RESILIENT STRUCTURES

DISTRIBUTION HARDWARE Design Guide

For Distribution Applications from

12kV to 46kV

INTRODUCTION

The RS Hardware Guide is a resource for Standards Engineers, Structure Designers and Line Workers to provide guidelines for designing hardware connections and selecting appropriate overhead line electrical and communication hardware.

This document discusses typical hardware connections on distribution poles along with the design methodologies and principles involved in choosing the right hardware.

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Conductor Attachments

1.1 Top Pin Insulators

PART #	QTY	DESCRIPTION
101323	4	4" x 4" washer for ⅝" bolts
101324	4	4" x 4" washer for ¾" bolts

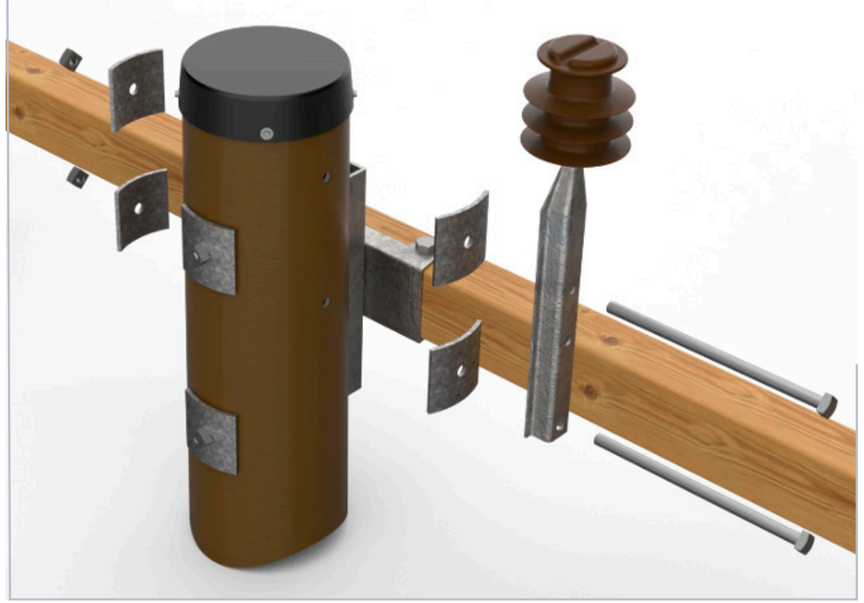
LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 7,460 lb | ¾" bolt – 8,940 lb
Transverse	⅝" bolt – 2,790 lb | ¾" bolt – 3,350 lb

For more information on moment calculation please refer to the **A.4a section under design methodologies** in the appendix.

Transverse load causes a moment acting on one bolt only. The longer the moment arm, the higher the transverse shear. Ensure the total load does not exceed the connection capacity.

1.2 Top Pin Insulators (side mount)

PART #	QTY	DESCRIPTION
101323	4	4" x 4" washer for ⅝" bolts
101324	4	4" x 4" washer for ¾" bolts



LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 7,460 lb | ¾" bolt – 8,940 lb
Transverse	4” x 4” washer – 4,160 lb
Longitudinal	⅝" bolt – 2,790 lb | ¾" bolt – 3,350 lb

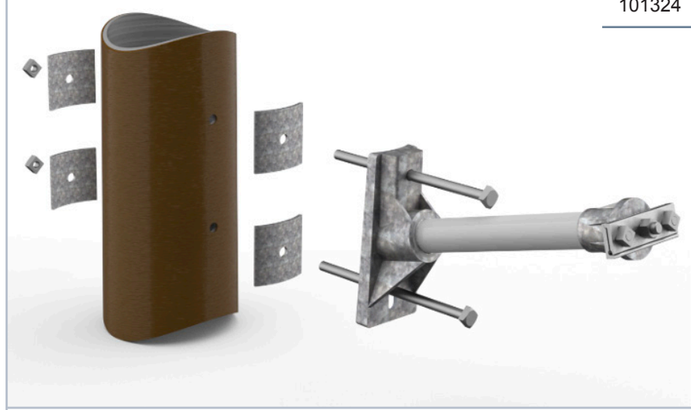
For more information on moment calculation please refer to the **A.4a section under design methodologies** in the appendix.

Imbalanced loads on the side mount causes a moment acting on one bolt. The longer the moment arm, the higher the transverse shear. Ensure the total load does not exceed the connection capacity.

For pin insulators mounted on the side, the transverse moment load will act on one backing washer.

1.3 Standoff Brackets

PART #	QTY	DESCRIPTION
101323	4	4" x 4" washer for ⅝" bolts
101324	4	4" x 4" washer for ¾" bolts



LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 7,460 lb | ¾" bolt – 8,940 lb
Moment	4" x 4" washer – 4,160 lb

For more information on moment calculation please refer to the **A.4a section under design methodologies** in the appendix.

The weight of the conductor causes a moment load by pulling the backing washers on the top bolt connection and pushing the gain base into the pole wall at the bottom bolt connection.

1.4 Armless Electric Distribution (V-Arm) or Vertical Pin Insulator Bracket

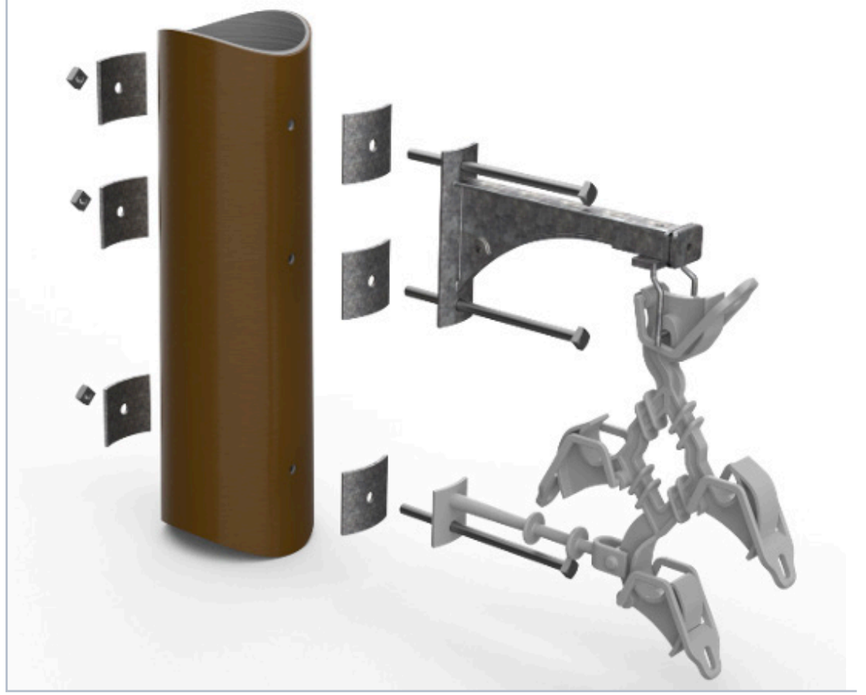
PART #	QTY	DESCRIPTION
101323	4	4" x 4" washer for ⅝" bolts

LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 7,460 lb
Transverse	⅝" bolt – 2,790 lb

For more information on moment calculation please refer to the **A.4a section under design methodologies** in the appendix.

