Techniques to Achieving Good Electrical Connections

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Mr. Ng Choon Guan has been involved in various engineering works since 1969 related to electrical and engineering including electrical conductor jointing and termination products and tools.

EXECUTING A GOOD ELECTRICAL CONNECTION

A good electrical connection is one that conducts current safely at a low temperature, resulting in energy saving, and can last for many years (30 years or even longer).

There are generally three important factors in executing a good electrical connection:

- Type of Connectors
- Crimping Tools and Dies
- Workmanship (Quality of work)

TYPE OF CONNECTORS

Connectors are either made of copper or aluminium; both have their own respective attributes.

COPPER CONDUCTORS

Copper connectors are used to join or end a copperconductor. These connectors are made of copper that comes in a high conductivity copper tube of suitable thickness. A lug will have sufficient palm area and barrel length, while a link will have sufficient link length, and is plated with tin to prevent corrosion. Copper has many grades. For electrical purposes, Electrolytic Copper (E.Cu) with purity of 99.9% and conductivity of 99% I.A.C.S. is always used.

Using low quality, recycled copper is not recommended, as the conductivity is only 50% to 85%. Referring to the comparison chart between compliant and non-compliant cable lugs according to MS 1540:2002 (Chart 1), for the same size of cable lugs, when conductivity is low and the wall thickness is less, the current capacity of the cable lug is greatly affected.

In the example of the 300mm² cable lug, the current capacity for the compliant lug is 561A, as compared to 224A for a non-compliant lug. There is a 59.9% reduction in current capacity.

As for the 240mm² cable lug, the compliant lug registered a current capacity of 485A while the non-compliant lug at only 304A, a 37.2% less in the current capacity.

Currently, many types of cable connectors are imported, some of which are either not suitable foroour use or are inferior in quality. These may result in high temperature (energy loss) at connections, or even burn the connectors. The only way to prevent this is to use a standard connector. With this in mind, the Malaysian Standard was developed and obtained in 2002 (MS1540 for Cable Lug) and in 2005 (MS1779 for Cable Link).

ALUMINIUM CONDUCTORS

Aluminium connectors are used to join or end terminal of aluminium conductors. Aluminium bi-metal connectors, on the other hand, are used solely to join or terminate to copper.

	Cable Lug Compliant to MS 1540:2002	Non-compliant Cable Lug	Cable Lug Compliant to MS 1540:2002	Non-compliant Cable Lug
Size	300mm²		240mm²	
Max. PVC Wire Current Rating in 3 Phase	561 A		485 A	
Weight	299 gram	215 gram (less 28.1%)	212 gram	137 gram (less 35.3%)
Length	110.1 mm	101.5 mm (less 7.8%)	103.7 mm	91.1 mm (less 12.1%)
Wall Thickness	3.9 mm	3.2 mm (less 17.9%)	3.3 mm	2.6 mm (less 21.2%)
Conductivity	99%	57% (less 42%)	99%	83% (less 16%)
Results	Current rating is 561 A	224 A (less 59.9%)	Current rating is 485 A	304 A (less 37.2%)

Chart 1: Comparison between Compliant and Non-compliant Cable Lugs

The correct aluminium connectors to use are those with electrical grade aluminium raw material 1050 or 1350. It has purity level of 99.5%, and conductivity is at 60%. Its hardness is soft. Non-electrical grade aluminium, due to its low purity, only has conductivity of 40% to 50% or lower. Its hardness is also wrong, resulting in the aluminium cracking during the crimping process. Therefore it is important to check and insist on electrical grade material when purchasing aluminium connectors.

When it comes to conductivity, aluminium is the best alternative to copper in terms of commercial value and engineering properties. Compared to copper, the specific gravity of aluminium is only a third but its electrical conductivity is up to 60% of that of copper. Aluminium is also 70% cheaper than copper. Due to its lightweight and low cost relatively, aluminium conductors are widely used in electrical projects today.

However, when aluminium comes in contact with copper, it can cause corrosion in a short span of time, resulting in a damaged contact. Since aluminium and copper have different electrical potential and expansion ratios, the hot and cold cycle with exposure to air will increase resistance and corrode the contact. This phenomenon is known as the coupling effect.

