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# **ELECTRICITE DU CAMBODGE**

## **TECHNICAL RULE**

**EDC-TR-003**



**Connections on MV Overhead Lines**

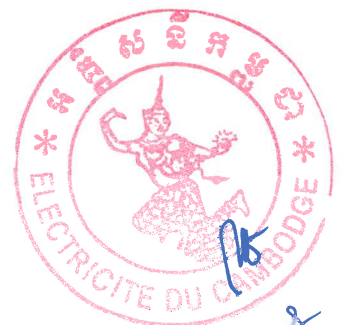
**July 2024**





**ELECTRICITE DU CAMBODGE**

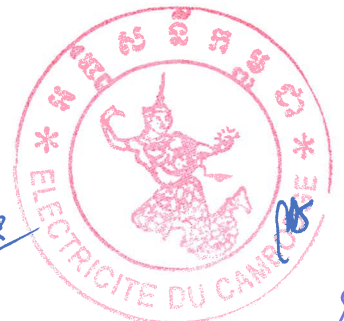
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EDC-TR-003: Connections on MV Overhead Lines

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# Connections on MV Overhead Lines

## 1 Scope of application

This technical rule defines and clarifies the different connections that are to be used and installed on MV OHL:

- between conductors,
- between conductors and switching or metering equipment,
- between conductors and UGC
- between UGC and Conductors
- as well as between UGC raising and switching equipment.

This Technical rule explains the main principles of installation on the most used equipment and processes. It cannot explain all particular uses or very specific equipment.

In this document it is assumed that the full wiring of PMT is made using covered conductors.

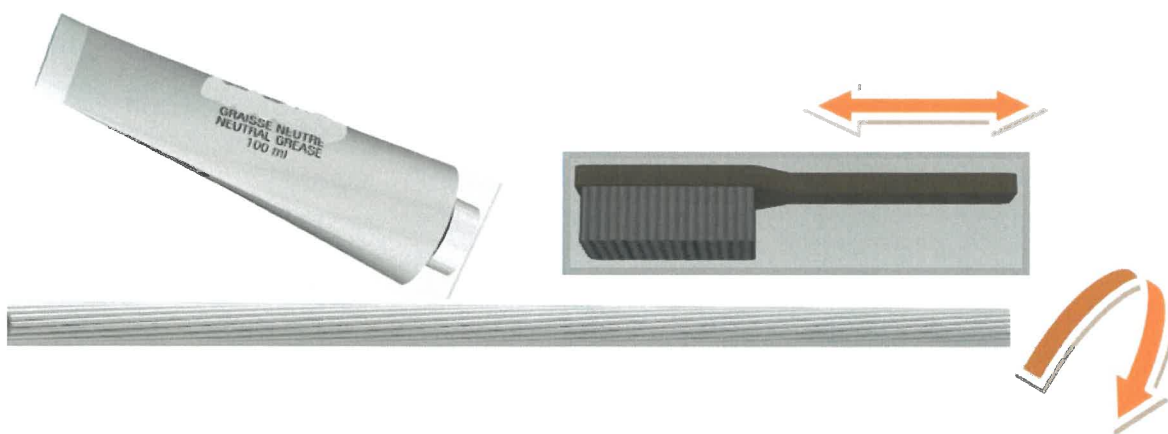
## 2 General Rules for conductors' preparation

Conductors used for OHL and UGC are made of aluminum or aluminum alloy.

**Care shall be taken in order to avoid any damage to conductor's wires** especially when removing the covering of MV covered conductors.

Additionally, as soon as in contact with oxygen (air), the surface of aluminum conductors is immediately corroded by a layer of aluminum oxide that is insulating.

So, to get the best possible connection, **it is essential to remove this aluminum oxide layer by brushing the bare conductor(s) under neutral grease** to "break" this layer and avoid new oxidation.

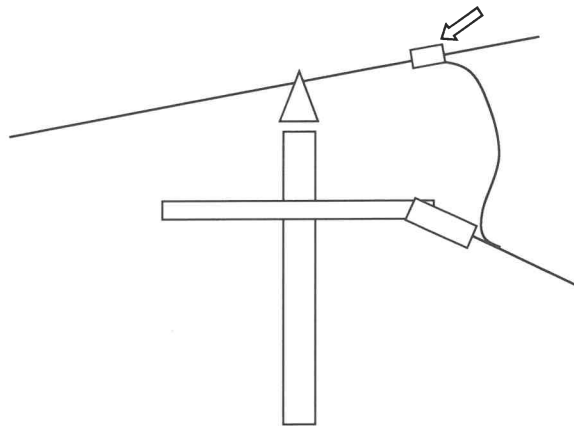


## 3 Connection with bare conductors

### 3.1 Tap on the Main conductor with Parallel groove clamp (PG clamp)

This is the most useful equipment for connection because of the large admissible range of conductor's cross-section as main and tap.





*Tap on the Main conductor with PG clamp*

**Installation:**

1. Insert the tap and main conductors inside the PG clamp after verification of the admissible cross sections.
2. Tight the head of the bolts using ratchet wrench with 6 faces socket then tight the lock nuts

**Advantage:** Low-cost

**Disadvantage:** Many bad quality PG clamps on the market. The quality of the PG clamp is very important for the connection lifespan.

**3.2 Tap on the Main conductor with ring hotline connector for bare conductors.**

This type of ring hotline connector is mainly used by MV hotline teams when working with hot sticks.

**IN ANY CASE, THE CROSS SECTION OF THE bare TAP LINE IS LIMITED TO 35 mm<sup>2</sup>**

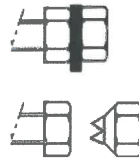


Nevertheless, thanks to the metric shear-off heads of tightening tap bolts and main ring bold, this ring connector can be installed by hand during dead work.





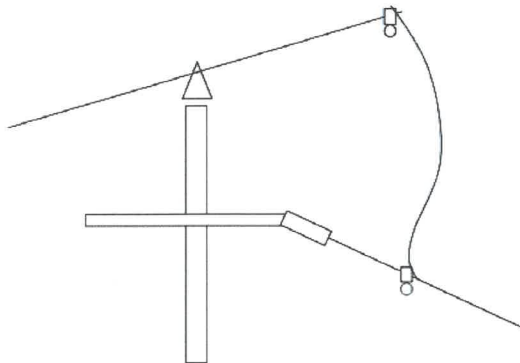
Shear off head on Ring main bolt



Shear off head(s) on tap bolt(s).