1.5 Spacer Cable

PART #	QTY	DESCRIPTION
101237	6	5" x 5" washer for ¾" and ⅝" bolts, for modules M01 through M04
101238	6	5" x 5" washer for ¾" and ⅝" bolts, for modules M05 or larger



LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 7,460 lb | ¾" bolt – 8,940 lb
Transverse	5" x 5" washer – 13,000 lb
Pulling Force	5" x 5" washer – 6,500 lb

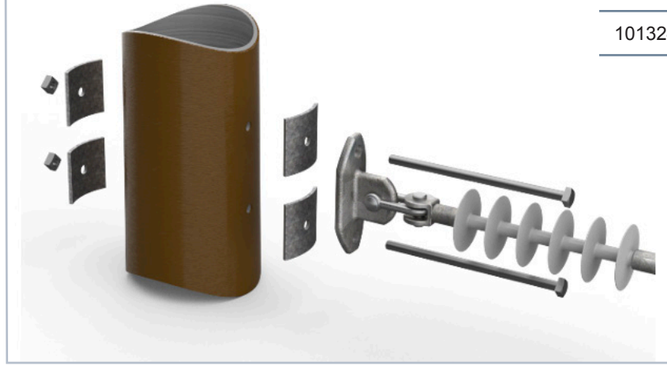
For more information on moment calculation please refer to the **A.4a section under design methodologies** in the appendix.

The applied weight causes a moment load pulling the backing washers on the top connection and pushing the gain base into the pole wall at the bottom connection.

1.6 Dead-end Strains

PART #	QTY	DESCRIPTION
101324	2	4" x 4" washer for ⅝" bolts

PART #	QTY	DESCRIPTION
100180	1	Guying tee for ¾" bolts
101324	4	4" x 4" washer for ¾" bolts



LOAD TYPE	CONNECTION CAPACITY
Vertical	¾" bolt – 4,470 lb | ¾" bolt – 8,940 lb
Pulling Force	4" x 4" washer – 4,160 lb | 4" x 4" washer – 8,320 lb

Neutral Attachments

2.1: Neutral Clevis

PART #	QTY	DESCRIPTION
101323	2	4" x 4" washer for ⅝" bolts

LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 3,730 lb
Transverse	4" x 4" washer – 4,160 lb.

2.1 Spools

PART #	QTY	DESCRIPTION
101323	6	4" x 4" washer for ⅝" bolts

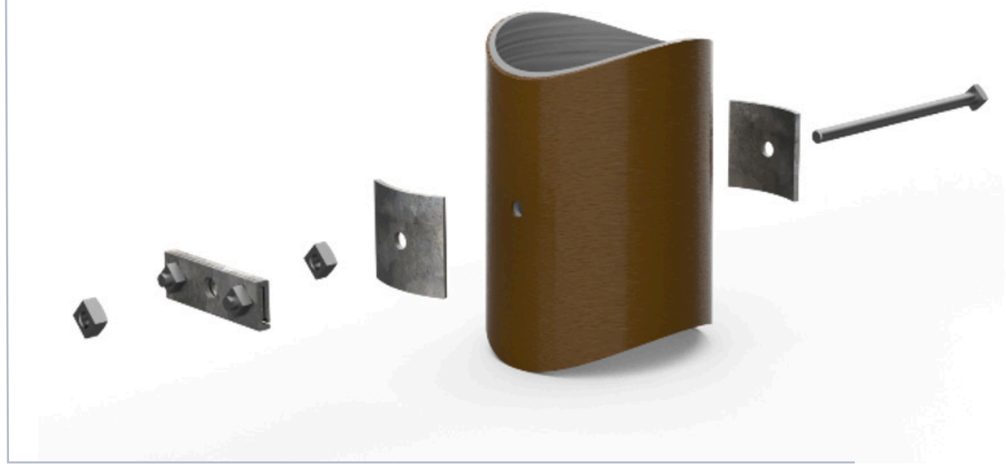
LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 7,460 lb | ⅝" – 11,180 lb | ⅝" – 14,910 lb
Transverse	4" x 4" washer – 8,320 lb | 4" x 4" washer – 12,480 lb | 4" x 4" washer – 16,640 lb

Ensure the pull load on the washer is equally applied on all backing washers. Some brackets may eccentrically load the spool, and the pull loads may be applied only on 1 or 2 washers; this will reduce the capacity at the connection.

Communication Attachments

3.1

PART #	QTY	DESCRIPTION
101322	2	4" x 4" washer for ½" bolts
101323	2	4" x 4" washer for ⅝" bolts



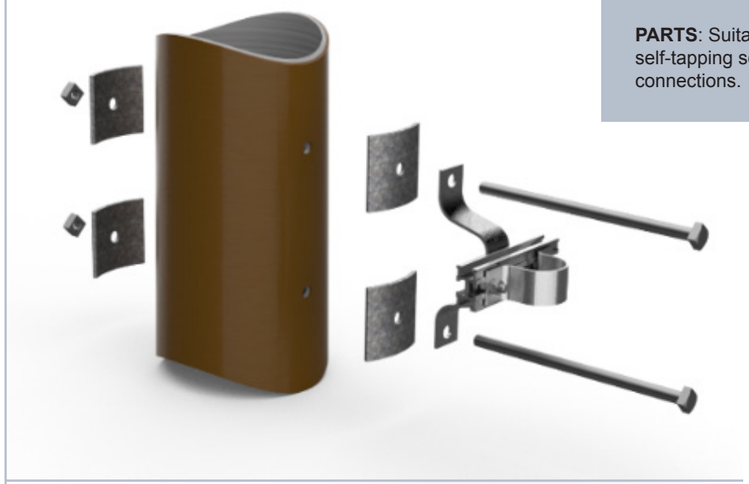
LOAD TYPE	CONNECTION CAPACITY
Vertical	½" bolt – 2,980 lb
Transverse	⅝" bolt – 3,730 lb

Linear Attachments

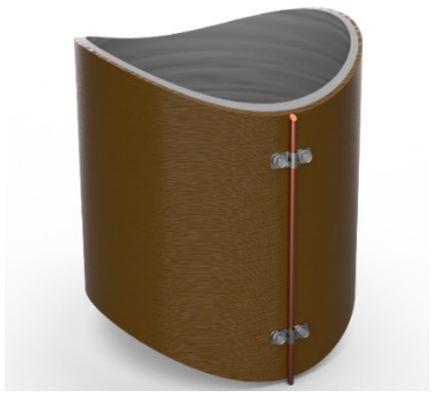
4.1 Riser Conduits

PART #	QTY	DESCRIPTION
101322	2	4" x 4" washer for ½" bolts
101323	2	4" x 4" washer for ⅝" bolts

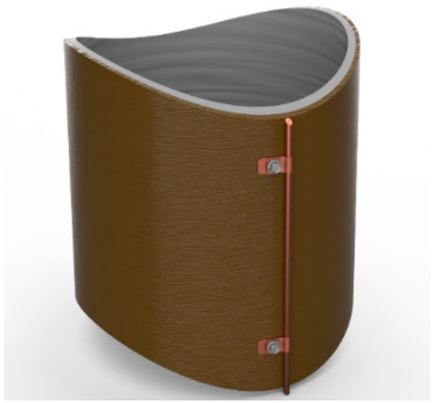
PARTS: Suitable sized conduit straps with self-tapping screws are sufficient for riser pipe connections.



4.2 Ground Wire Clamps



PARTS: Wire clamps with self tapping screws available for wire sizes from AWG #8 Cu to ½" coax. Please contact RS customer service for appropriate part numbers.

