INSTALLING LARGE ALUMINIUM CABLES

A guide to the installation and termination of large aluminium cables provided by the NECA FOUNDATION for trade use

This presentation includes background information to enable you to do reliable terminations of large aluminium cables.

national electrical and communications association

SOME IMPORTANT GENERAL INFORMATION

Aluminium cables have been in use for many years but have suffered from a reputation for unreliable connections due to incorrect termination methods.

This information focuses only on larger cables that are to be installed in buildings and/or underground wiring systems. The extensive use of aluminium cables in overhead aerial systems has become the industry norm due to the development of insulation displacement connection devices that ensure reliability of connections.

SOME IMPORTANT GENERAL INFORMATION

When compared to large copper cable, aluminium is generally more cost effective, lighter and more malleable. However for a given current carrying capacity, due to its lower conductivity, aluminium cables will be larger in size than copper cables. In general, regardless of the increase in cable size for a given current carrying capacity, and the more expensive bimetal lugs, aluminium is generally very cost competitive. The requirement for (bulkier) bimetal lugs means that larger connection spaces are required in switchboards for terminating aluminium cables. The greatly decreased weight of aluminium cable can lead to cost savings in the cable support (tray/ladder) system and fixings. As a general rule of thumb, dependent on cable market conditions, aluminium may not be cost competitive with copper for cables up to 35mm^2 for wiring within buildings, due to the need for more expensive bulky lugs, bulkier cable, and reduced switchboard room for circuit breakers etc. For cables greater than 35mm^2 the cost savings become greater as the cable size increases. **At the time of writing (2022), the cost of large aluminium cabling compared to copper will be less than half, making aluminium very cost competitive**.

A further consideration for the use of aluminium cables in place of copper cables is that the world supply of aluminium ore is plentiful compared to copper ore, relieving pressure on the available supply of copper.

SOME GENERAL KNOWLEDGE

All metals, when exposed to oxygen (air) form an oxide skin on the surface of the metal. In the case of chemically active metals like aluminium, this happens very quickly. In most metals (not iron/steel) once the oxide skin has formed the oxidation process is slowed dramatically due to the oxide skin preventing further contact with free oxygen. Lustrous (shiny) aluminium and copper have a thin oxide skin in place which is not easily visible. In the case of copper, the thin oxide skin has a relatively low impedance. In the case of aluminium, the oxide is hard and close to being an insulator. **Consequently, even shiny aluminium cable requires special techniques to overcome the effect of the oxide layer/skin and produce a reliable low impedance connection.**

When different metals are connected, in the presence of oxygen (air) a chemical process called electrolysis occurs. The variance in the chemically active nature of the two metals effects the rate at which this takes place. Aluminium and copper vary widely in chemical nature, making electrolysis a significant problem in electrical connections. The presence of electric current flow greatly accelerates the process of electrolysis, and the corrosion it incurs, compounding this problem.

When electrolysis occurs, the more chemically active of the metals will be corroded, with the less chemically active metal being protected from corrosion. This is used to protect steel (iron) by coating it with zinc, a very chemically active metal. In a copper/aluminium connection the presence of copper will accelerate the corrosion of the aluminium, producing a layer of non conductive aluminium oxide. The previous practice of fitting aluminium lugs to copper gear (switch gear, bus bars etc) with paste for protection against corrosion has proved to be unsuitable for long term use, as the paste dries and oxygen penetrates the connection.

The use of bimetal lugs solves the problems associated with connecting aluminium cable to copper and brass materials such as copper cables, switchgear, bus bars etc. The wide range of bimetal lugs is easily studied by researching manufacturers web sites – there is a bimetal lug available for almost all applications.

Bimetal lugs have a copper tag for connecting to switchgear, bus bars etc, and an aluminium tunnel for connecting to the aluminium cable. Thus connections are copper to copper and aluminium to aluminium.

The two metals in a bimetal lug are joined by friction welding in an argon atmosphere, producing a join that is structurally strong and electrically sound.

Copper end of lug for connecting to switchgear etc

Aluminium tunnel end of lug for connecting to aluminium cable

The table provides some comparisons between copper and aluminium cables.

