www.de-online.info

Der Elektro- und Gebäudetechniker

Hüthig & Pflaum Verlag GmbH & Co.
Fachliteratur KG
Lazarettstraße 4, 80636 München

de Special 22/2008

ELECTROINSTALLATION:

# Accurately connecting copper and aluminium

ORGAN DES ZVEH

**IN BRIEF**

Copper and Aluminium conductors are difficult to connect to each other. It is therefore necessary to avoid the ingress of moisture at all costs. For these applications special cable lugs are needed and accurate operating procedures should be adhered to.

# Accurately connecting copper and aluminium

**Copper due to its outstanding electrical properties are always the first choice when selecting a conductor for an electrical connection. A practicable alternative in many cases is aluminium particularly because of its low weight and easy application. In practice however the electrician can find it challenging to connect both these materials in a professional manner.**

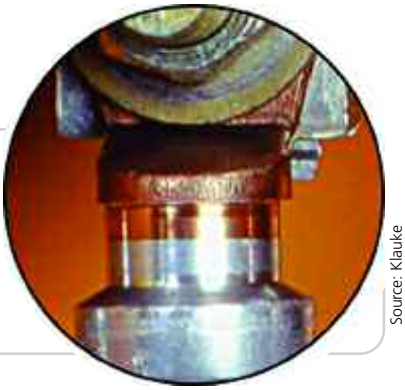
A copper-aluminium connection is used for instance in an industrial estate where local business use copper supply cables which are then fed off an aluminium ring main. But also in electrical substations it is necessary to connect aluminium conductors to copper bus bars. The main problem here is that connecting aluminium and copper is not straightforward. To ensure a safe and correct connection the use of special aluminium/copper cable lugs and connectors are essential. **(Picture 1)**.

## Aluminium-Copper: A problematic connection

Generally aluminium is a reactive material that oxidizes easily, but in practice it has proved to offer good corrosion resistance. This characteristic is due to a chemical reaction that takes place when in contact with atmospheric oxygen resulting in a very thin but also very resistant oxide layer being formed. (oxide barrier)

Source: Klauke

**Picture 1: Use of an incorrect crimping die and/or an incorrect crimp will result in an over compression (right) or an under compression (left) and in the worst case in fire.**



Source: Klauke

**Picture 2: The construction of Al/Cu cable lugs prevents any gaps which would allow the accumulation of liquid to take place which would start the oxidation process.**

When metals are connected to those with a higher electrical potential such as copper in the presences of an electrolyte (condensed water) will result in an electrochemical reaction taking place. During this process the differences caused in electrochemical potential can have a significant impact.

An electrical circuit is generated by the copper electrode (anode), the electrolyte (water) and the aluminium electrode (cathode). The voltage generated in this copper and aluminium circuit "semi metallic" state results in a short circuit.

As a result of the current generated the Aluminium surface breaks down causing the metal to electrolytically decompose. This destructive process is visible as a kind of blooming oxidation and begins already with the existence of tiny copper particles on the aluminium; this ongoing reaction itself does not cause the copper to corrode. In an electrical connection however the resistance is increased leading to increased temperatures which then in the worst case lead to a fire.

Therefore when connecting copper and aluminium it is important to ensure that no moisture can enter the connections. In an environment where moisture is present the contact points between the copper and aluminium need to be protected by using accurate operating procedures. **(see picture 2)**. Primarily this requires the use of aluminium/copper cable lugs and connectors. Due to the design of these lugs areas where moisture could accumulate and where the oxidation process could start have been avoided. For this reason aluminium/copper cable lugs and connectors are specified for the use in off-shore wind power stations.

## Aluminium/copper compression cable lugs

Leading manufacturers of high quality compression cable lugs for connecting aluminium connectors with copper bus bars **(see picture 3)** consist of an electrolytic aluminium (E-Al) compression and are joined to a copper palm (to EN 13600).

The available cross sections range from 16 mm² up to 400 mm². The field of application covers in principle all non-tension connections of aluminium cables acc. to DIN 48201, part 1, and aluminium ropes acc. to DIN 50182. Specifications and processing of alu-

minium / copper compression cable lugs are the same as those for pure aluminium versions.

Quality products manufactured by market leaders such as Klauke feature a consistent material thickness, exact diameters and correct fit are a prerequisite for ensuring high safety standards are always met. Like aluminium compression cable lugs conforming to DIN 46239, aluminium/copper compression cable lugs feature a barrier design allowing the use of oil soaked and paper insulated cables which prevents oil leakage.

### Aluminium conductors at a glance

Aluminium conductors are available in four different versions which require in some cases special processing. These are **(see picture 4)**.