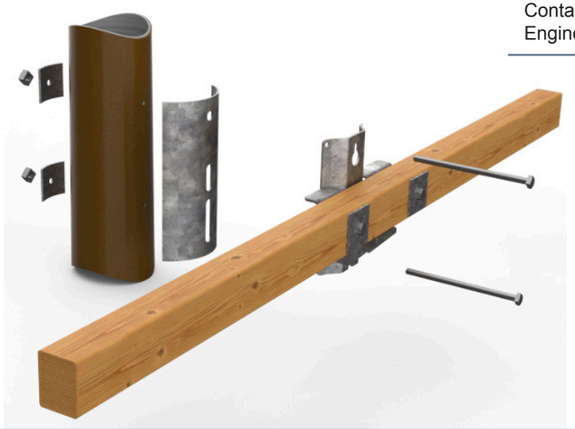


All ground wire connections shall be installed using self-tapping screws with appropriately sized ground wire clamps.

Crossarms

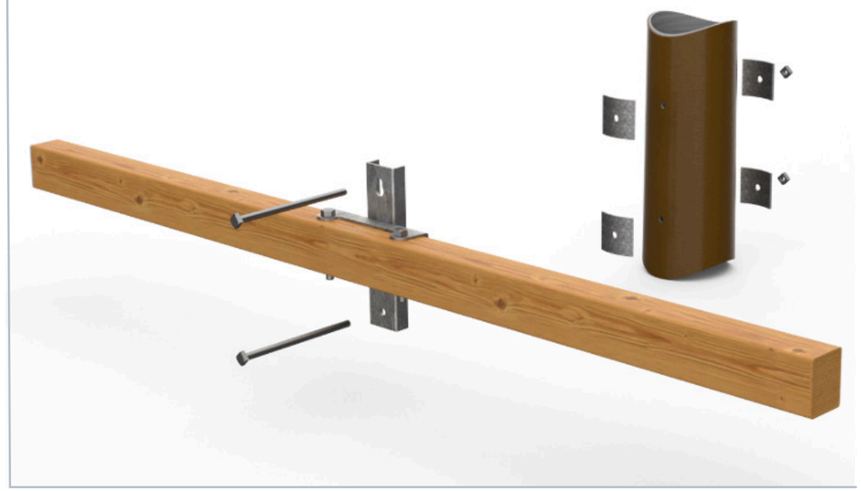
5.1 Crossarm 2-bolt Face Mount Brackets

PART #	QTY	DESCRIPTION
101323	2	4" x 4" washer for ⅝" bolts
101324	2	4" x 4" washer for ¾" bolts
Contact RS Engineering	1	Bearing plate



PART #	QTY	DESCRIPTION
Contact RS Engineering	2	Bearing plate

PART #	QTY	DESCRIPTION
101323	4	4" x 4" washer for ⅝" bolts
101324	4	4" x 4" washer for ¾" bolts



LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 7,460 lb | ¾" bolt – 8,940 lb
Longitudinal	4” x 4” washer – 8,320 lb
Transverse	⅝" bolt – 5,580 lb | ¾" bolt – 6,700 lb

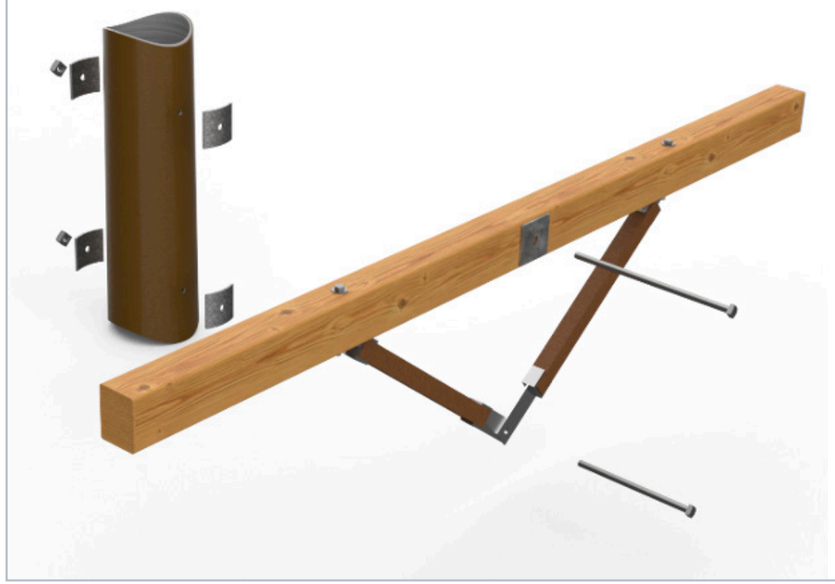
Connection requires a bearing plate under the cross-arm bracket with 4”x4” backing washers to prevent line contact of the gain base on the pole wall.

If the width of the bracket is small enough, a square curved washer can also be used as shown; provided the connection force can be handled by the washers.

Washers may be used as an alternative to bearing plates if the width of the cross-arm bracket is less than the width of the washers it is mounted against. This is to prevent line contact between the cross-arm bracket and the pole wall.

5.2 Crossarm with Vee Brace

PART #	QTY	DESCRIPTION
101323	4	4" x 4" washer for ⅝" bolts
101324	4	4" x 4" washer for ¾" bolts



LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 3,730 lb | ¾" bolt – 4,470 lb
Longitudinal	4" x 4" washer – 4,160 lb
Transverse	⅝" bolt – 2,790 lb | ¾" bolt – 3,350 lb

5.2a Crossarm Vee Brace with 3-bolt straps for heavy loads

PART #	QTY	DESCRIPTION
101323	3	4" x 4" washer for ⅝" bolts
101324	3	4" x 4" washer for ¾" bolts
100798	1	3-bolt strap for ⅝" bolts
100149	1	3-bolt strap for ¾" bolts

LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 11,180 lb | ¾" bolt – 13,420 lb
Longitudinal	4" x 4" washer – 4,160 lb
Transverse	⅝" bolt – 8,370 lb | ¾" bolt – 10,040 lb

HIGH ANGLES & HEAVY LOADS:
A 3-bolt strap is recommended to support the increased vertical and transverse load.

Alley Arms

6.1 Alley Arm

PART #	QTY	DESCRIPTION
101324	4	4" x 4" washer for ¾" bolts
Contact RS Engineering	1	Bearing plate

LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 3,730 lb | ¾" bolt – 4,470 lb ⅝" bolt – 7,460 lb | ¾" bolt – 8,940 lb
Transverse	⅝" bolt – 2,790 lb | ¾" bolt – 3,350 lb ⅝" bolt – 5,580 lb | ¾" bolt – 6,700 lb

Be cautious of moment loads applied at the connection due to the long alley arm. Ensure forces do not exceed the capacity in the table above.

6.2 Alley Arm for Vee Brace

PART #	QTY	DESCRIPTION
101324	4	4" x 4" washer for ¾" bolts
Contact RS Engineering	2	Bearing plate

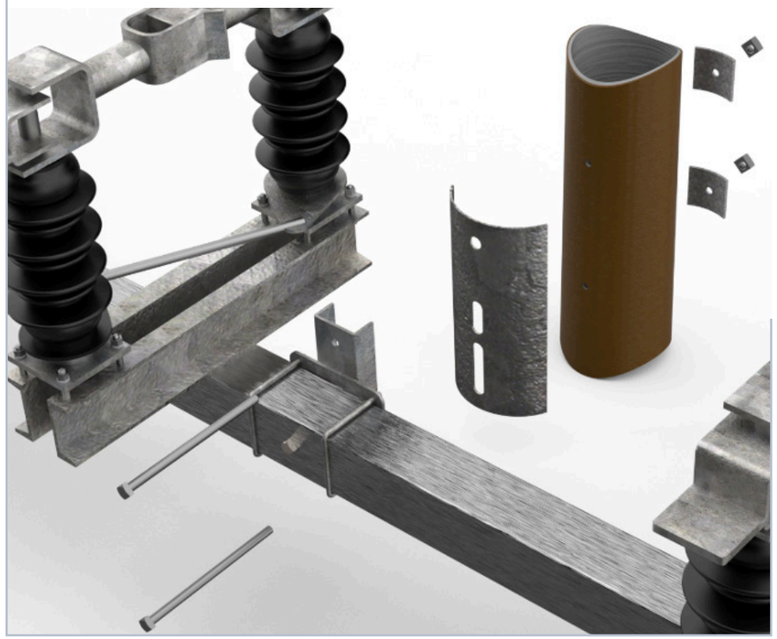
LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 3,730 lb | ¾" bolt – 4,470 lb
Transverse	⅝" bolt – 2,790 lb | ¾" bolt – 3,350 lb
Transverse	4” x 4” washer – 4,160 lb

Be cautious of moment loads applied at the connection due to the long alley arm. Ensure forces do not exceed the capacity in the table above.