**Installation:**

1. **Always use 1 Ring Hot line connector on both end of the connecting jump.** This will allow hot line teams to easily remove the jump latter in case of need.
2. Insert the tap conductor in the connector N°1 and tight the bolt (s) till the head(s) shear off.
3. Put the connector onto the main conductor maintain it and tight the ring bolt till the head shear off.
4. Measure the jump length and cut the conductor then repeat the operations above for the connector N°2.



The plastic “ball” (if any) covering the ring or the ring is ALWAYS in direction of the ground.

**Advantage:** Easy to install and prepare the future live line works.

**Disadvantage:** Must be very properly installed.

**3.3 Connection of covered conductor onto main bare conductor**

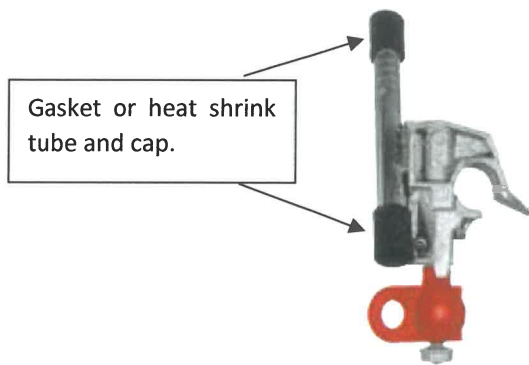
This case is typically the case of a pole mounted transformer (PMT) connected on a bare conductors OHL or a covered conductors tap line connected to bare OHL.



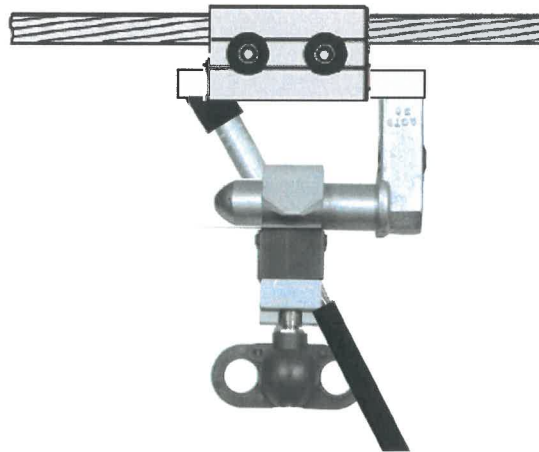
The connecting equipment is a pin branch joint for bare conductor in association with a pin connector for covered conductor.



*Pin branch joint for bare conductor.*



*Pin connector for covered conductor*



*Assembly of pin branch joint for bare conductor with pin connector for covered conductor*

### Installation

1. Install the pin branch joint in right location and position on the bare conductor by tightening the bolts of the PG clamp.
2. Cut the covered conductor at the right length and remove the covering on the length indicated in the installation instruction or the length of the tube of the pin connector plus 1 cm.
3. Insert the conductor in the tube of the pin connector. The end of the conductor must be visible.
4. The bi metallic lugs for bare conductors are hexagonally compressed onto the conductors using a 12 tons minimum hydraulic press.



The following regular hexagonal dies are used:

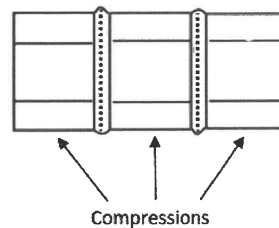
Conductor cross-section	Mandatory die (mm)
35 mm <sup>2</sup>	12,0 (E 120)
70 mm <sup>2</sup>	17,3 (E173)
150 mm <sup>2</sup>	23,0 (E230)
185 mm <sup>2</sup>	25,0 (E250)
240 mm <sup>2</sup>	28,0 (E280)

Use of 200 kN press with large dies is strongly recommended for 185 and 240 mm<sup>2</sup>.

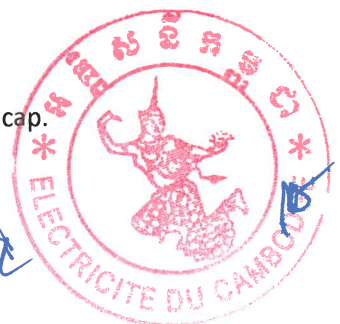


**Nevertheless, die references are checked before starting the compression.**

- Compress the tube of the pin connector starting by body side of the tube. 2 compressions minimum depending on the cross-section. Compress between the marks on the tube. **Keep about 2 mm between the hexagonal compressions.**



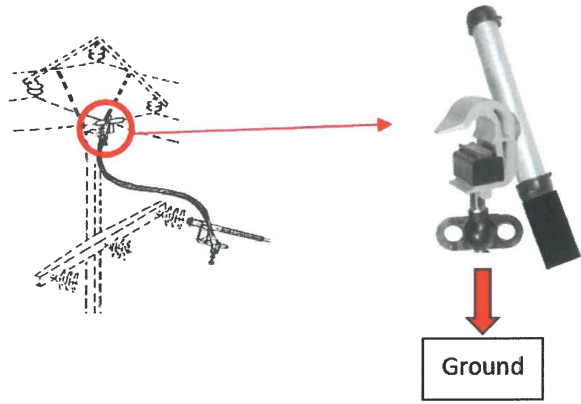
- Verify the correct position of gaskets or heat the heat shrink tube and cap.



g

- 7. Install the pin connector onto the pin keeping the plastic ball (if any) protecting the ring or the ring in direction of the ground.
- 8. Tight the bolt of the pin connector using ratchet wrench with short 6 faces socket till the bolt head shear off.