In the past, many aluminium conductors installed broke down after a short period of use. This caused consultant engineers to shy away from approving the use of aluminium conductors, resulting in it being less popular for use in indoor electrical wiring.

However, the scenario changed with the introduction of friction welding type Bi-metal connectors. Used widely today, the Bi-metal connector is the best solution to the contact problem between aluminium and copper.

Aluminium and copper are fused in a process called friction welding. This is done by spinning aluminium and copper in a machine to allow the metals to rub against each other, producing high heat. During this stage, a strong force is applied to weld the two metals together. A good quality friction welding will seal the two metal surfaces perfectly without any airgap and this prevents corrosion on the contact. A good and sufficient welding area also contributes to the mechanical strength of the connection.

Quality Bi-metal connectors are mainly produced in Europe, with dimensions that are compliant with France standard *NS 68-S-90* titled "Connection of Aluminium Conductor Insulated Cables by Deep Indentation" and type tested to IEC 61238-1 titled "Compression and Mechanical Connectors for Power Cable for Rated Voltages up to 30kV". TNB and Malaysia have also adopted the standard and the type test.

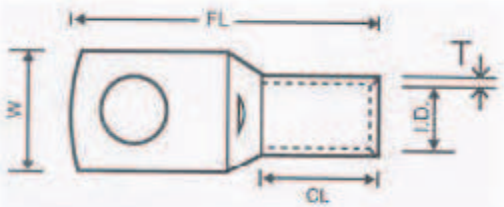
Many Bi-metal connectors are imported into Malaysia. Some are quality products but there are many inferior ones as well. Therefore it is important to select a Bi-metal connector that is compliant with the above standards and to type test it before it can be considered and accepted as safe to be installed in a project with aluminium conductors.

CRIMPING TOOLS AND DIES

The second important factor in executing a good electrical connection is to use the correct crimping tools and dies. A proper tool and die are necessary to perform a good connection. Simply buying an international branded tool is not good enough. One must consider a matching die before purchasing the tool.

The hexagon die is usually used for copper connectors. Having the right die is more important than the tools. The German "Din" standard die is not suitable for the Malaysian Standard applications. A customised die suitable for Malaysian connectors is required. Connector manufacturers will always recommend the right size of die and this is usually shown in the catalogue of connectors as illustrated in Chart 2 below:

Low Voltage Cable Lug for Copper Conductor
Crimp Type for Hexagon and Indent Die
High Conductivity Copper: 99% I.A.C.S
Copper Purity: 99.9%
Finishing: Tin Plated
"Type Tested to MS 1540:2002"



Conductor Size-Stud Hole	FL	CL	ID	T	W	Crimping Tool	Hexagon Die A/F	No. of Crimps
2.5mm² – M5	19	7.0	2.3	0.8	8.0	CK-10	Indent	1
35mm² – M5	42	15.0	8.4	1.2	16.0	CP-240	9.1	1
185mm² – M5	78	32.0	19.0	2.6	35.0	CP-240/CP-630	20.0	2/1
630mm² – M5	143	52.0	34.5	5.1	64.0	CP-630	37.0	3

* All dimensions in mm

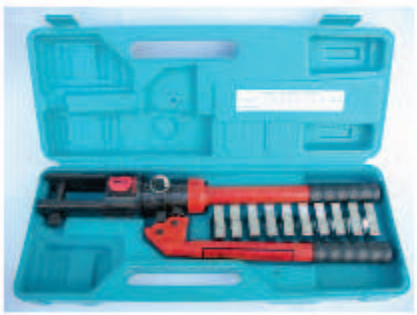
Chart 2: Crimp Type for Hexagon and Indent Die

For aluminium connectors, an indent die is commonly used. There are three advantages in using a constant volume containing die.