Switch Arms & Control Rods

7.1

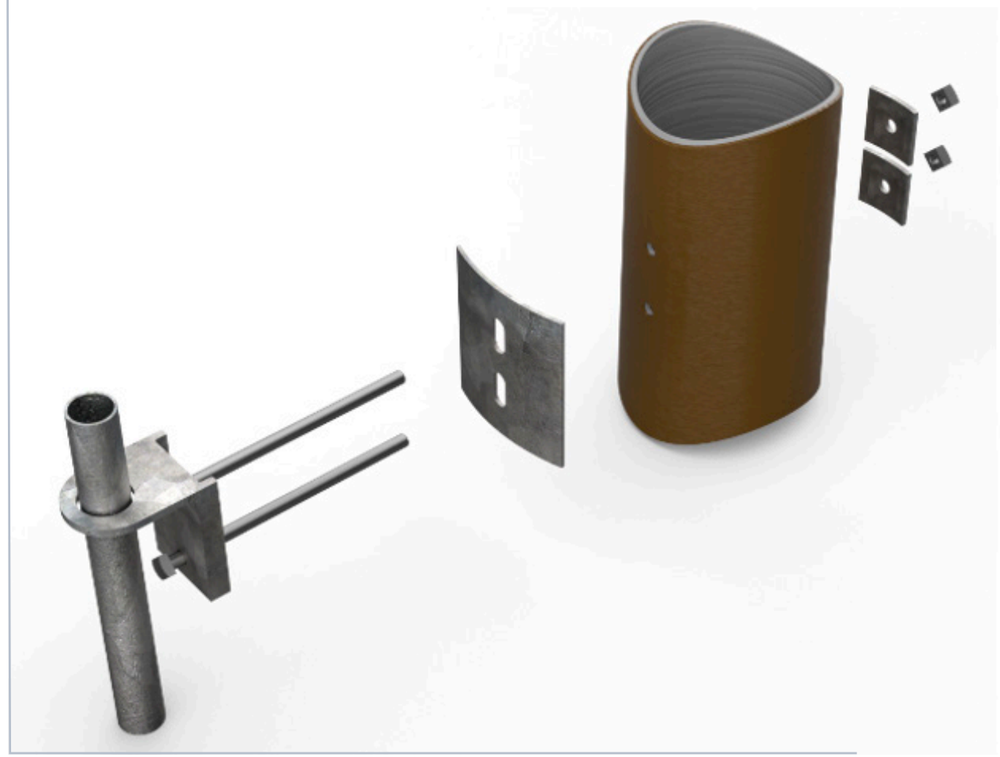
PART #	QTY	DESCRIPTION
101323	2	4" x 4" washer for ⅝" bolts
101324	2	4" x 4" washer for ¾" bolts
Contact RS Engineering	1	Bearing plate



LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 7,460 lb | ¾" bolt – 8,940 lb
Push/Pull Force	4" x 4" washer – 3,320 lb

7.2

PART #	QTY	DESCRIPTION
101322	2	4" x 4" washer for ½" bolts
101323	2	4" x 4" washer for ⅝" bolts
101039	14	Bearing washer

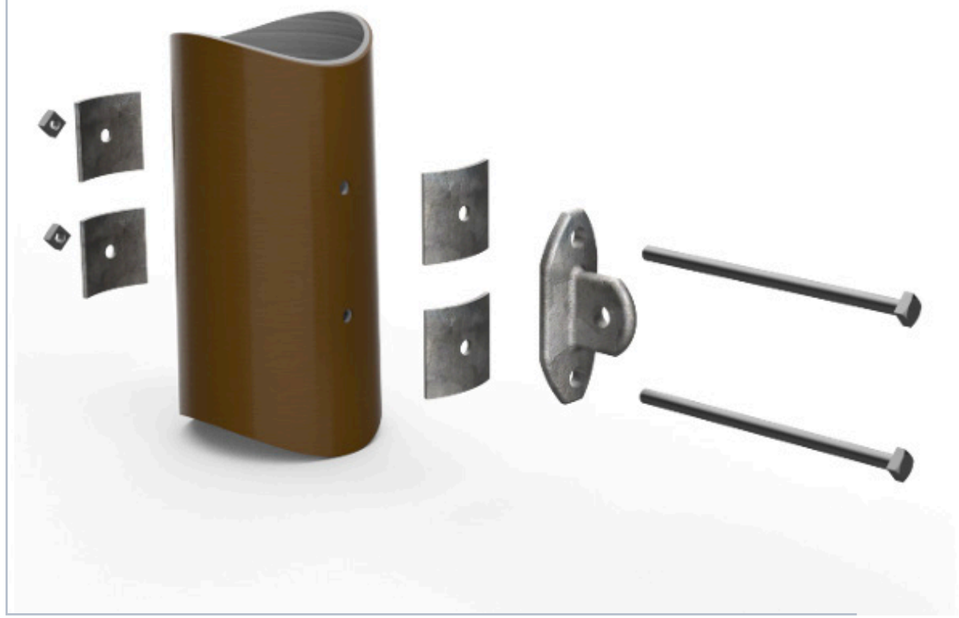


Guy Wires & Bridle Cables

8.1

PART #	QTY	DESCRIPTION
100180	1	Guying tee for ¾" bolts
101324	4	4" x 4" washer for ¾" bolts

LOAD TYPE	CONNECTION CAPACITY
Push/Pull Force	4" x 4" washer – 8,320 lb



BOLT QUANTITY
2 x ¾" [M20] Through Bolts

DETAILS	
2 x ¾" [M20] Through Bolts with Guying Tee Backed with 2 x Square Curved Washers 4" x 4" x ¼" [100mm x 100mm x 6mm]	2 x ¾" [M20] Through Bolts with Guying Tee Backed with 2 x Square Curved Washers 5" x 5" x 5/16" [127mm x 127mm x 8mm]