**Do not remove the plastic ball (if any) and do not tight more the pin connector using the ring.**



### 3.4 Connection of Bare Conductors onto LBS, Recloser, VT, CT, MV disconnecting switch and outdoor transformer

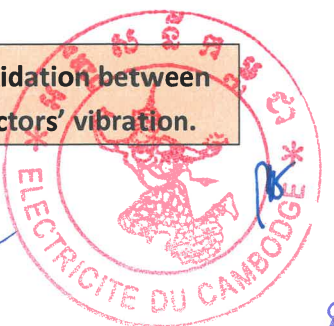
In case of conductor's connection to Load Break switch, recloser, CT, VT, MV disconnecting switch or outdoor transformer, as the equipment terminals are made of tinned copper or copper alloy, bi-metallic alu/copper hexagonal compression lugs shall be used as follows:



Installation of this type of bi metallic lug with friction welding between copper palm and aluminum tube



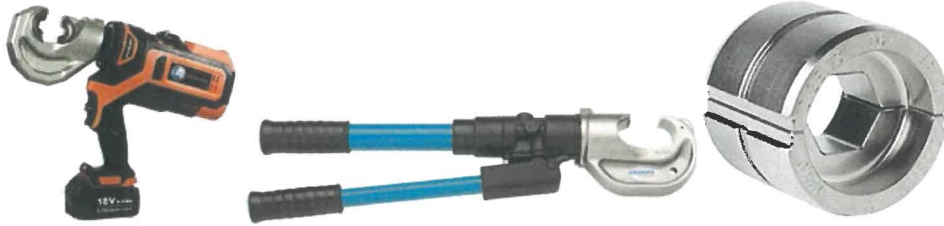
**This kind of lug is strictly forbidden on OHL for reason of fast oxidation between aluminum and copper part as well as very bad withstand against conductors' vibration.**



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**Installation**

1/ The bi-metallic lugs for bare conductors are hexagonally compressed onto the conductors using a 12 tons minimum hydraulic press.



The following regular hexagonal dies are used:

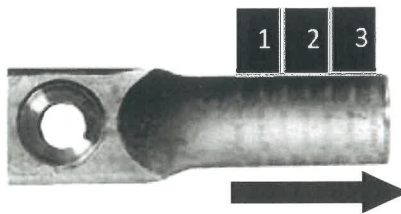
Conductor cross-section	Mandatory die (mm)
35 mm <sup>2</sup>	12,0 (E 120)
70 mm <sup>2</sup>	17,3 (E173)
150 mm <sup>2</sup>	23,0 (E230)
185 mm <sup>2</sup>	25,0 (E250)
240 mm <sup>2</sup>	28,0 (E280)

Use of 200 kN press with large dies is strongly recommended for 185 and 240 mm<sup>2</sup>.



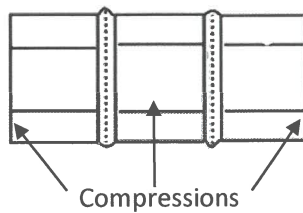
**Nevertheless, die references are checked before starting the compression.**

2/ Compressions are done with the following sequence:



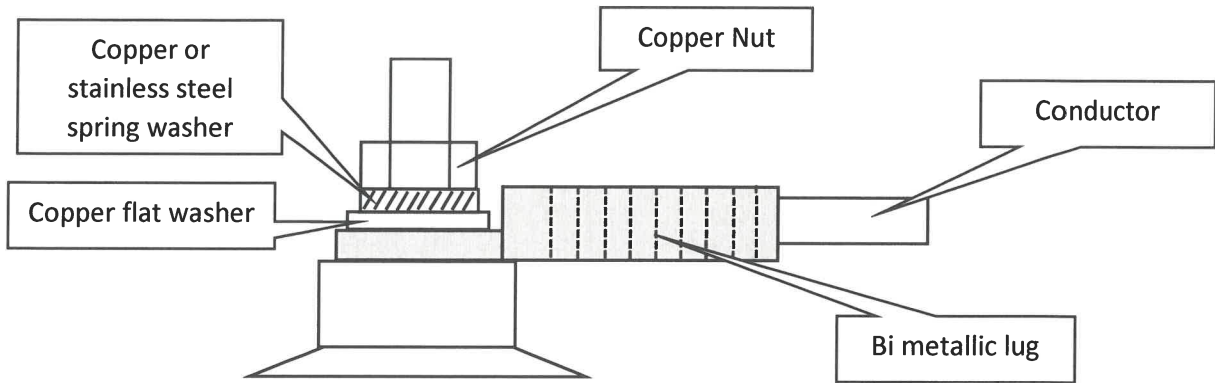
Always from palm to conductor. Here, 3 compressions are done, it can be more depending on the lug cross-section and dies larger.

3/ Keep no more than 2 mm between 2 compressions



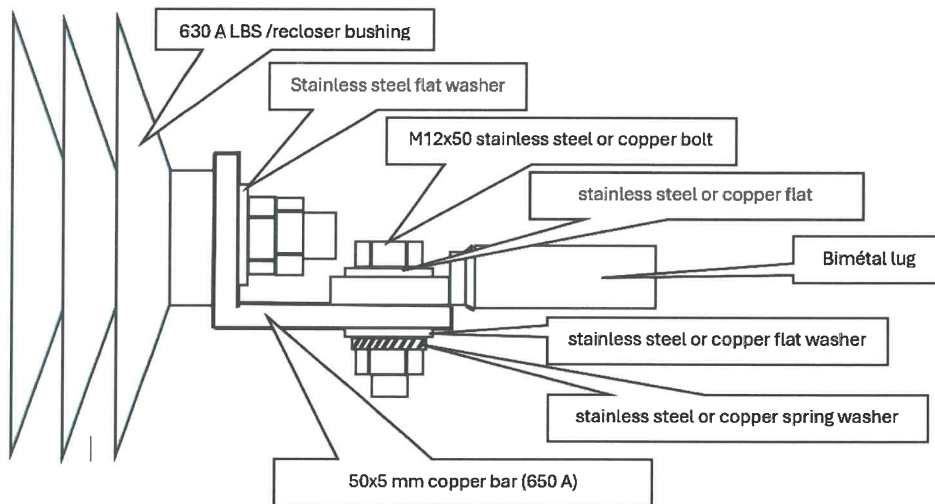
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4/ Connect on the bushing. (case of metallic flat base on the bushing)

