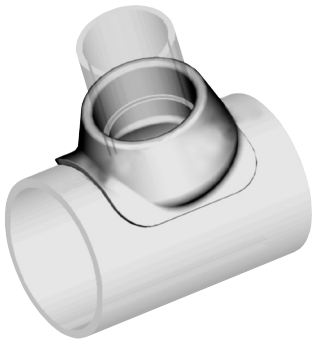
Catalog Number	Run 'A' Aluminum Tube	Tap 'AA' Aluminum Tube		Run Data		Dimensions Inches	
		Tube	AA	Nom. Tube	A	B	W
SWT17A17A	1-1/2"	1/2"	1.90 [48]	1-1/2"	1.90 [48]	3.19 [81]	2.64 [67]
SWT19A19A	2 1/2"	2-1/2"	2.88 [27]	2-1/2"	2.88 [73]	4.00 [54]	3.78 [96]
SWT21A17A	2" To 3-1/2"	1-1/2"	1.90 [48]	2"	2.38 [60.4]	3.19 [81]	2.62 [67]
				2-1/2"	2.88 [73]		
				3"	3.50 [89]		
				3-1/2"	4.00 [102]		
SWT21A18A	2" To 3-1/2"	2"	2.38 [60.4]	2"	2.38 [60.4]	4.00 [102]	3.33 [84]
				2-1/2"	2.88 [73]		
				3"	3.50 [90]		
				3-1/2"	4.00 [102]		
SWT21A20A	2" To 3-1/2"	3"	3.50 [90]	3"	3.50 [102]	4.56 [116]	4.52 [115]
				3-1/2"	4.00 [102]		
SWT22A18A	4"	2"	2.38 [60.4]	4"	4.50 [114]	4.00 [102]	3.50 [102]
SWT22A20A		3"	3.50 [102]			4.56 [116]	4.50 [114]
SWT22A21A		3-1/2"	4.00 [102]			5.50 [140]	5.00 [127]
SWT22A22A		4"	4.50 [114]			6.00 [152]	5.60 [142]
SWT24A20A	5"	3"	3.50 [48]	5"	5.56 [141]	4.72 [102]	3.50 [102]
SWT24A21A		3-1/2"	4.00 [102]			5.50 [140]	5.00 [127]
SWT24A24A		5"	5.56 [141]			7.38 [187]	6.84 [174]
SWT86A20A	6"	3"	3.50 [48]	6"	6.62 [168]	4.56 [116]	5.00 [127]
SWT86A24A		5"	5.56 [141]			7.38 [187]	6.84 [174]

Welded T Connector Type SWT-A-A-75

Welded T Connector, Type SWT-A-A-75
Bus "A" Frame Connector, 75°

Material: **Cast 356 Aluminum Alloy**

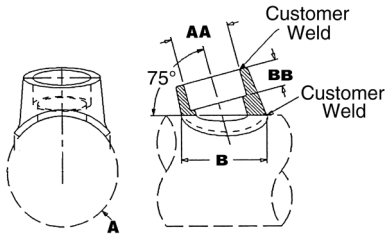
EHV Rated: **Self Shielding up to 550 kV**



NOTES:

1. Dimensions in brackets [ ] are in millimeters.

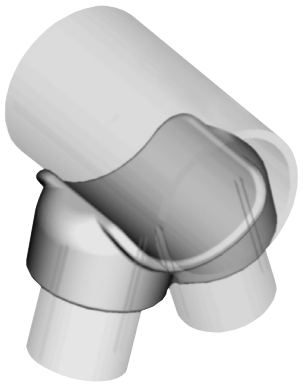
2. Conductor smaller than 3 inch bus size not recommended for 550 kV.