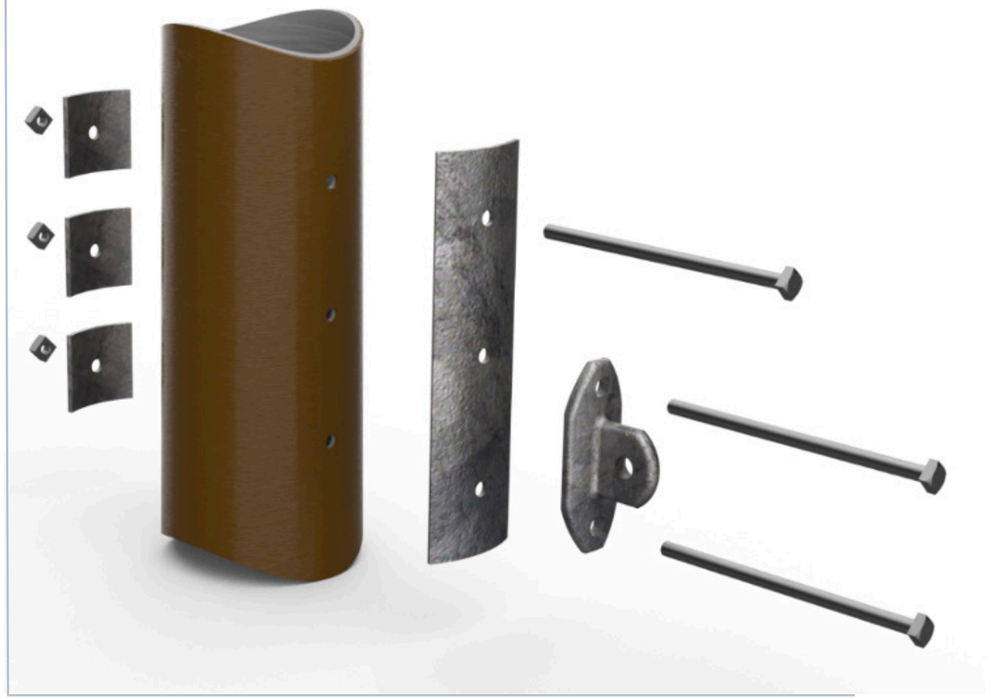
WASHER SIZE			
IMPERIAL	METRIC	IMPERIAL	METRIC
4" x 4" x ¼"	100mm x 100mm x 6mm	5" x 5" x 5/16"	127mm x 127mm x 8mm

HARDWARE LOAD CAPACITY			
(kN)	(kip)	(kN)	(kip)
266.9**	60**	266.9**	60**

GUY SLOPE	MAXIMUM GUY LOAD		GUY SLOPE	MAXIMUM GUY LOAD	
(Pole: Guy Anchor)	(kN)	(kip)	(Pole: Guy Anchor)	(kN)	(kip)
0.67:1	44.5	10.0	0.67:1	68.9	15.5
1:1	52.0	11.7	1:1	56.0	12.6
1.5:1	47.6	10.7	1.5:1	47.6	10.7
2:1	44.5	10.0	2:1	44.5	10.0
3:1	41.8	9.4	3:1	41.8	9.4
3.5:1	41.4	9.3	3.5:1	41.4	9.3
4:1	40.9	9.2	4:1	40.9	9.2

8.2

PART #	QTY	DESCRIPTION
100180	1	Guying tee for ¾" bolts
101324	3	4" x 4" washer for ¾" bolts
100149	1	3-bolt strap for ¾" bolts



For heavier connections a 3-bolt strap is recommended to handle the additional vertical load.

BOLT QUANTITY	
3 x ¾" [M20] Through Bolts	

DETAILS	
3 x ¾" [M20] Through Bolts with Guying Tee on a 3-Bolt Plate Backed with 3 x Square Curved Washers 4" x 4" x ¼" [100mm x 100mm x 6mm] (2 effective washers)	3 x ¾" [M20] Through Bolts with Guying Tee on a 3-Bolt Plate Backed with 3 x Square Curved Washers 5" x 5" x 5/16" [127mm x 127mm x 8mm] (2 effective washers)

WASHER SIZE			
IMPERIAL	METRIC	IMPERIAL	METRIC
4" x 4" x ¼"	100mm x 100mm x 6mm	5" x 5" x 5/16"	127mm x 127mm x 8mm

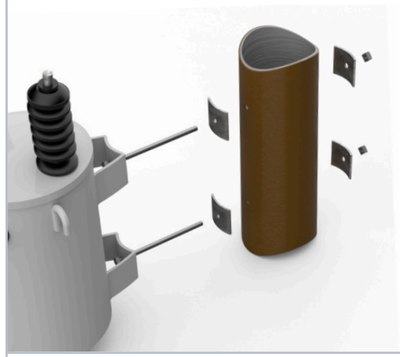
HARDWARE LOAD CAPACITY			
(kN)	(kip)	(kN)	(kip)
266.9**	60**	266.9**	60**

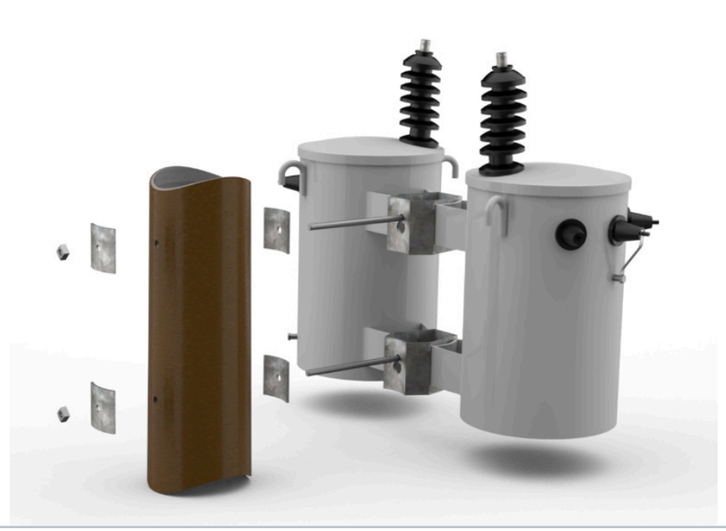
GUY SLOPE	MAXIMUM GUY LOAD		GUY SLOPE	MAXIMUM GUY LOAD	
(Pole: Guy Anchor)	(kN)	(kip)	(Pole: Guy Anchor)	(kN)	(kip)
0.67:1	44.5	10.0	0.67:1	68.9	15.5
1:1	52.0	11.7	1:1	81.0	18.2
1.5:1	65.8	14.8	1.5:1	72.1	16.2
2:1	66.7	15.0	2:1	66.7	15.0
3:1	63.2	14.2	3:1	63.2	14.2
3.5:1	Contact RS Engineering		3.5:1	Contact RS Engineering	
4:1	Contact RS Engineering		4:1	Contact RS Engineering	

Transformers, Arrestor & Fuse cutout

9.1 Transformers

PART #	QTY	DESCRIPTION
101323	4	4" x 4" washer for ⅝" bolts
101324	4	4" x 4" washer for ¾" bolts