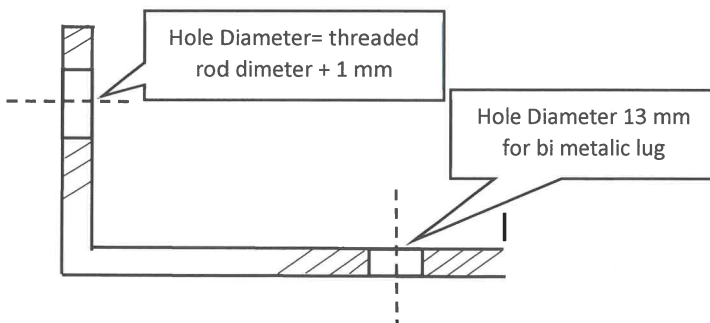


**3.4.1 Connection onto LBS or recloser bushings if the diameter bushings bolted part is more than 12 mm**

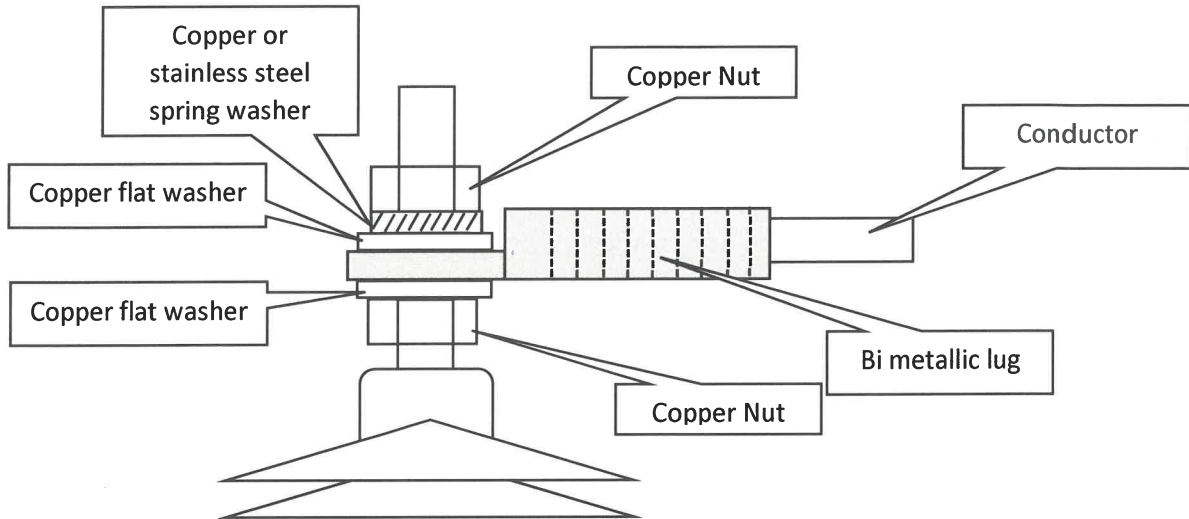
In that case, as the lugs cannot be pierced, it is necessary to add a specific copper bar between the bushing and the lug as follow:



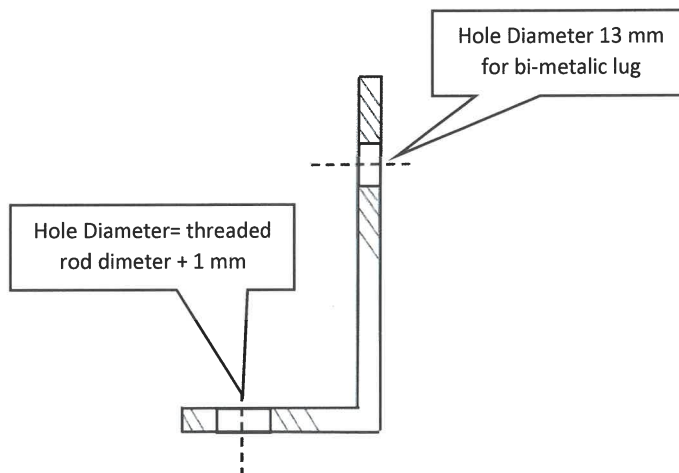
Detail of 50 mm x 5 mm copper bar:



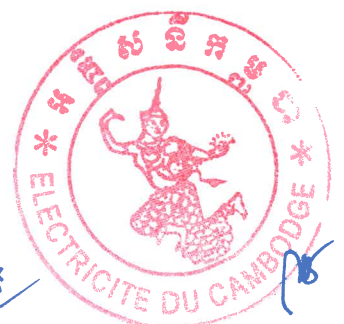
3.4.2 Case of no copper or stain steel flat part on the bushings (Mainly transformers)



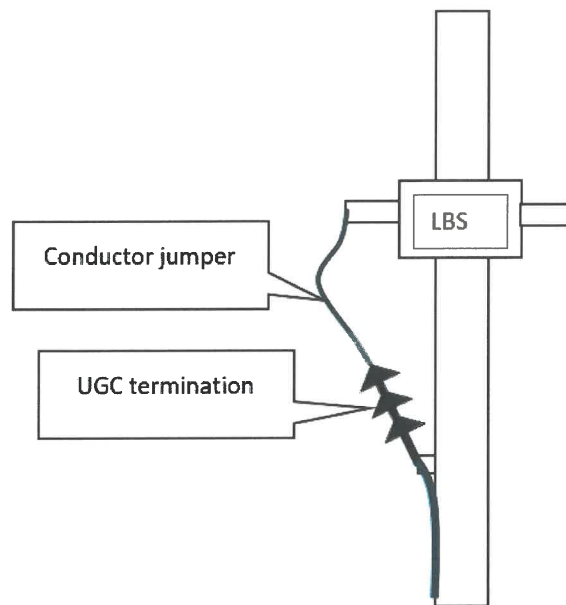
In the case, the threaded part of the transformer bushing is more than M12: use the copper bar above mentioned.



**CONNECTION OF UGC outdoor terminations DIRECTLY ONTO LBS OR RECLOSER BUSHING IS STRICTLY FOREBIDEN: Always use a jump made of covered conductor.**



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*Connection of LBS or recloser on UGC with a covered conductor of about 70 cm long*

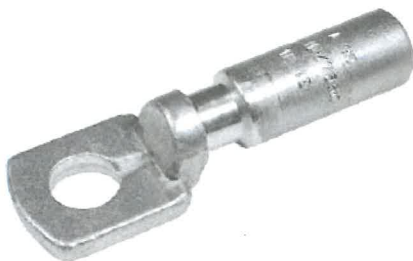
### 3.5 Connection between OHL and MV UGC

As MV UGC core is made of aluminum and OHL conductor are made of aluminum alloy, the connection between both shall be made with aluminum lugs.

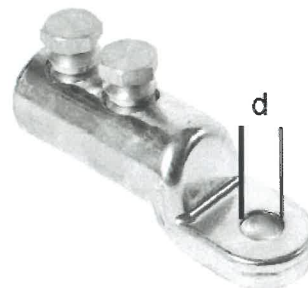
**Use bi metallic Aluminum-copper lugs between UGC and OHL are strictly forbidden.**



The following lugs are to be used with UGC outdoor termination:



*Aluminum lug with deep indent.*



*Tinned aluminum lug with mechanical tightening.*



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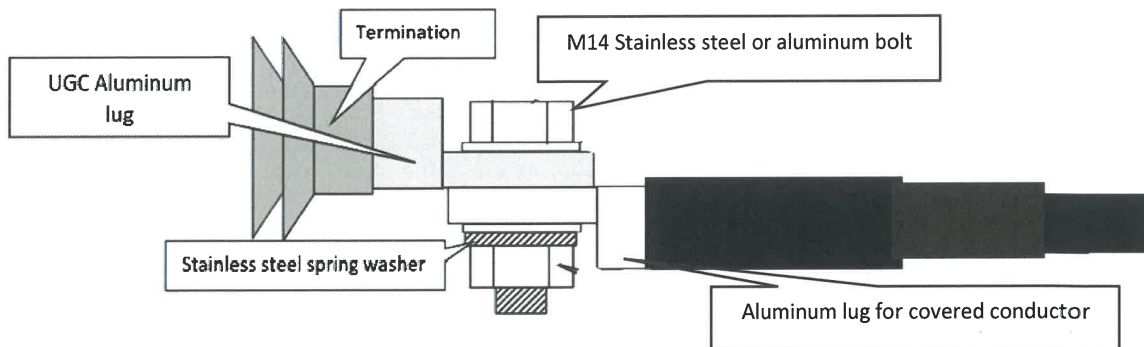
The following lug is to be used on the covered conductor:



Aluminum lugs for covered conductor.

**Installation:**

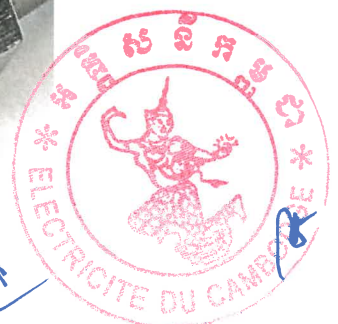
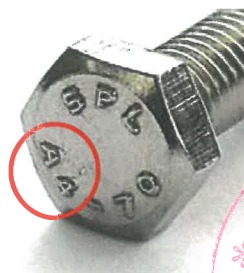
- 1/ Strictly follow the instructions for implementation of MV cable outdoor termination and terminal lug.
- 2/ Follow the instructions above for hexagonal compression of aluminum lug for covered conductor (like bi-metallic lug for bare conductor in Chapter 3.3 above).
- 3/ Connect both lugs together using stainless steel or aluminum bolt (M14), 2 flat stainless steel or aluminum washers and one stainless steel spring washer.



Connection between UGC and covered conductor

**How to recognize a stainless-steel bolt???**

- 1/ A magnet doesn't "stick" onto the bolt or washer.
- 2/ **A2 or A4** mentioned on the head or nut of the bolt.



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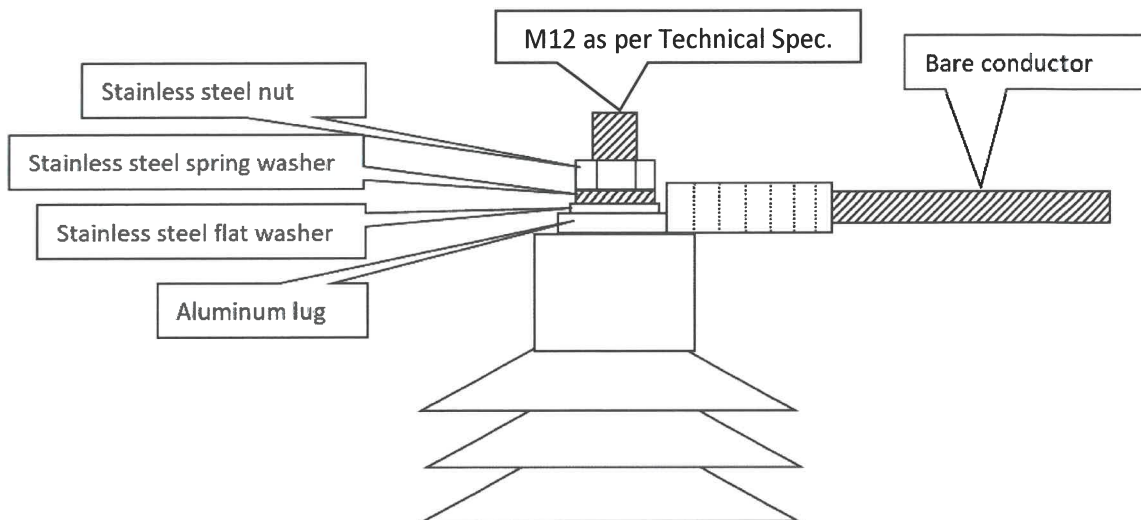
### 3.6 Connection of surge arresters

It is strongly recommended to connect surge arresters with covered conductors.

Anyway, as the terminal of surge arresters are made of stainless steel; aluminum lugs are used.



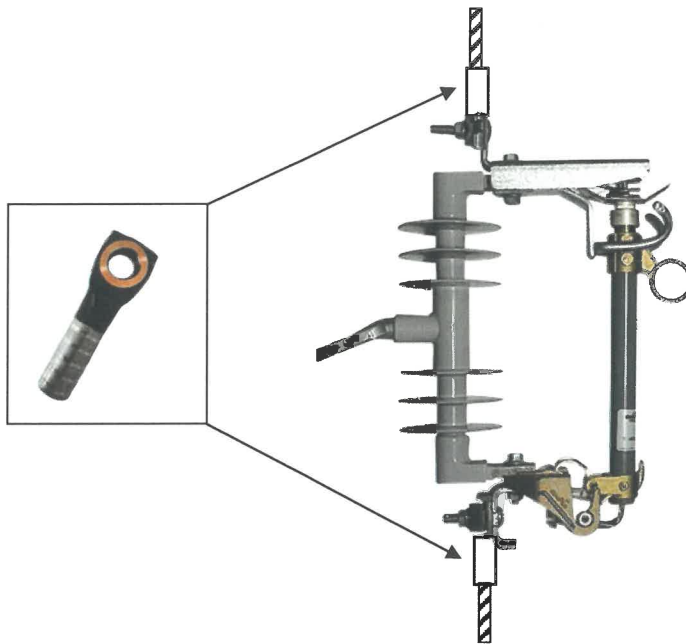
**Installation:** Please refer to the chapter 3.4 before: Hexagonal compression of aluminum end lug follows the same compression rules.