Catalog Number	Aluminum Tube				Dimensions In.	
	Run		Tap			
	Nominal	A	Nominal	AA	B	BB
SWT18A16A75	2"	2.38 [60.4]	1-1/4"	1.66 [42]	2.69 [68]	1.00 [25]
SWT19A17A75	2-1/2"	2.88 [73]	1-1/2"	1.90 [48]	3.19 [81]	1.00 [25]
SWT19A18A75	2-1/2"	2.88 [73]	2"	2.38 [60]	4.00 [102]	1.00 [25]
SWT20A18A75	3"	3.50 [89]	2"	2.38 [60]	4.00 [102]	1.00 [25]
SWT21A16A75	3-1/2"	4.00 [102]	1-1/4"	1.66 [42]	2.69 [68]	1.00 [25]
SWT21A18A75	3-1/2"	4.00 [102]	2"	2.38 [42]	4.00 [68]	1.00 [25]
SWT21A19A75	3-1/2"	4.00 [102]	1-1/2"	2.88 [73]	4.00 [68]	1.38 [35]
SWT22A18A75	4"	4.50 [114]	2"	2.38 [60]	4.18 [105]	1.00 [25]
SWT22A19A75	4"	4.50 [114]	1-1/2"	2.88 [73]	4.00 [102]	1.38 [35]
SWT22A20A75	4"	4.50 [114]	3"	3.50 [89]	4.56 [116]	1.38 [35]
SWT24A18A75	5"	5.56 [141]	2"	2.38 [60]	4.00 [102]	1.00 [25]
SWT24A19A75	5"	5.56 [141]	1-1/2"	2.88 [73]	4.00 [102]	1.38 [35]
SWT24A20A75	5"	5.56 [141]	3"	3.50 [89]	4.56 [116]	1.38 [35]
SWT86A20A75	6"	6.62 [168]	3"	3.50 [89]	4.56 [116]	1.38 [35]
SWT86A21A75	6"	6.62 [168]	3-1/2"	4.00 [102]	5.50 [140]	1.38 [35]
SWT86A22A75	6"	6.62 [168]	4"	4.50 [114]	6.00 [152]	1.38 [35]

Welded V Connector Type SWAT-A-A-30

Welded V Connector, Type SWAT-A-A-30
Bus "A" Frame Connector, 30°



Material: **Cast 356 Aluminum Alloy**

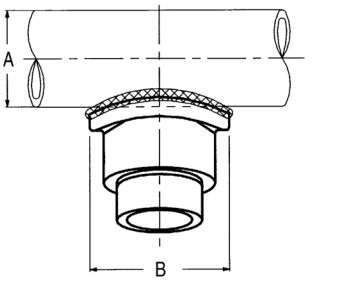
EHV Rated: **Self Shielding up to 550 kV**

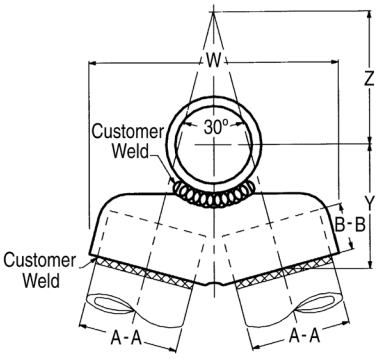
NOTES:

1. Dimensions in brackets [ ] are in millimeters

2. Conductor smaller than 3 inch bus size not recommended for 550 kV.

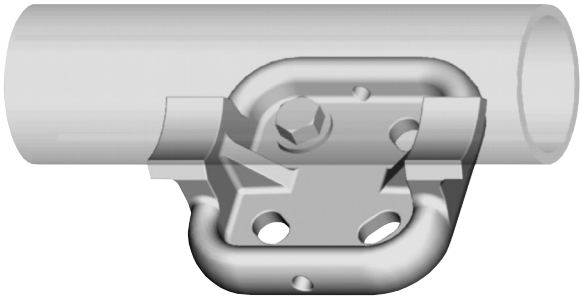
Catalog Number	Aluminum I.P.S.		B	B-B	W	Y	Z
	Run "A"	Tap "A-A"					
SWAT18A16A30	2" (2.375 Dia.)	1-1/4" (1.660 Dia.)	3.25 [83]	1.00 [25]	4.81 [122]	3.19 [81]	1.79 [45]
SWAT18A17A30		1-1/2" (1.900 Dia.)	3.50 [89]	1.00 [25]	5.25 [133]	3.00 [76]	2.34 [59]
SWAT18A18A30		2" (2.375 Dia.)	4.00 [102]	1.00 [25]	6.38 [160]	3.12 [71]	3.46 [88]
SWAT19A16A30	2-1/2" (2.875 Dia.)	1-1/4" (2.375 Dia.)	3.25 [83]	1.00 [25]	4.82 [122]	3.31 [84]	1.74 [44]
SWAT19A17A30		1-1/2" (1.900 Dia.)	3.50 [89]	1.00 [25]	5.25 [132]	3.28 [83]	2.00 [51]
SWAT20A17A30	3" (3.500 Dia.)	1-1/2" (1.900 Dia.)	3.50 [89]	1.00 [25]	5.12 [130]	3.44 [87]	1.87 [47]
SWAT20A18A30		2" (2.375 Dia.)	4.00 [102]	1.00 [25]	6.25 [159]	3.50 [89]	2.71 [69]
SWAT20A19A30		2-1/2" (2.875 Dia.)	4.38 [111]	1.38 [35]	7.19 [183]	3.88 [99]	3.41 [87]
SWAT21A18A30	3-1/2" (4.000 Dia.)	2" (2.375 Dia.)	4.00 [102]	1.00 [25]	6.31 [160]	3.16 [80]	2.68 [68]
SWAT21A19A30		2-1/2" (2.0875 Dia.)	4.38 [111]	1.38 [35]	7.38 [187]	4.00 [102]	3.09 [78]
SWAT22A18A30	4" (4.500 Dia.)	2" (2.375 Dia.)	4.00 [102]	1.00 [25]	6.50 [165]	3.81 [97]	2.82 [72]
SWAT22A19A30		2-1/2" (2.875 Dia.)	4.38 [111]	1.38 [35]	7.41 [188]	4.09 [104]	3.13 [80]
SWAT22A20A30		3" (3.500 Dia.)	5.12 [130]	1.38 [38]	8.62 [219]	4.28 [109]	4.05 [103]
SWAT24A19A30	5" (5.563 Dia.)	2-1/2" (2.875 Dia.)	4.38 [111]	1.38 [35]	7.38 [187]	4.47 [114]	2.87 [73]
SWAT24A20A30		3" (3.500 Dia.)	2.12 [130]	1.38 [35]	8.62 [219]	4.62 [117]	3.76 [96]
SWAT86A20A30	6" (6.625 Dia.)	3" (3.500 Dia.)	5.12 [130]	1.38 [35]	8.69 [221]	4.81 [122]	3.57 [91]
SWAT86A21A30		3-1/2" (4.000 Dia.)	5.88 [149]	1.38 [35]	9.69 [246]	5.19 [132]	4.11 [104]
SWAT86A22A30		4" (4.500 Dia.)	6.25 [159]	1.38 [35]	10.62 [270]	5.00 [127]	5.15 [131]





Welded Rigid Bus Support Type SWOH-A

Welded Bus Support, Type SWOH-A Fixed Bus Support to Insulator



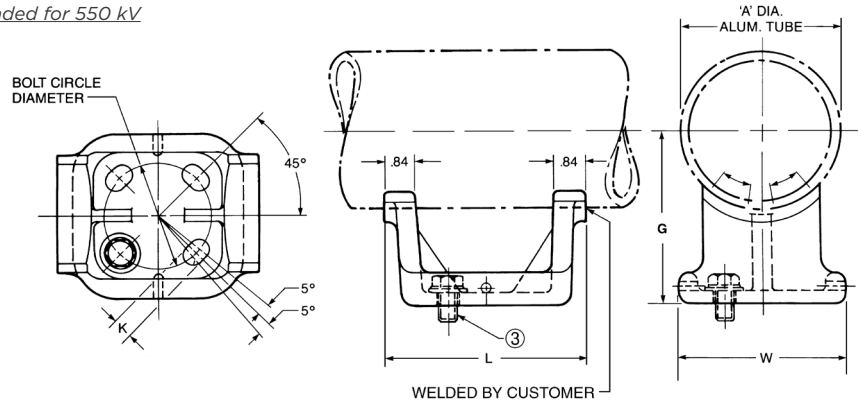
Material: **Cast 356 Aluminum Alloy**

EHV Rated: **Self Shielding up to 550 kV (used on Corona Free Post Insulators)**

NOTES:

1. *Dimensions in brackets [ ] are in millimeters.*
2. *"G" dimension conforms to NEMA standards.*
3. *Cap mounting (galvanized steel) hardware supplied as standard. For Base Mounting hardware add '-B" suffix to catalog number (example: SWOH22A-5B).*

Conductors smaller than 3 inch bus size not recommended for 550 kV



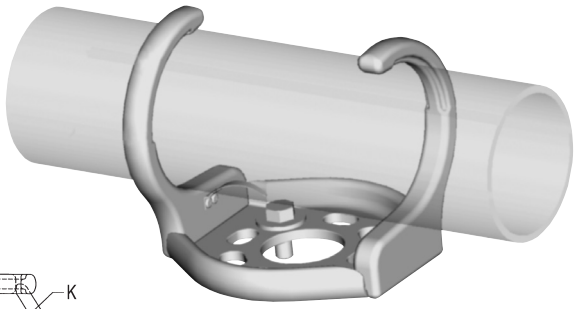
Catalog Number	"A" Dia. Alum. Tube	Bolt Circle Dia.	G	K	L	W
SWOH18A5	2.37" (2.375 Dia.) [60]	5.00 [127]	2.75 [70]	0.69 [18]	7.48 [190]	6.76 [172]
SWOH19A3	2-1/2" (2.875 Dia.) [73]	3.00 [76]	3.12 [79]	0.56 [14]	6.06 [154]	5.19 [132]
SWOH19A5		5.00 [127]		0.69 [18]	7.62 [194]	6.80 [173]
SWOH20A5	3" (3.500 Dia.) [89]	5.00 [127]	3.00 [76]	0.69 [18]	7.20 [183]	6.29 [160]
SWOH24A5	5" [141]	5.00 [127]	5.00 [127]	0.69 [18]	7.68 [195]	6.57 [167]

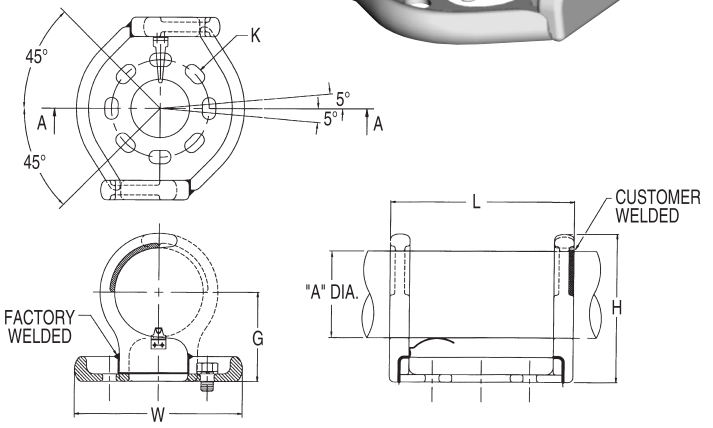
Welded Rigid or Slip Fit Bus Support Type SWHRH-A

Welded Rigid or Slip Fit Bus Support, Type SWHRH-A Fixed or Slip Fit Bus Support to Insulator

Material: **Cast 356 Aluminum Alloy**

EHV Rated: **Self Shielding up to 550 kV when used on Corona Free Post Insulators**





NOTES:

1. *Dimensions in brackets [ ] are in millimeters.*
2. *"G" dimension conforms to NEMA standards.*
3. *Cap mounting (galvanized steel) hardware supplied as standard. For Base Mounting hardware add '-B" suffix to catalog number (example: SWHRH22A-5B).*
4. *Conductors smaller than 3 inch bus size not recommended for 550 kV*

Catalog Number		Aluminum Conductor		G	H	3" Bolt Circle			5" Bolt Circle		
3" Bolt Circle	5" Bolt Circle	IPS/EHPS	"A" Dia.			K	L	W	K	L	W
SWHRH19A3CH	—	2-1/2"	2.88 [73]	3.12 [79]	5.21 [132]	0.56 X 0.75 [14 X 19]	7.76 [197]	6.62 [159]	0.69 X 0.88 [18 X 22]	9.37 [238]	8.61 [219]
SWHRH20A3CH	—	3"	3.50 [89]	3.62 [92]	6.15 [156]	0.56 X 0.75 [14 X 19]	7.76 [197]	6.62 [159]	0.69 X 0.88 [18 X 22]	9.37 [238]	8.61 [219]
—	SWHRH22A5CH	4"	4.50 [114]	4.50 [114]	7.52 [191]	0.56 X 0.75 [14 X 19]	7.76 [197]	6.62 [159]	0.69 X 0.88 [18 X 22]	9.37 [238]	8.61 [219]
—	SWHRH86A5CH	6"	6.63 [168]	5.50 [140]	9.71 [247]	0.56 X 0.75 [14 X 19]	7.76 [197]	8.61 [219]	0.69 X 0.88 [18 X 22]	9.37 [238]	8.61 [219]

Welded Expansion Bus Support Coupler Type SWXHP-A

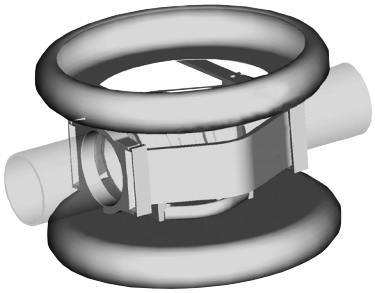
Expansion Bus Support Coupler, Type SWXHP-A Bus to Bus Expansion Coupler to Insulator

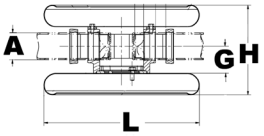
Material: Cast 356 Aluminum Alloy

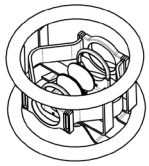
Corona Rings: Aluminum Alloy

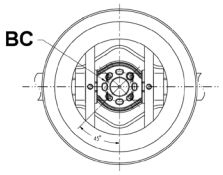
Straps: Laminated Aluminum Strap

EHV Rated: Self-Shielding up to 550 kV









NOTES:

**Conforms to NEMA standards*

1. *Maximum movement per end equals one-half of total movement specified in table.*
2. *Dimensions in brackets [ ] are in millimeters.*
3. *Cap mounting (galvanized steel) hardware supplied as standard. For Base Mounting hardware add '-B" suffix to catalog number (example: SWXHP20A5B).*
4. *Conductors smaller than 3 inch bus size not recommended for 550 kV*
5. *Bus support couplers are supplied without bus end plugs. If end plugs are required, add suffix '-EP' to catalog number (example: SWXHP20A5EP)*
6. *Table 3" Movement Z Reference is based on 80 ft max. bus run (total) or 40 ft per end*
7. *Table 4" Movement Z Reference is based on 110 ft max. bus run (total) or 55 ft per end*

Catalog Number Sch 40	"A" Dia. Alum. Tube	Bolt Circle Dia.	G*	H	L	Total Movement (note 1)
SWXHP22A5	4" (4.50 Dia.) [114]	5.00 [127]	4.50 [114]	14.90 [18]	26.00 [660]	4.00 [102]
SWXHP24A5	5" (5.56 Dia.) [141]	5.00 [127]	5.25 [133]	16.31 [18]		4.00 [102]
SWXHP86A5	6" (6.63 Dia.) [168]	5.00 [127]	5.50 [140]	17.34 [18]		4.00 [102]

Installation Data		
Bus Temp F°	3" Total Movement	4" Total Movement
	Z (note 6)	Z (note 7)
–20	0.75	0.75
–10	0.82	0.84
0	0.89	0.83
10	0.95	1.02
20	1.02	1.11
30	1.09	1.20
40	1.16	1.29
50	1.23	1.39
60	1.30	1.48
70	1.36	1.57
80	1.43	1.66 ← NOMINAL POSITION
90	1.50	1.75
100	1.57	1.84
110	1.64	1.93
120	1.70	2.02
130	1.77	2.11
140	1.84	2.20
150	1.91	2.29
160	1.98	2.39
170	2.05	2.48
180	2.11	2.57
190	2.18	2.66
200	2.25	2.75

Welded Elbow 90° Type SWL-A

Welded Elbow, Type SWL-A Bus to Bus Elbow, 90°

Material: **Cast 356 Aluminum Alloy**

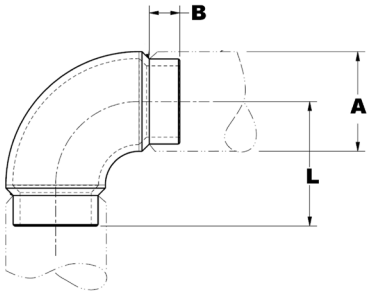
EHV Rated: **Self Shielding up to 550 kV**

NOTES:

Dimensions in brackets [ ] are in millimeters.