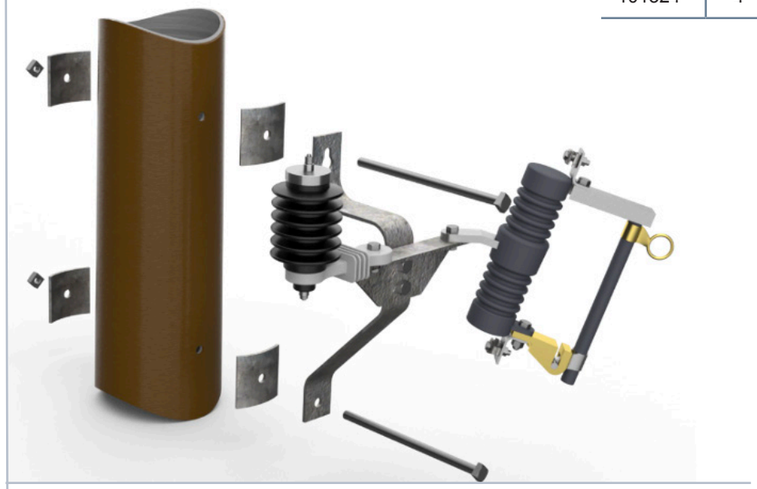




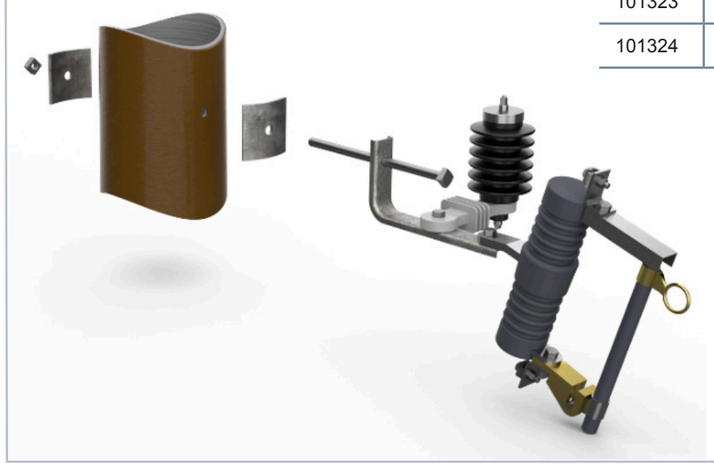
LOAD TYPE	CONNECTION CAPACITY
Vertical	⅝" bolt – 7,460 lb | ¾" bolt – 8,940 lb
Push/Pull Force	4" x 4" washer – 8,320 lb
Transverse	⅝" bolt – 5,580 lb | ¾" bolt – 6,700 lb

9.2 Fuse Cutout

PART #	QTY	DESCRIPTION
101323	4	4" x 4" washer for ⅝" bolts
101324	4	4" x 4" washer for ¾" bolts



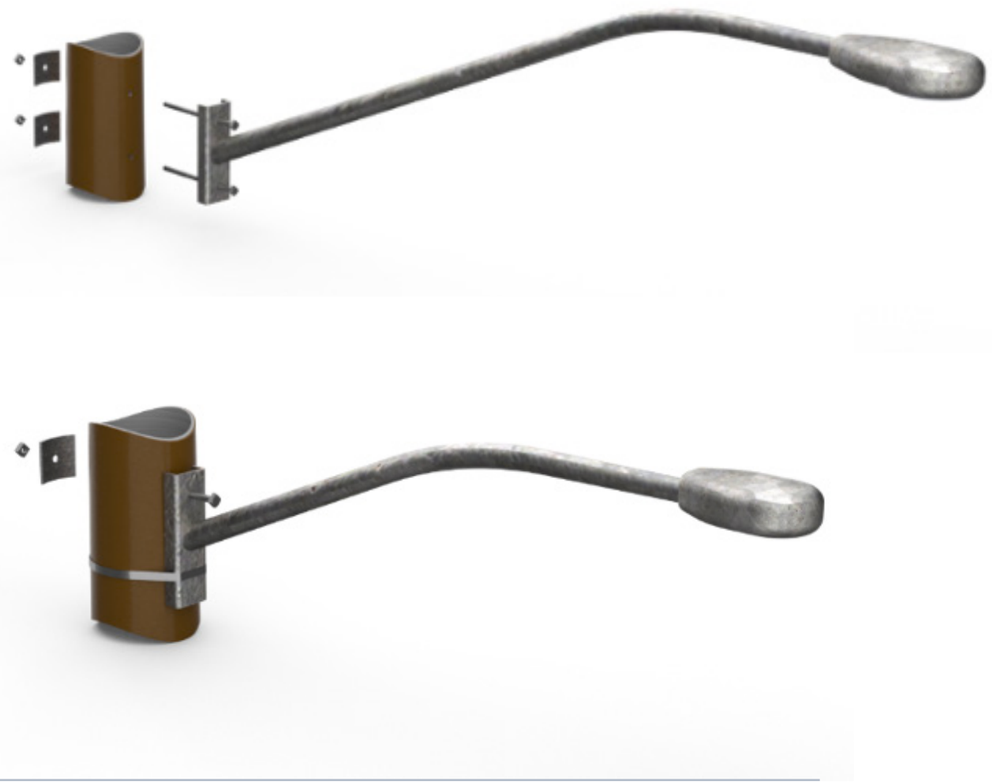
PART #	QTY	DESCRIPTION
101323	2	4" x 4" washer for ⅝" bolts
101324	2	4" x 4" washer for ¾" bolts



Lights, Cabinets & Miscellaneous

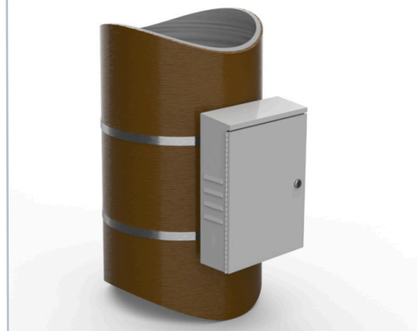
10.1 Lights

PART #	QTY	DESCRIPTION
101323	1 or 2	4" x 4" washer for ⅝" bolts
101324	1 or 2	4" x 4" washer for ¾" bolts



10.2 Cabinets

PART #	QTY	DESCRIPTION
101323	4	4" x 4" washer for ⅝" bolts
101324	4	4" x 4" washer for ¾" bolts



For all other attachments not covered in the guide please follow the **Design Methodologies** in the appendix section to determine the appropriate connection hardware.

For further assistance please contact RS Engineering.

Appendix

Design Methodologies:

In addition to the evaluation of pole performance, determining the connection hardware is equally important in successfully designing and utilizing the full capabilities of RS Poles.

There are four main considerations regarding hardware attachments to composite poles that are focused on maintaining the integrity of the pole wall at the connection location:

1. Smooth Backed Hardware

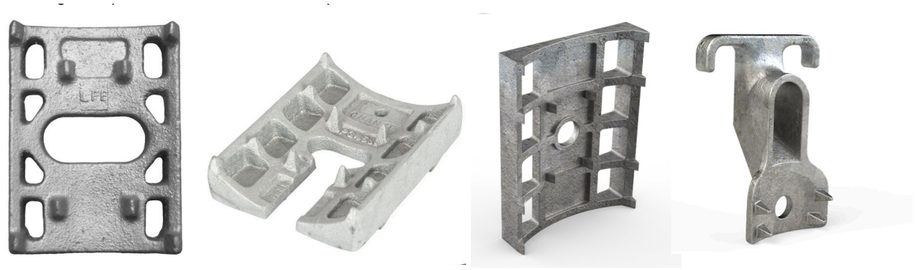
2. Sharp Edge/Line Contact

3. Hole spacing

4. Connection stress

A.1 Smooth Backed Hardware

All hardware, including washers, must be smooth-backed and shall not have any cleats, which are designed to penetrate the surface of a wood pole.

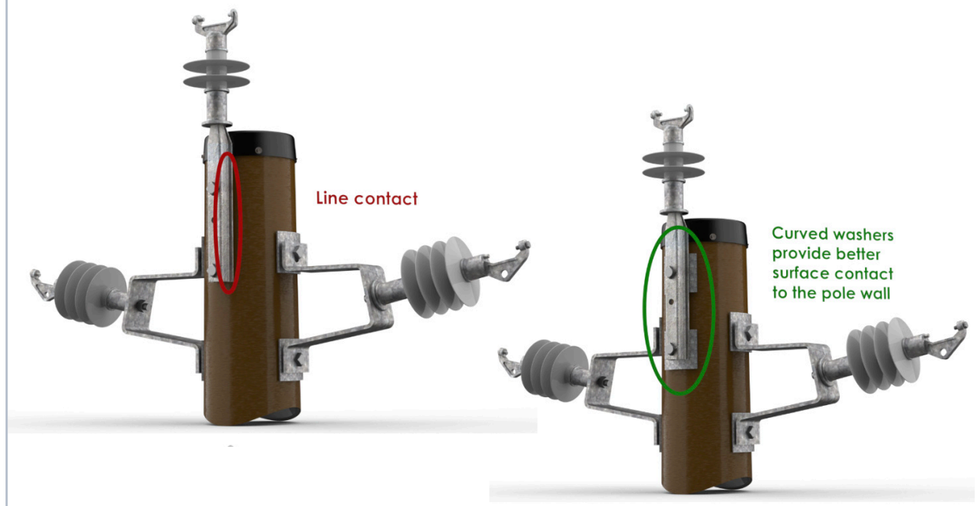


Examples of cleated hardware used on wood poles—these are to be avoided on RS composite poles.