As a general guide this table focuses on cables larger than $50mm^2$. For cables smaller than this, the cost of bimetal lugs, extra space requirements for connections, relative weight of copper cables per metre, etc means that aluminium may not be as cost effective. Each project should be judged on its own merits.

TOPIC	COPPER CABLE	ALUMINIUM CABLE
Weight	Copper is approximately three times heavier than aluminium. Allowing for the impact of insulation copper cabling will be at least twice the weight of an equivalent aluminium cable	Significantly lighter per metre, meaning less mechanical support required. Lower labour cost for installation. At least half the weight of copper cabling for the same current carrying capacity
Malleability	Unless fine stranded conductors are used the heavier copper cable is more difficult to bend and install	Softer metal, more flexible, easier to install Not generally available in extremely fine stranded cable
Availability	More readily available, wider range of insulation types	cables smaller than 16mm2 are generally not available
Conductivity/cable size for a specific current carrying capacity	Better conductivity means a smaller cable size	Lower conductivity means that a larger size cable will be required (see ANZS 3008.1)
Cable size for voltage drop	Lower voltage drop losses may be important	Higher voltage drop characteristics means that a larger cable is required. (see ANZS 3008.1) However due to a larger size being required for current carrying capacity, voltage drop requirements are similarly attended to.

INSTALLING AND TERMINATING LARGE ALUMINIUM CABLES. CABLE INSTALLATION PHASE

Ensure that when the cable is delivered the cable ends are fitted with seals (such as heat shrink) at each end to ensure that oxygen, water, etc. are prevented from coming into contact with the aluminium conductor. These seals should be maintained at all times, including during installation, up until removal as part of the termination task**. It is essential that the cable ends are not exposed or corroded in any way until they are stripped for termination**.

DO NOT TERMINATE AN ALUMINIUM CABLE THAT HAS ANY VISIBLE CORROSION OF THE CONDUCTOR MATERIAL

Aluminium cables are installed using the same techniques as for copper cables (laid on cable tray, in conduits and ducts, clipped to surfaces, etc.)
To comply with the requirements of AS/NZS 3000, regarding anchoring of cables to prevent undue movement during fault current situations, it is best to increase the number of tie down points to allow for the effect of greatly reduced cable weight under magnetic stress environments. Saddle or tie the cable more often than you would for heavier copper cables.

TERMINATION PHASE

Use the correct crimper and die size.

The dies used to crimp aluminium lugs are different to those used for copper lugs. Eg. A die suitable for crimping 240mm^2 copper cable lugs is not suitable for crimping the same size in aluminium lugs. Aluminium lugs are much thicker in the wall than copper lugs, and the aluminium is much softer than copper and can be damaged by excess compression.

Where a bi metal link is used to join a copper cable to an aluminium cable you will need two different compression dies – one for the aluminium end of the link and the other for the copper end. Where a simple indent crimper is used (for smaller cables) you will need to adjust the crimper setting for each end.

It is essential to use the correct die/crimper setting as too much compression will stress the conductor material, and insufficient compression will not achieve the necessary merging of the conductor strands. At the completion of compression the conductor strands and the wall of the lug tunnel should be a single block of metallic conductor. Over compression will cause damage to the conductor, resulting in mechanical weakness and reduced conductivity.

This picture shows the internal face of dies for copper and aluminium cables of the same size. The difference of crimping area is obvious and critical for a correct join.

Copper die

Aluminium die

Use inhibitor paste with aluminium connections.

Inhibitor paste is a greasy substance enriched with sharp metal (zinc) crystals. As a general rule, bimetal lugs are supplied with a quantity of inhibitor paste inside the aluminium end of the lug. The bimetal lug will be fitted with a sealing plug on the aluminium tunnel to prevent corrosion of the inner walls. **Do not remove this plug until just before fitting to the cable end**.

The purpose of the inhibitor paste is twofold – it seals the entry point where the cable conductor goes into the lug, and uses the sharp metal crystals to punch through any fine oxide on the conductor and lug tunnel to provide better connection between the two surfaces.