Conductors smaller than 3 inch bus size not recommended for 550 kV

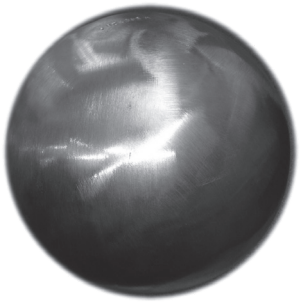
For 45° angle, add suffix '-45' to catalog number (example: SWL22A-45)



Catalog Number		Conductor Aluminum Tubing Size	Dimensions In./[mm]		
Sch. 40	Sch. 80		A Dia.	B	L
SWL18A	SWL58A	2"	2.38 [60.4]	1.00 [25]	3.50 [89]
SWL19A	SWL59A	2-1/2"	2.88 [73]	1.38 [35]	3.88 [99]
—	SWL90A	3"	3.50 [89]		4.68 [119]
SWL21A	SWL91A	3-1/2"	4.00 [102]		5.12 [130]
SWL22A	SWL92A	4"	4.50 [114]		5.63 [143]
—	SWL93A	5"	5.56 [141]	1.62 [41]	6.16 [156]
SWL86A	SWL96A	6"	6.63 [168]		6.16 [156]

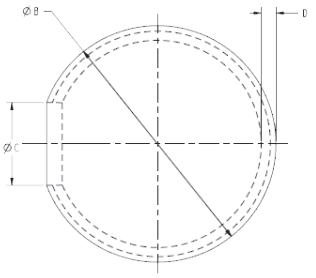
Welded Spherical Coupler; Terminal Pad Cap

Welded Spherical Coupler, Type WSBC-A Streamlined, Variable Angle; For Use on Aluminum Pipe to Pipe Connections



Material: **Aluminum Alloy**

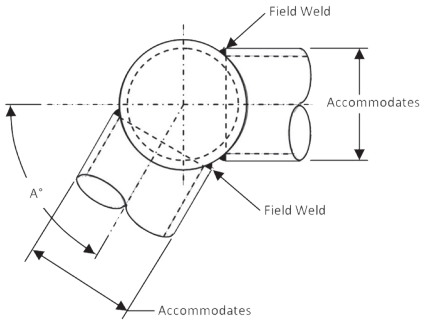
EHV Rated: **Self Shielding (operating voltages up to 500 kV)**



NOTES:

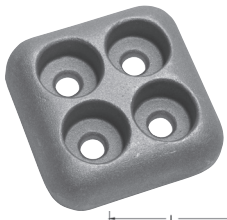
1. Dimensions in brackets [ ] are in millimeters.

Catalog Number	Conductor Range	Max kV	A° Max	⦸ B	⦸ C	D
WSBC74A	1-1/2" SPS	230	130°	5.00 [127]	1.75 [44]	.31 [8]
	2" SPS		115°			
	2-1/2" SPS		105°			
	3" SPS		90°			
	3-1/2" SPS		80°			
	4" SPS		50°			
WSBC83A	3" SPS - 5" SPS	345	90°	8.00 [203]	2.75 [70]	.44 [11]
	6" SPS		60°			
	8" OD SPS		40°			
WSBC128A	3" SPS	500	140°	12.00 [305]	2.75 [70]	.38 [10]
	3-1/2" SPS		135°			
	4" SPS		130°			
	5" SPS		120°			
	6" SPS		100°			
	8" OD SPS		90°			



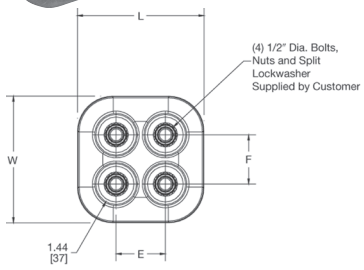
Type STS-A-NCG, Single Piece Terminal Pad Cap; EHV

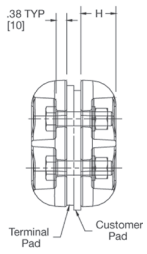
Bolted 1-piece terminal pad cap of cast Aluminum; Stainless Steel Hardware.



Material: **Aluminum Alloy**

EHV Rated: **Self Shielding (operating voltages up to 500 kV)**





NOTES:

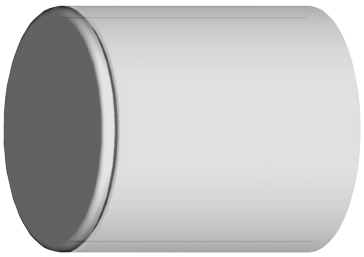
1. Dimensions in brackets [ ] are in millimeters.

2. Catalog number is for one shielding cap only. If more than one is required, specifiy total quantity.

Catalog Number	E	F	H	L	W	Maximum Shielded Area
STS44ACG10	1.75 [44]	1.75 [44]	1.50 [38]	4.00 [102]	4.00 [102]	3.5 x 3.5
STS44A4NCG2	1.75 [44]	1.75 [44]	1.25 [32]	4.50 [114]	4.50 [114]	4 x 4
STS46A6NCG1	1.75 [44]	1.75 [44]	1.25 [32]	4.50 [114]	6.50 [165]	6 x 4

End Plug Type WLB-A; Corona Bell Type SCB-A

End Plug, Type WLB-A Bus to End Cap; used with shielded bus support/ expansion couplers



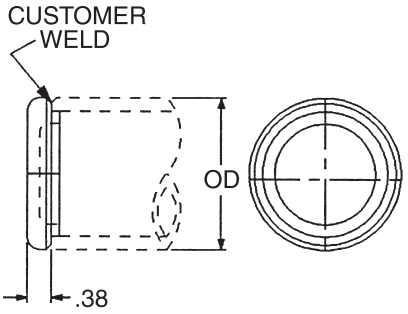
Material: **Cast 356 Aluminum Alloy**

EHV Rated: **up to 550 kV when used with shielded bus and expansion connectors**

NOTES:

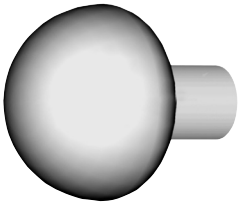
1. Dimensions in brackets [ ] are in millimeters.

2. Conductor smaller than 3 inch bus size not recommended for 550 kV.



Catalog Number		O.D.	Conductor Aluminum Tubing Size
Sch. 40	Sch. 80		
WLB15A	—	1.32 [34]	1"
WLB16A	—	1.66 [42]	1-1/4"
WLB17A	—	1.90 [48]	1-1/2"
WLB18A	WLB58A	2.38 [60]	2"
WLB19A	WLB59A	2.88 [73]	2-1/2"
WLB20A	WLB90A	3.50 [89]	3"
WLB21A	—	4.00 [102]	3-1/2"
WLB22A	WLB92A	4.50 [114]	4"
WLB24A	—	5.56 [141]	5"

Corona Bell, Type SCB-A Bus to Corona Bell



Material: **Aluminum Alloy**

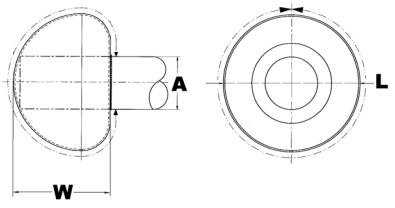
EHV Rated: **Self Shielding up to 550 kV**

NOTES:

1. For bolted design contact factory.

2. Dimensions in brackets [ ] are in millimeters.

3. Conductor smaller than 3 inch bus size not recommended for 550 kV.



Catalog Number	Accommodates 'A' Dia. Aluminum Tube
SCB22A	4" (4.500 Dia.)
SCB24A	5" (5.563 Dia.)