Most hardware manufacturers offer the same cleated hardware in a smooth-backed version. Alternatively, RS stocks a large variety of smooth-backed hardware ready to ship with your pole order.

A.2 Sharp Edge / Line Contact

Some gain bases and bracket attachments have a single line of contact at each edge when it is attached to the curved surface of the composite pole.



Utilizing washers to avoid line / edge contact.

To avoid sharp edge contact, the backing radius of the hardware shall match the radius of the composite pole at the attachment elevation. This requirement applies to all hardware that come in contact with the pole surface. (ex. Post insulator gain bases, crossarm brackets, washers, OPGW/static wire connections, dead-end guying tees, curved bearing plates, etc.)

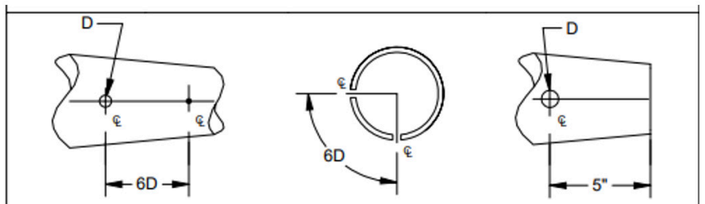
Pole and hardware matching are important as RS modular poles are tapered. (The pole radius varies over the length of the pole.) If the hardware and pole are mismatched (i.e. typically backing radius of the hardware is smaller than the pole radius at the attachment elevation), an intermediary steel bearing plate or washer can be placed between the hardware and the pole surface to create protective cover for the pole such that the edges of the hardware will not damage the pole.

A.3 Hole Spacing

To maintain the integrity of the pole wall, it is important that hole to hole spacing on the hardware, and the position of two pieces of hardware relative to each other, follow the hole spacing requirements.

RS hole spacing requirements are:

- **6D Hole Spacing:** Holes are spaced six times the diameter (6D) of the larger hole away from each other (**Figure A.3**). Most existing line hardware has 6” bolt spacing, which will be in line with the 6D requirement for all ⅝", ¾" and ⅞" bolt spacing.
- **5” Center to Edge:** Holes need to maintain a minimum 5” clearance from the hole center to the edge. This applies to the tip and base of every module of RS modular poles.
- **Slip Joint No Drill Zone (NDZ):** There is an additional 3” no drill zone below the bottom edge of the top module in the slip joint. (This allows for slip joint compression in the event of a high vertical load.) Along with the 5" center to edge requirement, this creates an 8" no drill zone band at every slip joint.



6D MINIMUM HOLE SPACING = 6 x LARGEST HOLE DIAMETER

BOLT SIZE	HOLE SIZE	6D MINIMUM DISTANCE OF HOLE ℄ TO HOLE ℄	5" MINIMUM DISTANCE OF HOLE ℄ TO EDGE
1"	1-1/16"	6-3/8"	5"
7/8"	15/16"	5-5/8"	
3/4"	13/16"	4-7/8"	
5/8"	11/16"	4-1/8"	
1/2"	9/16"	3-3/8"	

Hole spacing (6d) and NDZ rules to consider for drilling holes in RS Poles.

A.4 Connection Stress

RS Composite Poles are assembled from hollow tubular sections; this requires a detailed approach in determining the forces involved at hardware attachments.

In general, the stresses on the composite wall due to hardware attachments can be broken down into:

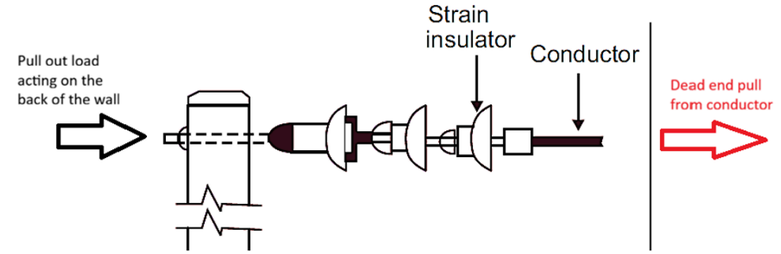
1. Wall bearing stress
2. Bolt bearing stress

It is important that the connection stresses are evaluated accurately and suitable hardware is installed to avoid any localized failure on the pole wall.

Wall Bearing Stress

The wall bearing stress is the applied load divided by the actual contact area of the specific hardware component against the pole wall.

For example, a dead-end strain attachment applies a load through the bolt and the nut at the back of the connection point. This in-turn propagates a bearing stress at the pole wall.

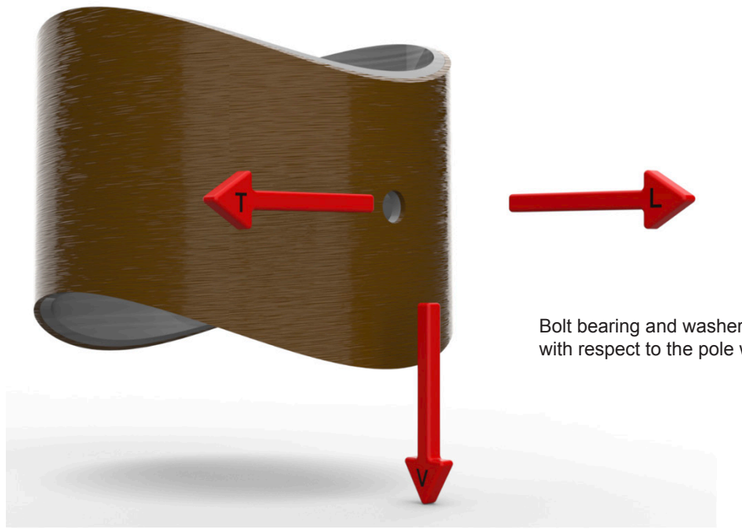


The pull force from the dead-end strain acts through the bolt and on the backing washer.

The pull-out load must be distributed equally across the pole wall. Square curved washers are used to achieve equal load distribution on the pole wall. Some hardware, like braces, apply a push load to the wall. A washer is required to spread the load. The orientation direction of the Push/Pull load is perpendicular (normal) to the pole wall.

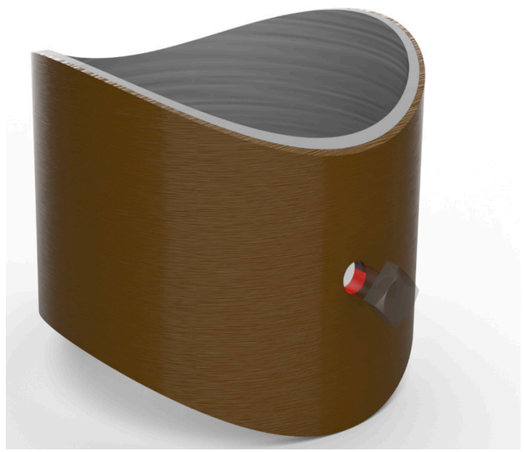
Bolt Bearing Stress

The bolt bearing stress is the compressive contact pressure of the bolt shank and internal wall of the hole. All bolt connections on the pole can be resolved into vertical bolt bearing load (V) and transverse bolt bearing load (T).



Bolt bearing and washer bearing loads orientation with respect to the pole wall.

The longitudinal pull-out load (L) is the wall bearing load which is discussed in the previous section.



Effective bearing area based on wall thickness and bolt diameter.

When the orientation of a bearing load is parallel to the poles central axis, it is a vertical bolt bearing load. When it is tangential to the circumference of the pole, it is a transverse bolt bearing load.

When evaluating the vertical stress of a through bolt attachment, only the wall thickness on one side of the pole is considered. As in most hardware attachments, the load acts on one side of the pole wall only.

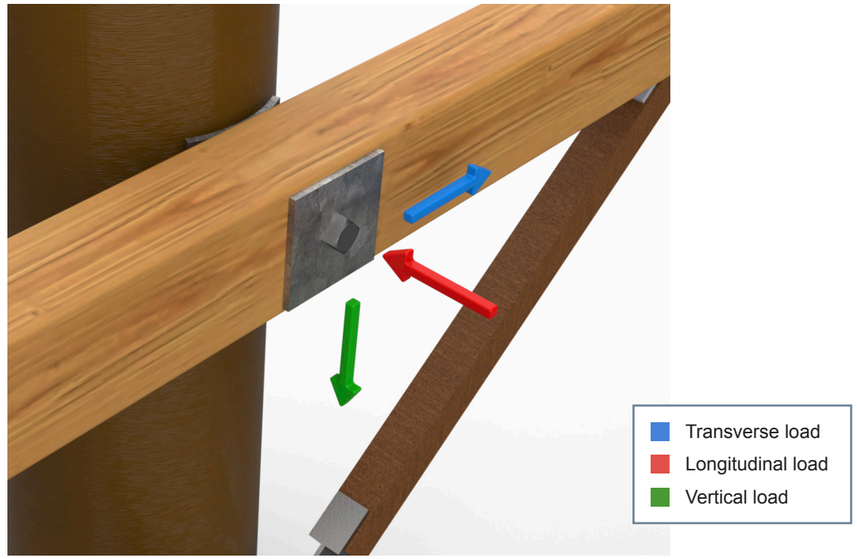
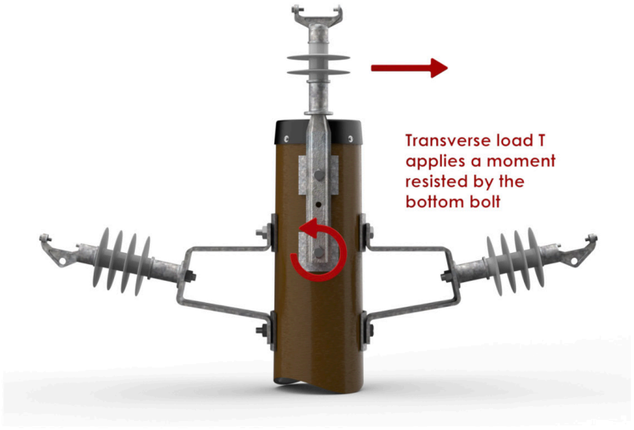


Illustration of the vertical transverse and push pull force direction from a crossarm attachment.

The figure above is an example of a cross-arm attachment applying a vertical, transverse and longitudinal load on the pole wall. The vertical component is from the weight of the conductor, the transverse load is from the wind acting on the conductors along the span length, and the longitudinal load is the conductor tension due to conductor stringing and a combination of vertical loads including any ice imbalance.

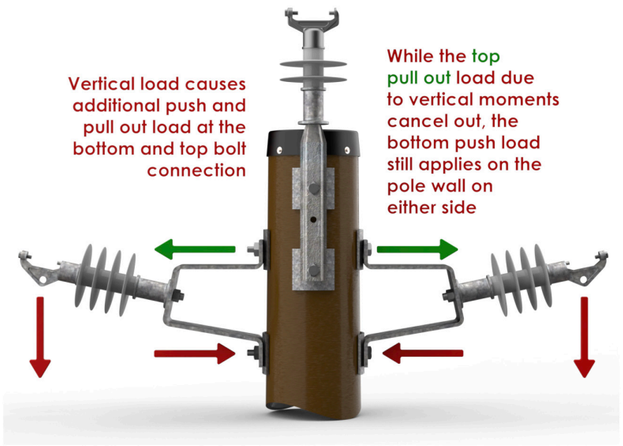
A.4a Force Moment Calculations

Some hardware also applies moment loads. These additional moments must be resolved into bolt bearing and washer bearing stress for determining the hardware connection.



Transverse bolt bearing moment due to transverse load.

The transverse load on the top pin insulator applies a moment load which in turn applies a pivoting motion through the top bolt attachment. This moment is only resisted by the bottom bolt in the transverse bolt bearing direction.



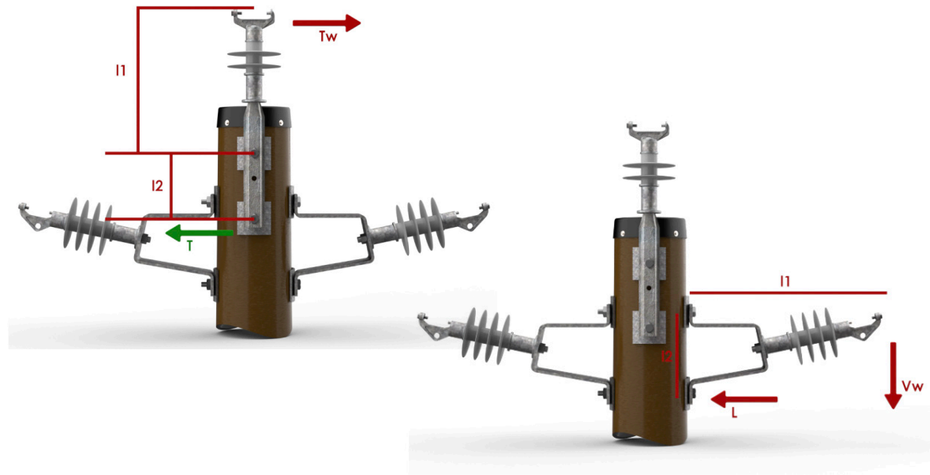
Push and pull out load due to the vertical moment acting on the bracket.

Like the transverse moment, the vertical load on the standoff bracket applies a push and a pull load on the bottom and top bolt connection perpendicular to the pole wall and it requires appropriately sized washers to spread the push load. When there is an uplift, the load direction and the pivoting moment action reverses.

The transverse force on the bolt due to transverse load from conductor:

Transverse moment $F_t = T_W \times l_1$, where T_W is transverse load due to wind on the conductor and l_1 is the moment arm length.

The transverse force at the connection $T = F_t / l_2$, where l_2 is the counter moment arm length or bolt spacing in this case.



(left): Moment arm length on a typical top pin connection.
(right): Moment arm length on a typical standoff bracket connection.

The vertical load causing a pull moment:

The vertical moment $V_t = V_W \times l_1$, where V_W is the vertical load of the conductor.

l_1 is the moment arm length. In this case, the distance between the conductor attachment point to the bottom of the gain base.

The pull force at the connection $L = V_t \times l_2$, where l_2 is the counter moment arm which is the bolt spacing of the bracket.

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