- round solid conductor(re)
- sector solid conductor(se)
- round stranded conductor (rm)
- sector stranded conductor (sm)

Source: Klauke

**Picture 3: A professional connection of an aluminium conductor with a copper busbar is done by means of an aluminium cable lug and a copper palm.**

These abbreviations will be found next to other markings on all Al/Cu compression cable lugs and identify which conductors will suit the appropriate cable lug. **(see picture 5)**.

Markings on the product provide the installer with essential informations. Marking "16 KL25 150 rm/sm 185 re/se" stands for

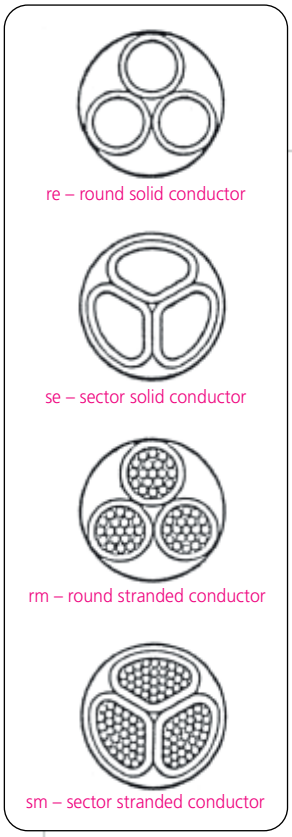
- 16: Metric bolt size for connecting bolt – size M16.
- KL: Manufacturer (in this case Klauke)
- 25: Die code
- 150: Cross section of conductor in $mm^2$
- rm/sm: for round multi-stranded and sector stranded conductors
- 185: Cross section of conductor in $mm^2$
- re/se: for round single stranded solid and single sector solid conductors

The die code also needs special consideration. For an accurate and safe crimp the die reference should be the same as that shown on the cable lug. The die code can be seen on the die face as a mirror image so that after compression the die code is visible on the cable lug for final control and inspection.

For an accurate processing of Al/Cu compression cable lugs it is generally

recommended to use hexagon crimping dies acc. to DIN 48083 part 4. In order to ensure an accurate and professional crimp avoiding over or under compression is the use of appropriate crimping tools. Poor crimps can result in an increase in joint resistance and temperatures that can lead to fires. To prevent such issues Klauke solely recommend using the manufacturers crimping tools to crimp their cable lugs.

For instance the special crimping dies for aluminium have a crimp width of 7 mm, i.e. 2 mm wider than the crimping dies for copper cable lugs and connectors. This, however, only applies to 60 kN crimping dies. The reason for this is that dies with a larger crimp width are able to connect a wider conductor surface area with the cable lugs and balance the poor conductivity of aluminium. To easily identify which die should be used, Klauke manufactures aluminium dies in a silver colour while dies for copper are yellow-gold coloured.




Source: Klauke

**Picture 4: Various shapes of aluminium conductors**

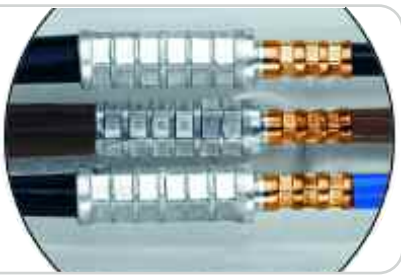
Source: Klauke

**Picture 5: The markings on the cable lug provide information relating to the crimps, the manufacturer, cross section and allocation of cable.**

Source: Klauke

**Picture 6: High quality aluminium cable lugs come with a special compound which improves the contact properties and ensures a perfect electrical connection.**

**Picture 7: Aluminium and copper conductors with different cross sections are being connected using reduction sleeves.**



Source: Klauke

Source: Klauke

**Picture 8: Normally the aluminium section (right) has a larger diameter than the copper section (left) to equalize the poor conductivity of aluminium.**

### Connecting compound for aluminium connecting material

All cable lugs and connectors for aluminium conductors come with a special compound **(see picture 6)**. This aggravates the non-conductive oxide layer which is quickly formed on the surface. This compound improves the contact properties and enables a perfect electrical connection, and also prevents further oxygen penetrating the contact joints where further oxidation could take place. To maintain the functional capability of the compound all leading brand cable lugs are sealed with a plastic plug to prevent the compound from drying-out and leakage.

### Al/Cu Connectors

For a correct connection of aluminium and copper conductors leading manufacturers such as Klauke offer reduction compression joints with a cross section range from 10 $mm^2$ up to 300 $mm^2$. **(see picture 7)**. These products serve mainly the reconstruction of power lines, i.e. non-tension connections of aluminium conductors acc. to DIN EN 60228 resp. aluminium wires acc. to DIN EN 50182 with copper cables acc. to DIN 48201, part 1 and copper conductors acc. to DIN EN 60228. These compression joints consist of interconnected aluminium (E-Al) and copper parts (acc. to EN 13600).

Normally the aluminium part of the cross section has a much larger diameter **(see picture 8)** to compensate for the poor conductivity of aluminium. As with the cable lugs here too plastic plugs are used to prevent drying-out and leakage. Important: The use of Al/Cu compression joints requires that the correct processing guidelines for copper and aluminium are observed.

Consequently the aluminium section needs to be crimped like an aluminium compression cable lug (see above). Characteristically for Al/Cu compression joints are the different crimping marks which are 7 mm on the aluminium section and 5 mm on the copper part for crimping dies up to 60 kN.

Source: Klauke

**Picture 9: When used in the ground cast-resin joints protect the connections against moisture. It is important to consider that the connection is not subject to bending to avoid the risk of fracture.**

The procedure for the copper section is absolutely identical as on copper compression cable lugs. The crimping marks on the product give detailed information as to origin and application of the Al/Cu compression joints. The marking "KL14 50 rm/70 re/se" signifies

- KL: Manufacturer (in this case Klauke)
- 14: Die code
- 50: Cross section of designed conductor in $mm^2$
- rm/sm: for round stranded and sector stranded conductors
- 70: cross section of solid conductor in $mm^2$
- re/se: for round solid and sector solid conductors

The marks on the copper section also indicate the correct procedure. The standard suggests crimping dies acc. to DIN 48083 part 1, 3 and 4 for solid-, fine and fine stranded conductors; for braided round wires the standard refers to specifications of the manufacturer. Generally Klauke recommends using hexagon crimping dies acc. to DIN 48083 part 4 for processing the copper section of their compression joints.

Advice: When using crimp connections in the ground it should be strictly observed that the connecting joints should be protected against moisture. **(Picture 9)**. For this application Klauke recommends use of cast-resin joints.

For the application of Al/Cu compression joints and cable lugs the following should also be considered: These products should not be exposed to bending stresses which could fracture the contact point. Application on overhead lines is therefore excluded.

## Preview: Crimp profiles at a glance

With a further feature story in one of the next issues of "de" we close the series on cable lugs and connectors. This article will deal with the various crimp profiles which correct selection depends very much on materials and cable types used.

Lutz Remmel, Product Manager
Electrical connecting systems,
Gustav Klauke GmbH
www.klauke.com

## MEHR INFOS

**Contribution on this issue**

**http://www.de-online.info/archiv/2008/01-02/index.php?Page=elektroinstallation04.html**
- Which cable lug for which application?, "de" 1-2/2008, S.33

**http://www.de-online.info/archiv/2008/08/index.php?Page=elektroinstallation02.html**
- Cable lugs for special applications, "de" 8/2008, S.27

**http://www.de-online.info/archiv/2008/17/index.php?Page=elektroinstallation02.html**
- Best Practise for Installation of Aluminium Connectors, „de" 17/2008, S.26

**Book on this issue**

Schmolke, Herbert: Selection and design of cables and conductors 2007.2, revised and extended edition. 120 pages, paperback, with CD Rom, 18€,
ISBN 978-3-8101-0263-8,
**www.de-online.info/ shop/fachbuecher/schmolke_kabel.html**

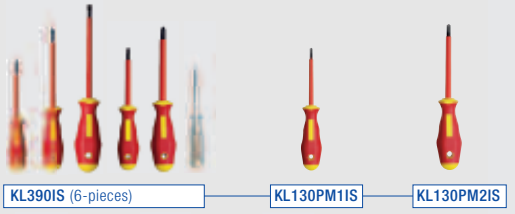
BRDESONDER222008GB 10.000 02/09 I

KLAUKE®

# All in one. One for all.

## Engineers professional tool-bag

**The quality bag comes with genuine Klauke tools.**



KL390IS (6-pieces) — KL130PM1IS — KL130PM2IS

KL044200IS — KL050205IS — KL020165IS

KL745HK — KL710 — KL403

The ideal companion for electricians, fitters or installation engineers: The **Klauke Engineers professional tool-bag** has space for the complete tool range and provides safe storage of laptop, documents, mobile phone or business cards. The clever compartmentation as well as removable single components turn the tool-bag into a very flexible system meeting all day-to-day requirements.

**For more information please visit www.klauke.com**

*Verbindungen mit System*
*The Power of Partnership*

KLAUKE®
A Textron Company