In the hypothetical case that surge arrester terminal are made of tinned copper alloy or brass, a bi-metallic alu/copper lug shall be used similarly to connection of LBS or recloser.

### 3.7 Connection of bare conductor jump onto Fuse Cut Out (FCO)

For incoming and outgoing connections on FCO, as this equipment is supplied with a tinned connector, the bare conductor shall be connected using bimetallic lugs for bare conductors. The existing connector must be removed.



#### 4 Connection with covered conductors

Covered conductors are the preferred solution for installing jumps even on bare conductors OHL for the reason of better protection against eventual phase to mass and phase/phase contact but also for a better protection of wildlife.

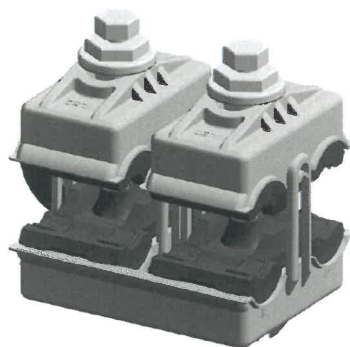
**The full wiring of PMT is mandatory done with COVERED CONDUCTORS.**

The specific accessories for covered conductors are specifically designed to avoid penetration of water inside the covered conductors by a gasket or heat shrink tube with compound inside.

##### 4.1 Tap covered conductor onto main covered conductor.

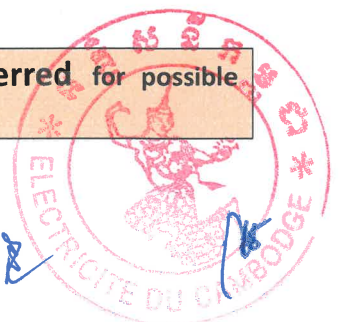
###### 4.1.1 MV Insulation Piercing Connector (MV-IPC)

The specific MV IPC is a little bit the PG clamp of the covered conductors.



*MV IPC for covered conductors*

**Connection with pin branch joint and pin connector is preferred for possible disconnection latter by live line work teams.**



*[Handwritten signature]*

**Installation:**

1. Carefully select the right location of the MV IPC on main covered conductor.
2. Fully insert the MV IPC onto the main covered conductor.
3. Insert the tap covered conductor inside the MV IPC.
4. tighten the Bolt (s) of the MV IPC with a ratchet wrench fitted with short length 6 faces socket till the shear off head is broken.

**Advantages:**

- Fully waterproof.
- Easy to install.

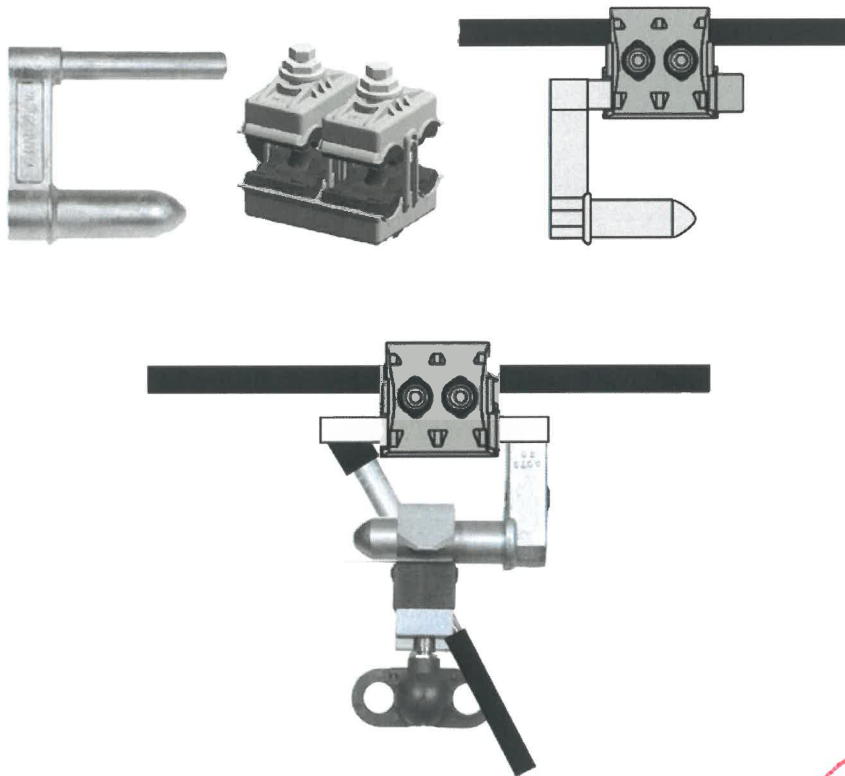
**Disadvantages:**

- Cannot be disconnected temporarily.
- If removed cannot be re-used and the pierced covered conductor must be repaired and protected from water penetration

**4.1.2 Pin branch joint for covered conductor**

The connecting equipment is a pin branch joint for bare conductor in association with a pin connector for covered conductor.

The pin branch joint for covered conductor is similar to the pin branch joint for bare conductor but the PG clamp is replaced by a **specific Insulation Piercing connector** able to pierce the covering of the covered conductor.

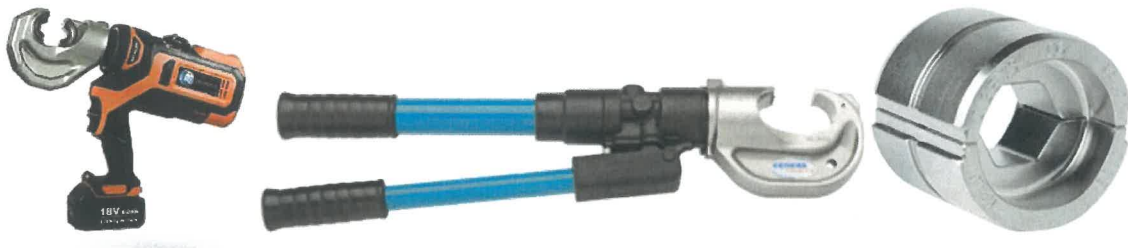


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**This technical solution is strictly dedicated to connection of tap spur (covered or bare onto a main covered conductor line) because designed to be disconnected and connected again many times by Live line work.**

**Installation:**

1. Carefully select the right location of IPC on main covered conductor.
2. Fully insert the IPC onto the main covered conductor (Piercing side).
3. Insert the Pin branch inside the IPC.
4. Tighten the Bolt (s) of the IPC with a ratchet wrench fitted with short length 6 faces socket till the shear off head is broken.
9. Cut the tap covered conductor at the right length and remove the covering on the length of the tube of the pin connector plus 1 cm.
10. Insert the conductor in the tube of the pin connector. The end of the conductor must be visible.
11. The bi metallic lugs for bare conductors are hexagonally compressed onto the conductors using a 12 tons minimum hydraulic press.



The following regular hexagonal dies are used:

Conductor cross-section	Mandatory die (mm)
35 mm <sup>2</sup>	12,0 (E 120)
70 mm <sup>2</sup>	17,3 (E173)
150 mm <sup>2</sup>	23,0 (E230)
185 mm <sup>2</sup>	25,0 (E250)
240 mm <sup>2</sup>	28,0 (E280)

Use of 200 kN press with large dies is strongly recommended for 185 and 240 mm<sup>2</sup>.

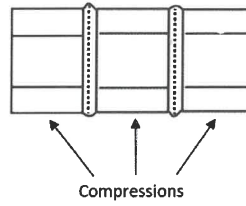


**Nevertheless, die references are checked before starting the compression.**

12. Compress the tube of the pin connector starting by the pin connector body side of the tube. **2 compressions MINIMUM depending on the cross-section.** Compress between the marks on the tube. **Keep about 2 mm between the hexagonal compressions.**

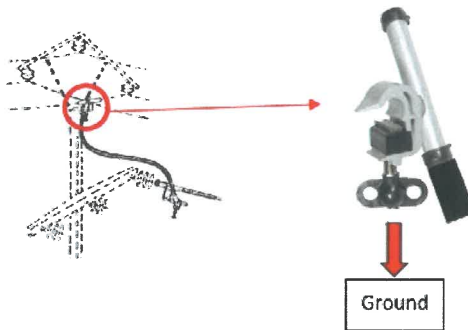


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13. Verify the correct position of gaskets or heat the heat shrink tube and cap.
14. Install the pin connector onto the pin keeping the **plastic ball protecting the ring in the direction of the ground**.
15. Tight the bolt of the pin connector using **ratchet wrench with short 6 faces socket** till the bolt head shear off.

**Do not remove the plastic ball and do not tight more the pin connector.**



#### 4.2 Connection of covered conductor onto LBS, Recloser VT, CT, MV disconnecting switch and outdoor transformer

This connection is the same than in chapter 3.4. Only the bi-metallic lug for bare conductor is replaced by bi-metallic lug for covered conductor as follow.

The installation rules are the same.



*With gasket*



*with heat shrinkable tube*



+



2

### 4.3 Connection between covered conductors OHL and MV UGC

This connection is the same than in chapter 3.5. Only the lug for bare conductor is replaced by aluminum lug for covered conductor as follow.

The installation rules are the same.



*With gasket*



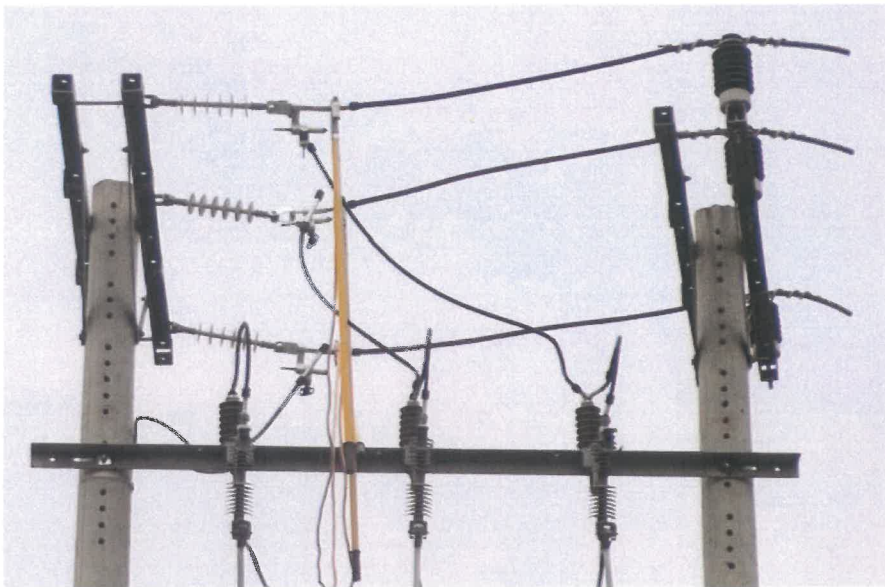
*with heat shrinkable tube*



### 4.4 Connection of PMT onto covered conductor OHL

#### 4.4.1 There is double anchorage with tie termination with pin

In that case, the PMT (jumpers between OHL and surge arresters) is connected by using a pin connector for covered conductor onto the pin of the tie termination.

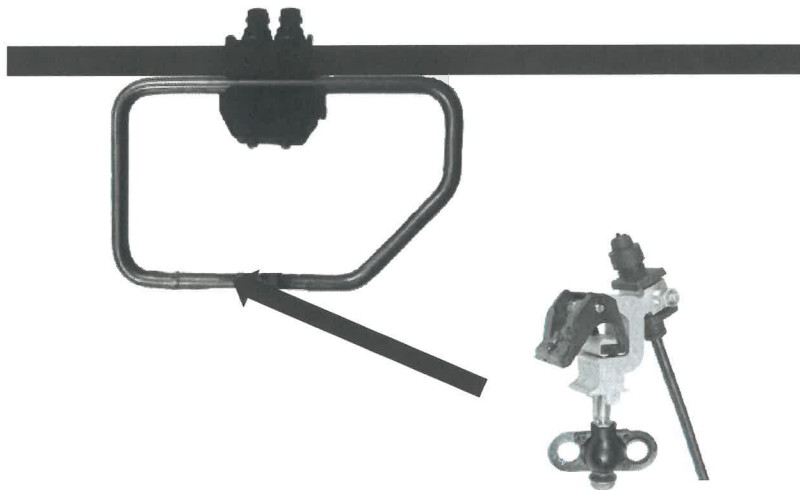


Installation of pin connector: see above

#### 4.4.2 There is no double anchorage but only line post insulators

In that case, MV IPC plus bail associated with a specific hand/ring connector shall be used. This allow the disconnection of the PMT for maintenance by LLW teams.





Installation is similar to MV IPC and hand/ring connector above.

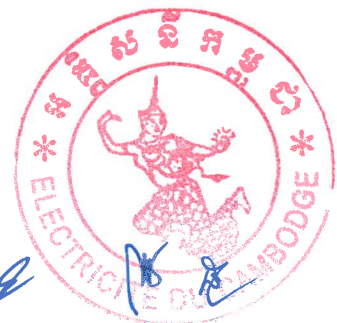
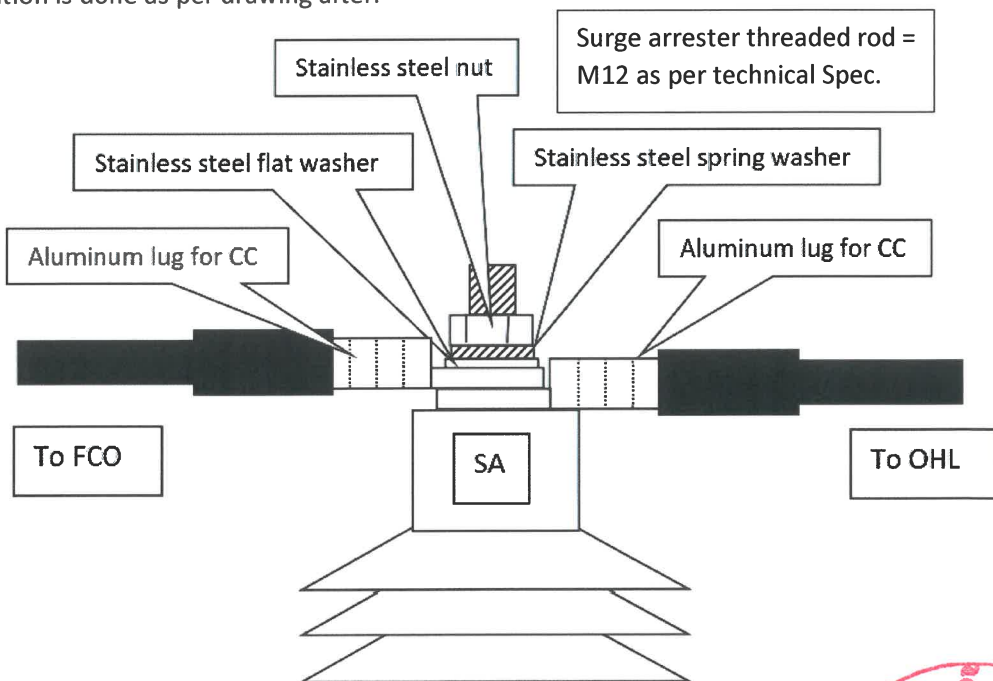
**4.5 Connection of PMT surge arresters**

On PMT, it is strongly recommended to connect surge arresters with covered conductors.

Anyway, as the terminal of surge arresters are made of stainless steel: 2 aluminum lugs for covered conductors are used (see pictures afore).

**Installation:** Please refer to the chapter 3.4 afore: Hexagonal compression of aluminum end lug follow the same compression rules.

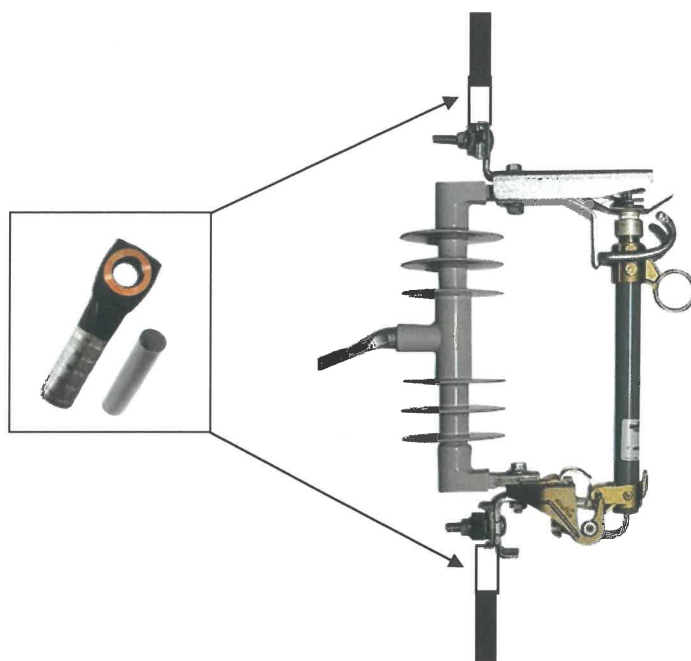
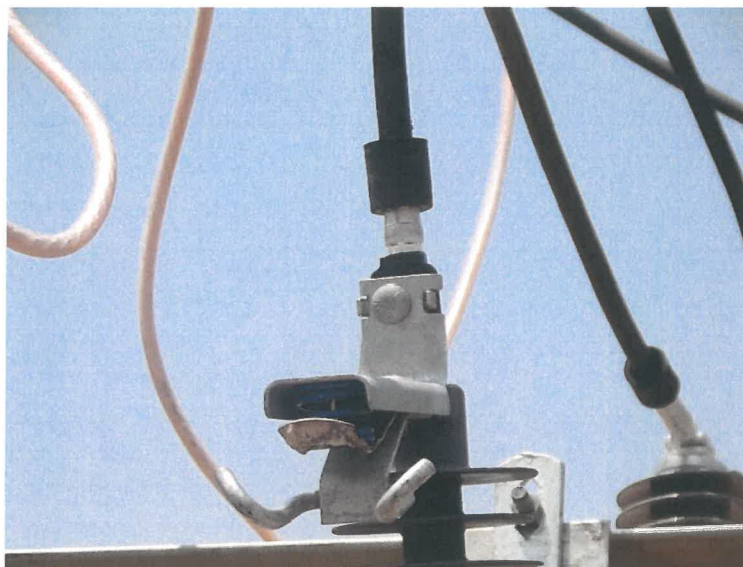
Installation is done as per drawing after.



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#### 4.6 Covered conductors on Fuse Cut Out

The connection of covered conductors on FCO is done like for bare conductors' installation by using bimetallic lugs for covered conductors. The existing connector must be removed.



*Installation of FCO with covered conductors*



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