BIMETAL LUG WITH INHIBITOR PASTE INSIDE THE BARREL OF THE LUG

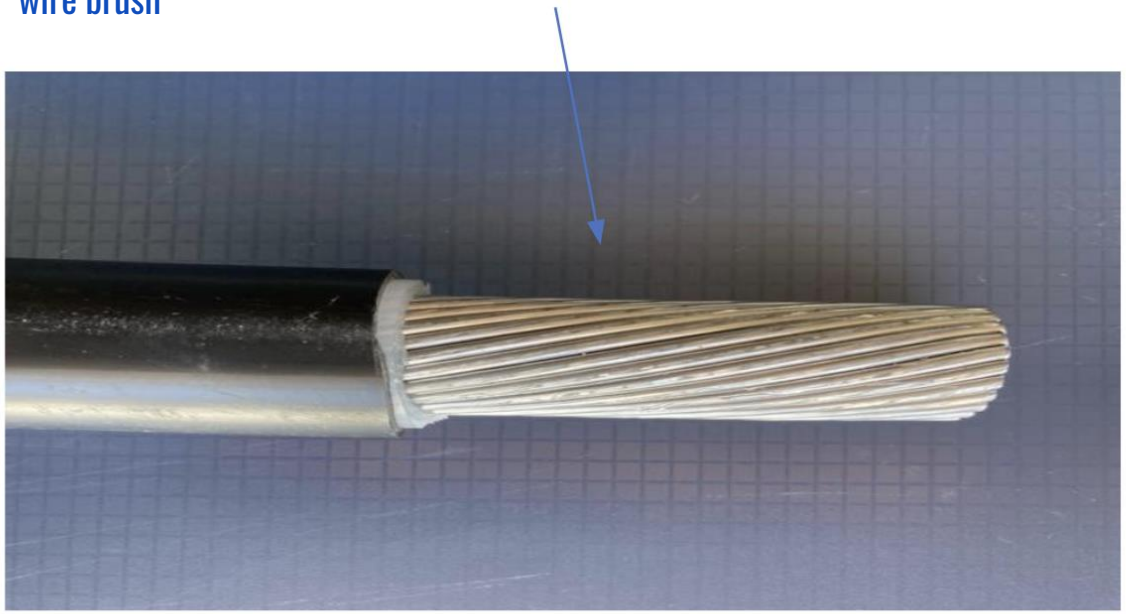
The red plastic cap is removed just before fitting to the cable end

Prepare the cable end for fitting to the lug.

Do not strip the cable end until just prior to fitting the lug. Using the lug for a guide, strip just enough insulation to allow the conductor to reach to the end of the lug tunnel. It is important that the gap between the cable insulation and the lug is as small as practical.

Inspect the aluminium conductor material for oxidization. The aluminium should be lustrous (shiny) with no easily visible corrosion. Using a stiff wire brush, scratch the conductor material to remove any existing oxides. **Do not use sand paper or emery paper**, etc., as these leave mineral deposits embedded in the aluminium, causing resistance in the joint. Fit the lug on the cable end, turning it to assist the spread of inhibitor paste on and into the cable strands. Remove the lug and use the stiff wire brush to scratch the aluminium again, while the inhibitor paste seals the material against any further corrosion.