- The connector will not bend after crimping
- The length of connector barrel is controlled after crimping
- Crimping position by index on the container

Selection of Crimping Tool and Die:

There are many type of crimping tools in the market today, which includes small mechanical tools, hand operated hydraulic tools and electric/battery operated tools. It is important to choose the right tools. Choosing a tool which can crimp from 16mm² to 1000² is not practical due to its weight, size and cost. The correct way is to select a small hand tool for 1.5mm² to 10mm² connectors, a mid-range hydraulic tool for 16mm² to 240mm² connectors and a big hydraulic tool for connectors up to 630mm². For big connectors that are 300mm² or larger, an electric pump is strongly recommended so that it is easier for the installer. It is also important to make sure the installer crimps the connectors according to instructions.



16mm² to 240mm² Hydraulic Tool

185mm² to 630mm² Hydraulic Tool

1.5mm² to 10mm² Hand Tool

16mm² to 240mm² Hydraulic Indent Tool

Battery Tool

300mm² to 630mm² Hydraulic Indent Tool

There are various schools of thought on whether the deep-indent type compression is superior to the hexagon type compression. However, results from scientific experiments show that there is absolutely no difference in using the hexagon die or deep-indent die, when matching connector and die are used. Countries like USA, Australia and Germany all use the hexagon die for aluminium connectors, while France, Italy and Malaysia use the indent die.

For copper connectors, current global trend favours indent dies for small conductors and hexagon dies for larger conductors. For aluminium connectors, deep-indent dies are used for all conductors. In fact, indent dies are getting more popular for aluminium connectors because of the advantages in using a containing die.

Manufacturers of electrical compression terminals and joints will have a good understanding of the best way to compress their own connectors; therefore it is recommended to approach them for advice when necessary.

WORKMANSHIP (QUALITY OF WORK)

The human factor is equally important in achieving a good electrical connection. It is vital that wiremen and electricians work according to the manufacturer's instructions. After removing the insulation and cleaning the conductor (if necessary), the wireman or electrician plays an important role in selecting the same size connector and die to execute a good full crimp by using the right crimping tool. For bigger connectors, crimping should be done more than once, or according to manufacturer's instructions as shown in the connector products catalogue.

In Malaysia, precise tools and dies are now easily available. Therefore, when quality connectors are selected, and work is carried out in compliance to standard procedure, all joints and terminations will easily achieve good electrical connections.

CONCLUSION

The Malaysian Standard on cable lugs and links is meant to standardise and prevent the use of inferior and unsuitable cable lugs in the connection of conductors to electrical equipment. The guidelines for overall installed cable lugs dimensions were drafted with due consideration to the current practices in the industry and the common usage of crimping tools and dies.

To avoid unnecessary problems, the Malaysian Standard should be specified when purchasing cable lugs or cable links. Engineers and planners have the responsibility to specify cable lugs or links that comply with the Malaysian Standard. Users too, should insist on buying the right cable lugs and links so that the connections will be at an optimum temperature. This will avoid dangerous applications and help ensure electrical installations are safe. The use of non-matching die for cable lugs, cable links, and sector copper conductor in electrical installation can be prevented if users are aware of the right standard equipment being used for standard Malaysian cable lugs, links and connector (either copper or aluminium).

Last but not least is workmanship, where the right procedure of crimping must be followed to ensure that the cable lugs, links, connectors and crimping equipment will result in achieving good if not excellent electrical connection. ■

IEM DIARY OF EVENTS

Title: Talk on Design & Construction of Stabilised Subgrades for Malaysian Roads

7 April 2016

Organised by : Civil and Structural Engineering Technical Division
Time : 5.30 p.m. – 7.30 p.m.
CPD/PDP : 2

Title: Talk On "A Simplified Equation for Voltage Drop"

9 April 2016

Organised by : Electrical Engineering Technical Division
Time : 9.00 a.m. – 1.00 p.m.
CPD/PDP : 0

Title: Professional Interview Workshop on Enhanced PI Process

9 April 2016

Organised by : Standing Committee on Examination and Qualification
Time : 9.00 a.m. – 1.00 p.m.
CPD/PDP : 2

Kindly note that the scheduled events below are subject to change. Please visit the IEM website at www.myiem.org.my for more information on the upcoming events.