Clean shiny aluminium, suitable for connecting after scrubbing with a wire brush



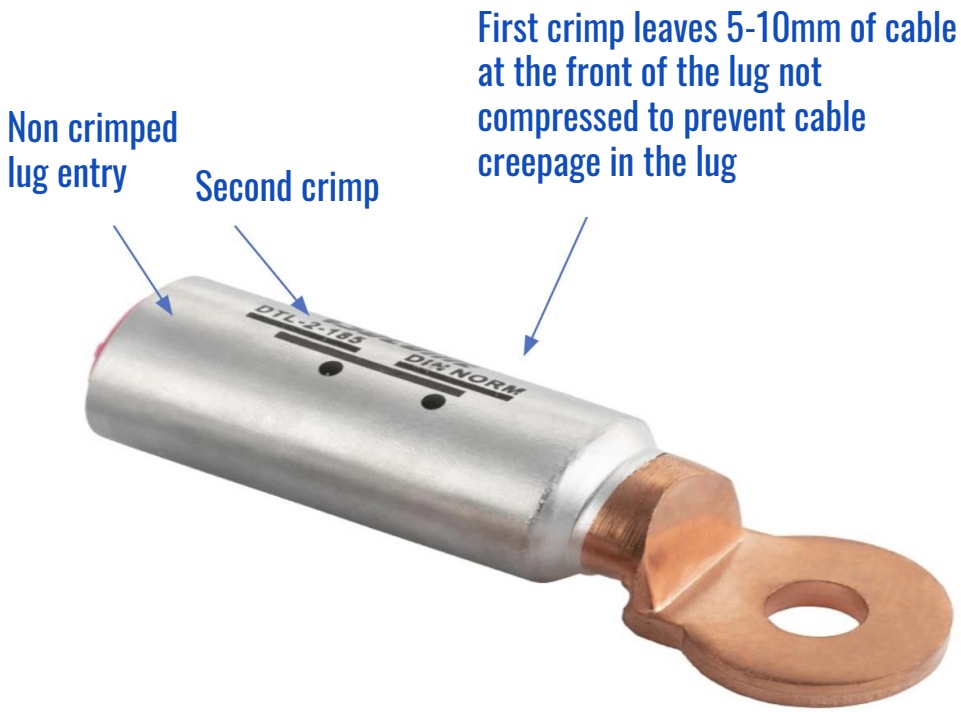
Use correctly sized and rated heat shrink to seal the lug against the entry of oxygen over time, to provide a long lasting reliable connection.
Heat shrink is made in two types – molecular stretched (for electrical work) and solvent based (for short term covering of products). Solvent based heat shrink continues to shrink and dry out, eventually leading to cracking and breakdown. Most lower cost heatshrink is solvent based and not suitable for electrical work.
Better quality heatshrink has lettering denoting the stretched size and the smallest size that it can shrink to. Ensure you select a heatshrink that will fit over the lug and shrink to provide a tight fit to the cable insulation and the barrel of the lug.
The heatshrink pictured below has a maximum (stretched) diameter of 63mm and a minimum diameter (after being shrunk as far as possible) of 19mm. This size would be suitable for cables and lugs with a diameter of more than 19mm.

Crimping the lug onto the cable end

Ensure that the correct crimping die is fitted to the crimper. This must be the correct size for the aluminium cable (not a copper die) For hand operated crimpers, when terminating smaller cables, ensure that the crimper is set at the correct point for the aluminium cable size.
Strip the cable end to a length that fully reaches into the barrel of the lug. You will need to remove and reinsert the cable in order to displace inhibitor compound and allow the cable to fully enter the lug.
Make a temporary mark on the lug that is approx. 15mm back along the lug from the cable end. This will be where the first crimp is done. Some lugs (as pictured below) have marks to center the die on.

Performing the first crimp back from the end of the conductor material produces a non compressed lump at the cable end, anchoring it in the lug and preventing the cable conductor from creeping out of the lug during further compressions. This also avoids stressing the joint between the aluminium and copper parts of the lug.
Further compressions are then performed, working toward the lug entry point. This allows excess inhibitor paste to be squeezed out of the lug, rather than being trapped inside the lug, affecting compression of the conductor materials.

Avoid crimping the entry point of the lug as this creates a mechanical weakness at the entry point.



Completing fitting the lug to the cable

After crimping is complete, remove any excess inhibitor compound that has been squeezed out of the lug during compression by simply wiping with a rag or tissue.
Fit heat shrink insulation (preferably exterior grade) over the lug, and at least 25mm over the cable insulation, and set the insulation in place by heating. This will seal the gap between the cable insulation and the lug, ensuring that oxygen cannot penetrate the joint, preventing any future corrosion of the aluminium.
The lug is now ready to connect to the switchgear, as with any other type of lug.

This information, and the following video are focused on the termination of large single core aluminium cables, as these are the most likely to be used in general building wiring. There are a great many other types of cables that require specialized knowledge to correctly terminate.
If you need information and training in the installation and termination of other cable types, such as solid core cables, neutral screened, high voltage, paper/ lead sheathed, etc, NECA provides training in the knowledge and techniques required to correctly work with these cable types.

NECA Member Services

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VIDEO OF FITTING A BIMETAL LUG TO A 300MM^2 ALUMINIUM CABLE.

Watch this video to better understand the termination of a large aluminium cable: