Charging Leads for Tesla Model S and X

January 2017

Disclaimer

This document is provided only for information and describes the method and materials used by the author; it does not purport to give detailed or definitive instructions and the author does not accept any liability for your work. It is your responsibility to ensure that any leads that you make up are safe and that the circuit that you use includes appropriate safety devices.

Table of Contents

List of Figures

Charging Leads for Tesla Model S and X

1 Background

Tesla cars sold in the EU are designed to be charged using a 16A three phase supply delivering 11kW because, in most of continental Europe, most houses get a 3-phase supply. High-power items such as water heating, domestic heating, ovens, swimming pool pumps etc. usually run off the 3-phase supply. Low-power items such as lighting and general domestic sockets run off one of the three phases. Most houses will have, or can easily have fitted, a 3-phase socket supplying 16A (11kW).

In the UK, however, most houses get a single-phase supply. High power items such as ovens are supplied by dedicated high-current circuits.

The UMC enables you to charge the car from a 3- or single-phase supply by means of adapters. In the UK, a 32A single-phase (blue) adapter is provided whereas, on the Continent, the UMC comes with a 16A 3-phase (red) adapter. In all cases, an adapter is also provided that lets you connect the UMC to a domestic socket; for the UK, the adapter terminates in a 13A plug but there are several types for the various continental countries (see below).

For the UK, in order to allow 32A single-phase charging via the UMC (designed for 3-phase supply), the blue UMC adaptor splits the live current into three parts to keep each current stream below 16A. The neutral wire of the UMC is larger than the live wires to handle 32A safely.

One of the most important features of the UMC adaptors is that they automatically tell the car how much current to draw:

Blue adaptor:	32A single phase
Red adaptor:	16A (1, 2 or 3 phases as long as L1 is live)
Schuko Euro adaptors:	13A (rather than the Schuko standard of 16A, for safety)
British 13A adaptor:	10A (rather than the BS1363 standard of 13A, for safety)

Table 1 – Common UMC adaptors

Figure 1 – Red and blue adaptors

Figure 2 – Schuko and British 13A adaptors

2 Safety First at All Times

The potential danger with electric-car charging lies in the combination of high current and long duration required to charge the battery. Charging a Tesla will show up any weakness in the electrical supply chain. Therefore, if you are going to make your own charging leads, the materials must be of high quality, cables must be of adequate size and quality and terminations must be well made. Any small point of electrical resistance, such as a poor connection, will get warm, which will increase its electrical resistance, which in turn will make it get warmer still; quickly, the temperature can rise to the point where things start to ***melt*** or ***catch fire***.

3 Starting Point

Because of the need described above to cope with a 3-phase supply, the starting point for most of the adapter leads described is the red, 3-phase adapter for the UMC, which you can buy from Tesla (Red Industrial Adapter, part #1024110-02-A - £75 + VAT / £90 inc VAT as of January 2017).

4 Cable Size and Quality

Cable size is important to minimise voltage drop and heat generation.

For 16A applications, 2.5 mm² is considered the minimum requirement.

For 32A applications, 6 mm² is considered the minimum requirement.

Cable quality is important to ensure that the insulation does not get easily damaged by abrasion, by contact with solvents, or by use outside its intended temperature range. Standard flexible cable used in domestic applications is not suitable because it has PVC insulation, which will crack at low temperatures; it also kinks and stays coiled and so does not lie flat after storage and could create a trip hazard.

The recommended cable is called H07RN-F, which is a highly flexible rubberised cable, suitable for low temperatures and resistant to abrasion and chemicals. It is easy to handle and will lie flat on the ground even after being coiled for a long time. H07RN-F actually means:-

H	Harmonized colour coding
07	450/750 Volts
R	EPR- ethylene polychloroprene rubber) high resistance to abrasion
N	PCP (polychloroprene) sheath, oil, grease & water resistant
F	fine wire flexible cord
PCP	Flame retardant to IEC 60332-1-2

Table 2 – H07RN-F explanation

The cable should be appropriately marked, as follows:

Figure 3 – 3G2.5 cabling

The 3G2,5 means it has 3 conductors, each of 2.5mm² cross sectional area, so a single-phase cable.

Or as follows:

Figure 4 – 5G2.5 cabling

The 5G2,5 means it has 5 conductors, each of 2.5mm² cross sectional area, so a 3-phase cable.

Figure 5 – 3G6 cabling

The 3G6 means it has 3 conductors, each of 6mm² cross sectional area, so a single-phase cable.

Figure 6 – Length markings on cable

Some cable comes with length markings which make measuring easy. In this case, the triangle at the left of the picture occurred every 0.5m.

5 Adaptor and Extension Lead Choices

The choice of adaptors and extension leads is designed to allow a Tesla to be charged from any socket you are likely to find in the UK, Ireland and most countries on the Continent.

5.1 IP Rating

Standard industrial plugs and sockets have an International Protection Marking (sometimes called Ingress Protection) of IP44, meaning that they can safely be used in the rain, but cannot be used in a pool of water. The UMC and related equipment are also rated IP44.

https://en.wikipedia.org/wiki/IP_Code

5.2 Schuko sockets

Industrial sockets (built to IEC60309, sometimes called CEE sockets) are colour coded for voltage (blue for 240V single phase, red for 415V 3-phase) and vary in size according to their current rating; a 32A socket is larger than a 16A socket and has larger conductors.

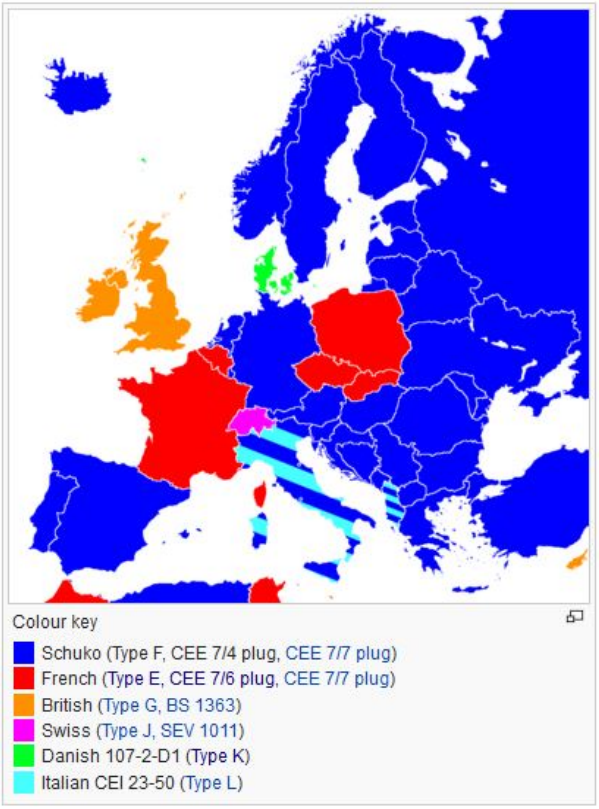
You are most likely to encounter the following:

- 32A 3-phase (red): throughout UK & Europe at industrial premises.
- 16A 3-phase (red): throughout Europe at domestic premises. Rare in the UK.
- 32A single phase (blue): in the UK for domestic & some public charging. Rare in Europe.
- 16A single phase (blue): throughout UK & Europe at campsites, marinas, French market places, etc.

European sockets vary with country, but the "Schuko" socket is common across many countries.

It can be found in three main versions, with either two side-earth contacts (Type F) or the so-called French version with an earth pin (Type E). In Italy (Type L), the earth pin is located in the middle of socket, and a Tesla adaptor is also available with this specific plug. However, in most cases, the power sockets in Italy also provide earth connections on the edges to conform to the standard Type F Schuko.

The countries in blue use the side earthed version, the countries in red use the earth pin version.



These pictures show the side earthed (2) version used in the countries coloured blue.

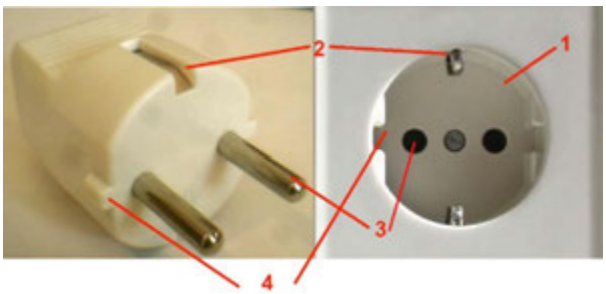


Figure 7 – Standard Schuko plug and socket

The picture below shows the French version with an earth pin, used in the countries coloured red.

Figure 8 – French Type E socket

These sockets can be wired with either contact as the live. With the side-earthed socket, if the UMC is plugged in, lights up red and will not charge then the plug can be removed and inserted the other way and the UMC should charge. The French-type socket, however, allows the plug to be inserted only one way round, which may not be the correct way for the UMC; hence the need for an adaptor to get round this problem.

https://en.wikipedia.org/wiki/AC_power_plugs_and_sockets

https://en.wikipedia.org/wiki/Schuko

6 Extension Leads

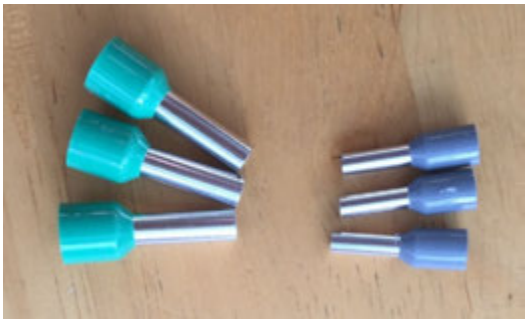
Extension leads should be as short as possible to minimise voltage drop and, to minimise heat build-up. Any wound-up leads **must** be unwound and **never** used coiled.

To minimise the number of leads that need to be carried, 3-phase leads may be used to carry single phase current.

It is suggested that you have leads 5m, 10m and 20m in length. They can be used singly or combined to provide the following lengths: 5m, 10m, 15m, 20m, 25m, 30m and 35m. In this way, excessive amounts of cable lying on the ground can be avoided. It also provides some redundancy in case one cable gets stolen whilst charging.

7 Making Cables and Adaptors

You should use ferrules for cable terminations, not bare wire. These are crimped onto the cable to provide protection to the strands and to provide a good contact. They cost less than £5 per 100 from eBay.



The ferrules are colour coded, and there are two different standards, a French one and a German one. Here, the French one is shown where green is for 6 mm² cable and grey is for 2.5 mm² cable.

Figure 9 – Insulated Ferrules

A crimping tool is required - £10-15 from eBay.

Figure 10 – Ferrule crimping tool

7.1 The Basic Extension Leads

Anyone unfamiliar with assembling cable and adaptors should start with the industrial fittings as they have plenty of room and can accommodate varying lengths of wire.

The following details describe ABL-Sursum-manufactured fittings which are recommended due to their ease of use. Other manufacturers' fittings may vary in assembly. To open the plug or socket, press on the black tab (marked "press to open") and rotate the black and red sections anti-clockwise.

Figure 11 – 16A red socket (1)

The triangles on the two sections align and the two sections can be pulled apart (There might be some final resistance and a “click” before the triangles align). There is a second triangle on the red section marked “close”.

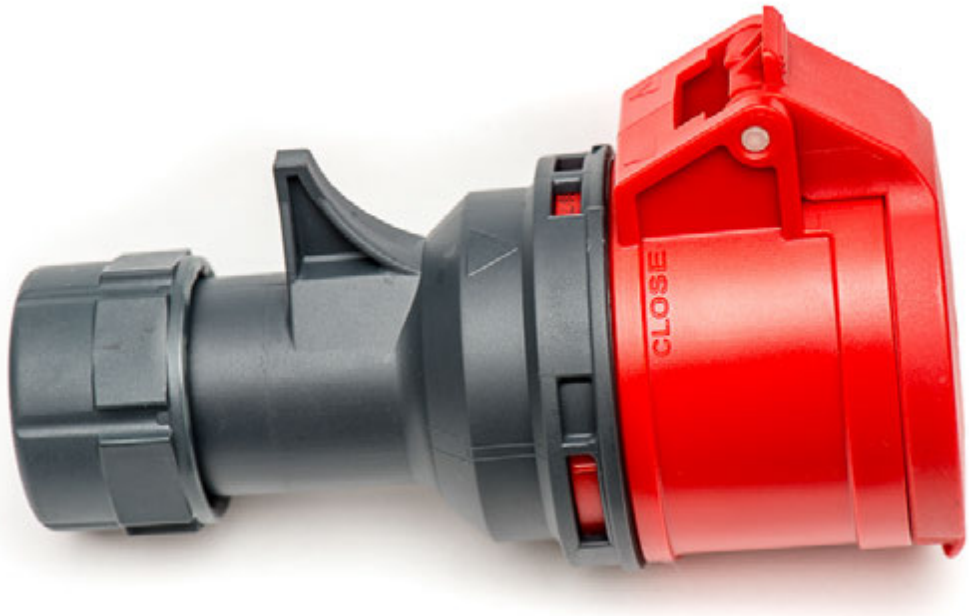


Figure 12 – 16A red socket (2)

Start with a 5m length of 3-phase (5G2.5) cable.

Slide the grey socket and plug covers onto the cable now as it can be difficult to get the cable through the covers once the ferrules are in place. If needed, use tape to hold the covers away from the ends where you will need to work.

Remove about 4cm of the outer insulation from the cable, using a scalpel or very sharp knife. You can also buy a tool for this.

DO NOT damage any of the coloured inner insulation. If you do, cut the end off and start again.

Figure 13 – First cut to remove insulation

The results:

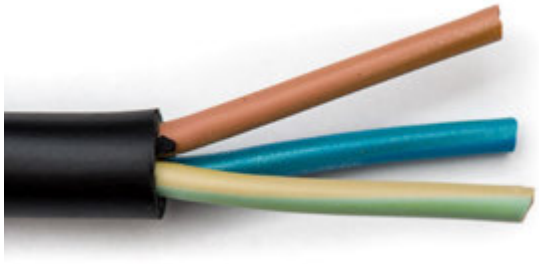


Figure 14 – Single phase cable for some adaptors

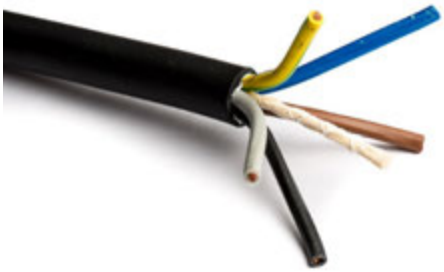


Figure 15 – 3-phase for extension leads & some adaptors

The string in the centre of the 3-phase cable should be cut off. Now remove about 1cm of the coloured insulation using a wire stripper and put on the ferrules.

Figure 16 – Stripped insulation showing wire

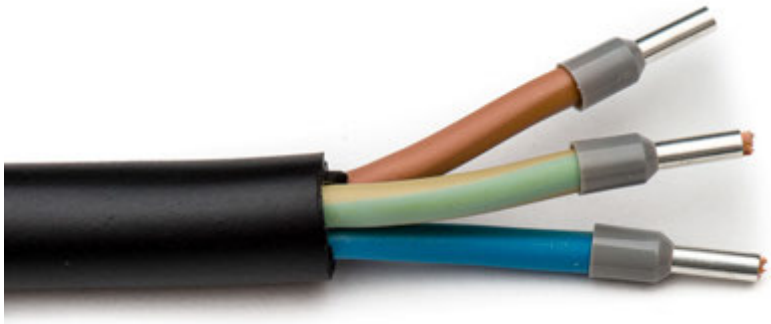


Figure 17 – Ferrules placed on stripped ends

And then crimp them using the crimping tool

Figure 18 – Ferruled single phase cable

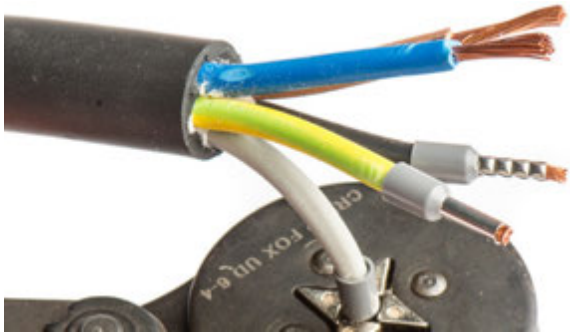


Figure 19 – Three phase in various stages of crimping

The European harmonized colour coding of the individual conductors is: -

Earth:	green & yellow
Neutral:	blue
Live 1:	brown
Live 2:	black (3-phase only)
Live 3:	grey (3-phase only)

Table 3 - European harmonized colour coding

Trim the excess cable from the live (brown, black, grey wires) and neutral (blue wire) ferrules. For industrial connectors, the earth ferrule can be left with a little excess of cable as the earth is fitted with a longer terminal.

Insert the ferrules into the contacts, ensuring the right colour is used for each terminal (Table 1). Tighten the contact screws properly. Go round again and check.

Here is a 16A red 3-phase socket (left) and plug (right). Note the colour progression of the wires is clockwise on one and anti-clockwise on the other.

Figure 20 – Wiring of 16A red 3-phase socket

Figure 21 – Wiring of 16A red 3-phase plug

Note that the earth wire is held in with two screws and its connection protrudes more than the others. This is so that if the wire is pulled out of the connector, the earth wire should be the last one to fail, ensuring safety.

Now attach the covers by aligning the arrows on the covers with the open arrows on the red pieces, push together and rotate clockwise until the arrows on the covers align with the red close arrows, and the locking tab clicks into place.

Strain relief is extremely important to prevent damage to the terminals in case someone pulls the cable. In this case, strain relief is provided by tightening the grey collar (arrow below) which causes a set of dogs to grip the outside of the cable. Push the cable slightly into the housing and tighten the grey collar well. Ensure that the cable is firmly held by the dogs. Tightening the collar well is also **essential to prevent water ingress** as per the IP44 rating.

Figure 22 – Collar on 16A red 3-phase socket

You should now have a complete 3-phase 5m long extension lead looking like this. Here it has been wrapped and bound with Velcro so that it will fit beneath the boot floor with the plug and socket out of the way at the edges of the boot to maintain maximum useful storage space beneath the floor (note: this might not work if you have a sub-woofer).

Figure 23 – 3-phase 5m extension lead

For longer leads, it's recommended to fold them using the "over/under" technique. This ensures the cable is not twisted if it were rolled and pulling one end of the lead will not result in knots or kinks.

Now each conductor within the cable should be tested to ensure no errors have been made and that that there is no measurable resistance.

Figure 24 – Measuring electrical resistance

Measure each of the 5 conductors. All conductors must show 0.0 Ohm. Even 0.1 Ohm is too much and must be rectified.

It is important that the plug is fully inserted into a socket. Here the red plug is not fully inserted into the extension lead red socket, resulting in a gap in the centre and the safety prong failing to engage, as seen in the blue circle below.

Figure 25 – Insufficiently inserted plug and safety prong

With the plug fully home, the centre gap disappears and the safety prong engages as can be seen in the blue circle below. The safety prong helps prevent accidental disconnection of the plug from the socket.

Figure 26 – Fully inserted plug and locked safety prong

Similarly on the UMC plug adapters, there is a recess into which the safety prong inserts

Figure 27 – Safety prong on UMC

7.1.1 Materials Sources

The cable, plug and socket used above came from www.cse-distributors.co.uk who keep these items in stock. These plugs and sockets are high quality, easy to use and are recommended.

www.cse-distributors.co.uk	
5G2.5 cable part number:	H07RN-F-5C-2.5
Plug:	AS51S30-PLUG-RED
Socket:	AK51S30-SOCKET-RED
Alternatively:	
http://www.screwfix.com	
Plug:	2115F
Socket:	5974F

Ready-made extension leads, complete with Portable Appliance Testing certificates, can be ordered from www.industrialextensionleads.co.uk

7.2 UK 13A Adaptor

In order to use the extension lead with a UK 13A socket, the following adaptor is needed.

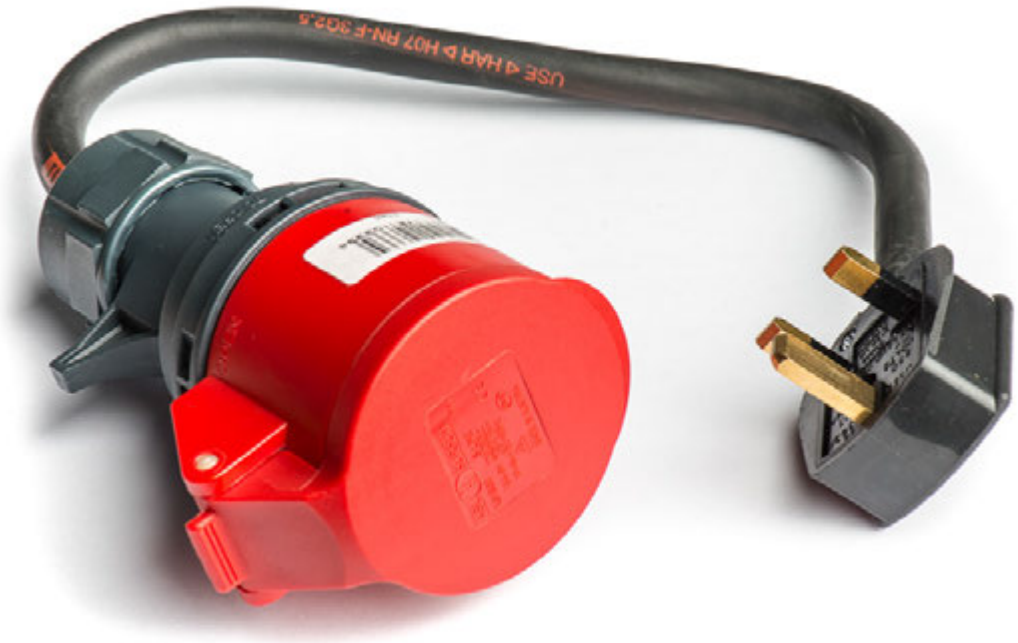


Figure 28 – 13A UK plug to 16A red socket

This is made with 0.5m of single phase 3G2.5 cable. Given the thickness of the cable it is important to choose a suitable plug. It should be a rubberised plug which will not break when dropped, with access and strain relief fittings suitable for the thick cable.

The cable will still be a tight fit. The wires need to be individually cut to length to match the dimensions of the plug. Due to the lack of space the plastic ends of the ferrules should be removed with side cutters. Tighten the fittings well. **Carry some spare fuses and a screwdriver.**

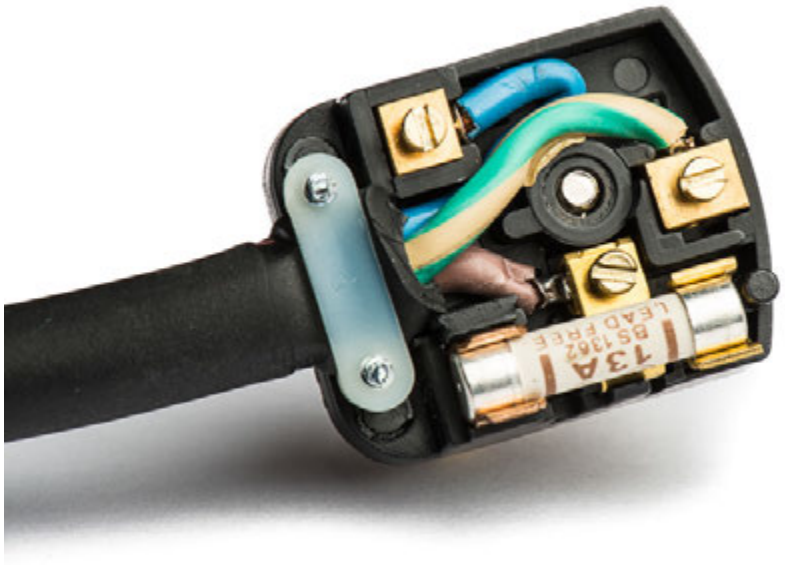


Figure 29 – Wiring of UK 13A plug

Fitting the socket is similar to that of the extension lead, except only L1, neutral and earth are used.

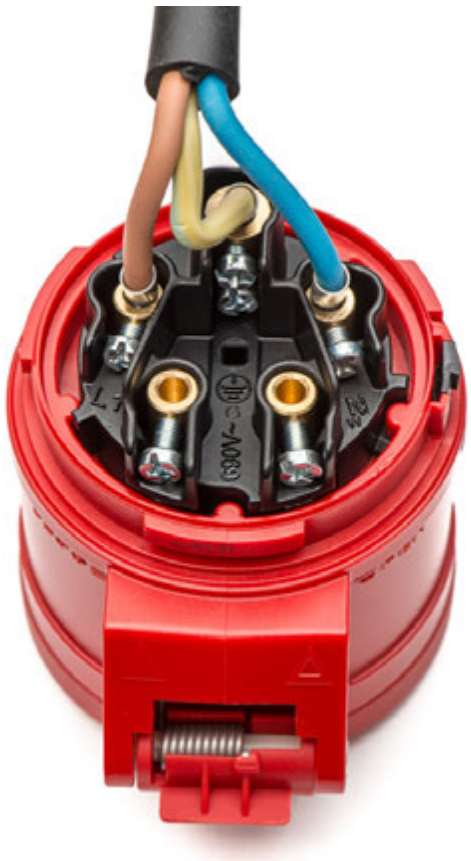


Figure 30 – Wiring of 16A red socket with only a single phase

Again, the resistances of the 3 conductors must be tested and seen to be 0.0 Ohm.

Safety warning labels should be attached to both plug and socket as the car will try to draw 16A if the current is not set manually.

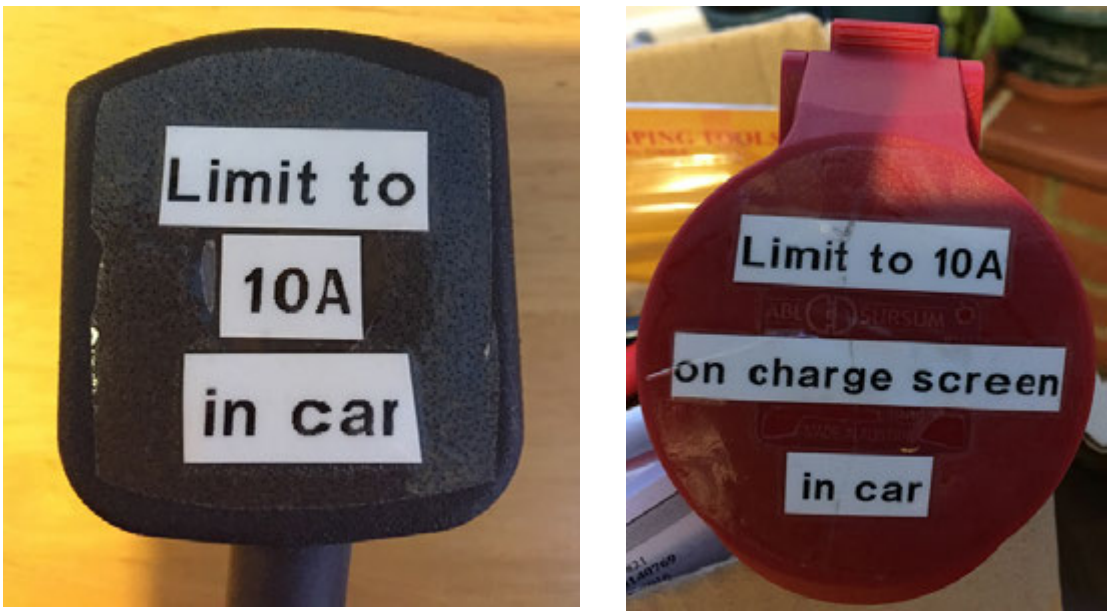


Figure 31 – Safety warning labels on plugs and sockets

7.2.1 Material Sources

The 13A plug was sourced from a local hardware shop to suit the cable.

www.cse-distributors.co.uk
3G2.5 cable part number: H07RN-F-3C-2.5

7.3 Standard Schuko Adaptor

In order to use the extension lead with a standard Schuko socket, the following adaptor is required.

Figure 32 – Schuko plug to red 16A socket

These Schuko plugs and sockets are high quality items, rated to IP54 so can be used in the rain. The copper screw is turned anticlockwise (towards A) to release the retaining mechanism and then the central section can be withdrawn.

Figure 33 – ABL-Sursum Schuko plug

After reassembly, turn the screw clockwise (toward Z) to lock and seal the unit. The socket also features a window with a “power on” indicator. They are robust enough to drive a car over.

Strain relief, and ingress protection along the cable, are provided by tightening the large nut at the end, like on the red plugs.

When connected, they seal and the cap has a similar safety prong to the red socket.

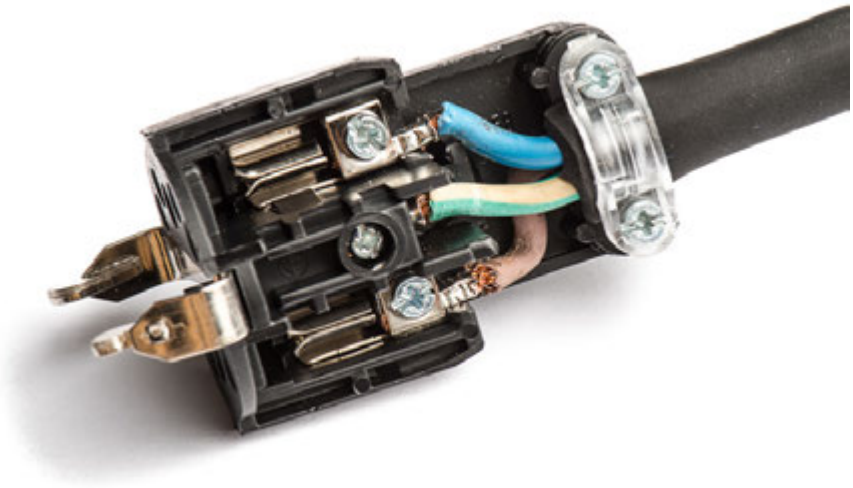


Figure 34 – ABL-Sursum Schuko socket

Whilst Figure 34 shows the internals of the socket, the plug is similar. Space is limited and care is required for a neat installation. The following picture (Figure 35) shows a French Schuko plug end of a standard IEC lead which has been tested and the live pin marked with red tape. Wire the plug in the same way, ensuring the connectors of the socket and plug are connected the same way.

Figure 35 – Checking with an ohmmeter and identifying Live pin with red tape

Once again, test the resistances and apply safety warning labels.

Figure 36 – Safety warning labels on plugs and sockets

7.3.1 Material Sources

www.cse-distributors.co.uk	
3C-2.5 cable part number:	H07RN-F-3C-2.5
Red socket part number:	AK51S30-SOCKET-RED
http://uk.rs-online.com/web/	
Schuko plug stock number:	8245605

7.4 "French" Schuko Adaptor

In France, Belgium, Poland, Slovakia, the Czech Republic, as well as parts of North Africa, there is no rule as to which pin is live or neutral, so you might come across a socket that has the poles reversed; in this case, an adapter wired in the normal way (7.3) would be of no use - the UMC would not work. The solution is to make up another adapter cable as shown below; this consists of a Schuko socket, wired in the standard way described in 7.3 and a standard Schuko plug. This lets you insert the adapter shown in 7.3 into the Schuko socket either way round, thus providing for either polarity.

Assembly is similar to that shown in 7.3.

7.4.1 Material Sources

www.cse-distributors.co.uk	
3C-2.5 cable part number:	H07RN-F-3C-2.5
http://uk.rs-online.com/web/	
Schuko plug stock number:	8245605
Schuko socket stock number:	8245608

7.5 16A Blue "camping" Adaptor

In order to use the extension lead with a 16A single phase blue industrial socket, as found at campsites, marinas and French market places, the following adaptor is required.

Figure 37 – 16A single phase blue plug to 16A red socket

Assembly is similar to that already described above.

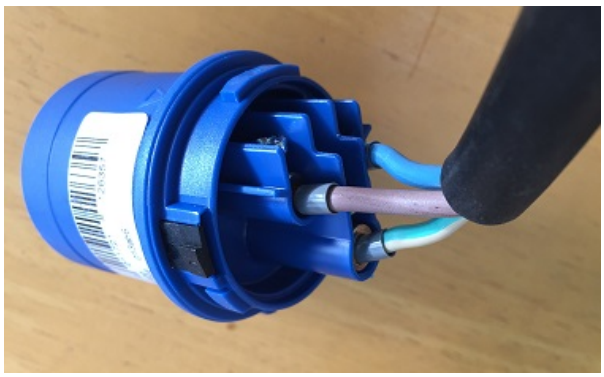


Figure 38 – Wiring of the 16A single phase blue plug

7.5.1 Material Sources

www.cse-distributors.co.uk	
Cable part number:	H07RN-F-3C-2.5
Red socket part number:	AK51S30-SOCKET-RED
Blue plug part number:	AS31S20-PLUG-BLUE
Alternatively:	
http://www.screwfix.com	
Plug:	3017F
Socket:	5974F

7.6 32A Blue Adaptor

If you need regular access to a 32A blue Commando socket you should make a dedicated extension lead, 32A blue plug to 32A blue socket using 6 mm² cable (3G6) as shown in Section 4, and use the blue UMC adaptor to charge at 32A.

However, to be able to charge at any 32A blue commando socket that you might find on your travels using the extension leads, albeit only at 16A, you will need the following adaptor.

Figure 39 – 32A single phase blue plug to 16A red socket

This is similar to item 7.5, but with the larger 32A blue plug.

In order to prevent confusion, reminder notices are useful.

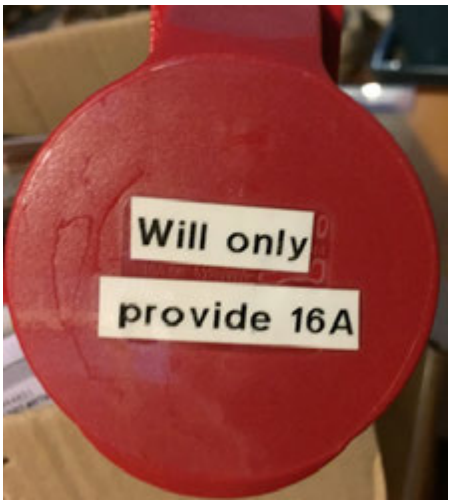


Figure 40 – Reminder labelling of 16A limitation

7.6.1 Material Sources

www.cse-distributors.co.uk	
cable part number:	H07RN-F-3C-2.5
red socket part number:	AK51S30-SOCKET-RED
blue plug part number:	AS32S20-PLUG-BLUE
Alternatively:	
http://www.screwfix.com	
Plug:	7273F
Socket:	5974F

7.7 32A Red Adaptor

In order to charge from the 32A red sockets commonly found on industrial premises, 3-phase 16A circuit breakers are, in theory, required. A very compact and affordable unit is available from www.amazon.de

Figure 41 – 32A red plug to 16A socket with circuit breakers

It features a 32A red plug, 3-phase 16A breakers and 16A red socket, in a rain proof (IP44) housing. The cost is about €70 delivered to the UK.

However, for occasional charging from 32A red sockets, depending on the location, policy of the owner, public access etc. you might take the view that as the UMC and the car are very safe devices with a number of built in safety features, 16A breakers are not required. In this case the following adaptor may be used. **This decision is the responsibility of the owner/user at each time and place they wish to use a 32A red socket.**

Figure 42 – 32A red plug to 16A red socket adaptor

In order to prevent this adaptor from being used with unknown and possibly unsafe loads, it should be kept locked in the car and clearly marked as being for Tesla charging only.

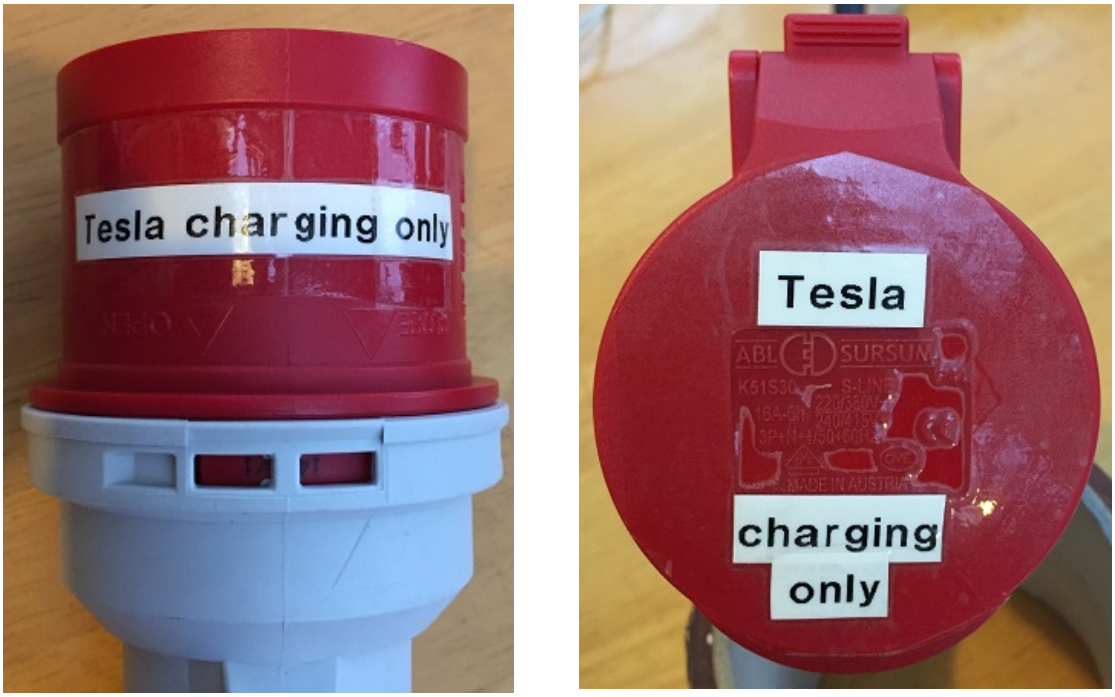


Figure 43 – Reminder labelling to Tesla charging only

7.7.1 Material Sources

The combined adaptor and circuit breaker can be obtained from www.amazon.de
https://www.amazon.de/Schwabe-Ger%C3%A4testecker-Steckdose-wiedereinschaltbarer-Absicherung/dp/B007OV5FAI/ref=sr_1_fkmr2_2?s=diy&ie=UTF8&qid=1483548561&sr=1-2-fkmr2&keywords=drehstrom+32a+16a+adapter+sicherung
If that link no longer works, search using these key words "schwabe mixo adapter 60703" or "drehstrom 32A 16A adapter sicherung".

For the simple adaptor cable:
www.cse-distributors.co.uk

Cable part number:	H07RN-F-5C-2.5
Red socket part number:	AK51S30-SOCKET-RED
Red plug part number:	AS52S30-PLUG-RED

Alternatively:
http://www.screwfix.com

Plug:	2600F
Socket:	5974F

8 The Letterbox and Hotel Adaptors

In order to provide building security whilst charging overnight, it is sometimes necessary to run a cable through a letterbox so that all doors and windows can remain securely shut. Similarly, in hotels with windows that only open a small amount, it is necessary to get the extension lead through a small gap. The standard red plug or socket will not fit, and so one of these adaptors is required.

Figure 44 – Adaptors with the 3-phase and single phase Hylec connectors

On the left is a three-phase connector, diameter approximately 35mm, on the right a single-phase connector, diameter approximately 25mm.

These connectors are beautifully made, rated to 17.5A and IP68, meaning they can be fully submerged in water. Ideal for the pump in your carp pond.

Since they are compact, wiring these connectors requires some degree of care and precision.

8.1 The Single-Phase Connector

Figure 45 – Exploded view of Hylec single-phase connector

The components of the connector, note the turquoise sealing sleeves (Figure 46).

Figure 46 – Hylec sealing sleeves

With 2.5 mm² (3G2.5) cable, only the outer part of the sleeve is needed and it is a tight fit. Lubrication may be needed – silicone is best.

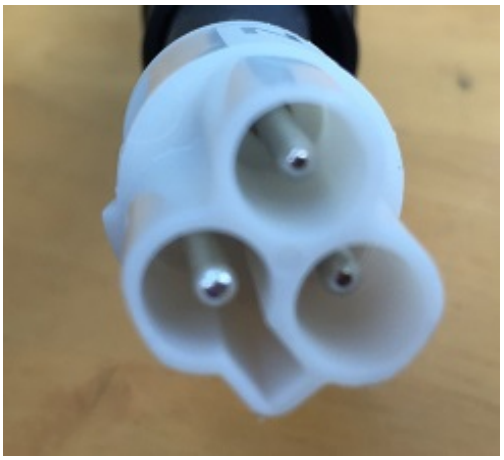


Figure 47 – Hylec single-phase male connector

The connector half with the pins shown in Figure 47 above, should be wired to the 16A red **socket**. The earth pin has the key slot. There are L and N markings on the white shell, although they may be difficult to see. Good light and a magnifying glass may be needed.

Figure 48 – Assembly of Hylec single-phase connector

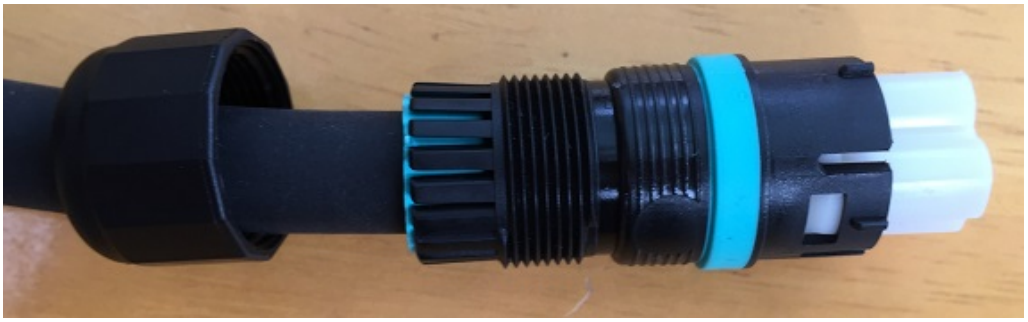


Figure 49 – Assembly of Hylec single-phase connector (2)

The white female / socket part is wired to the 16A red **plug**.

In Figure 50 below, the other end of the connector on the left goes to the 16A red socket. The other end of the connector on the right goes to the 16A red plug.

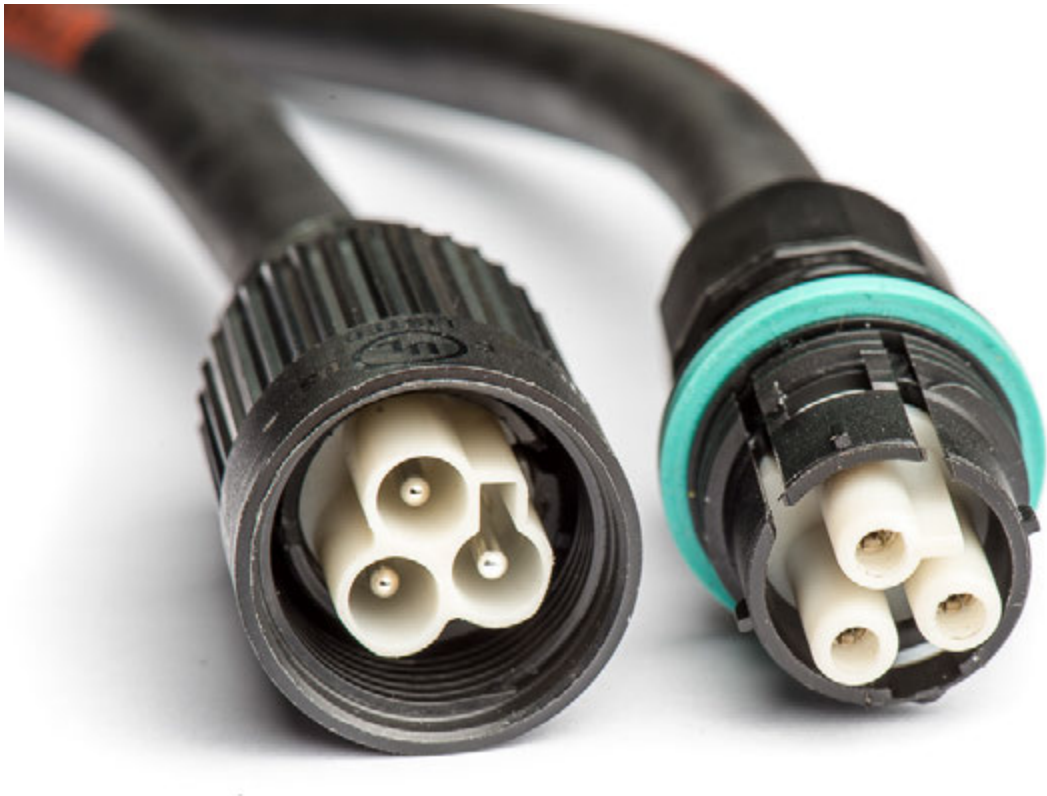


Figure 50 – Close-up view of the Hylec single-phase connectors

The white cylinder locks into the black outer, then getting the turquoise sleeve underneath all the little black fingers is challenging.

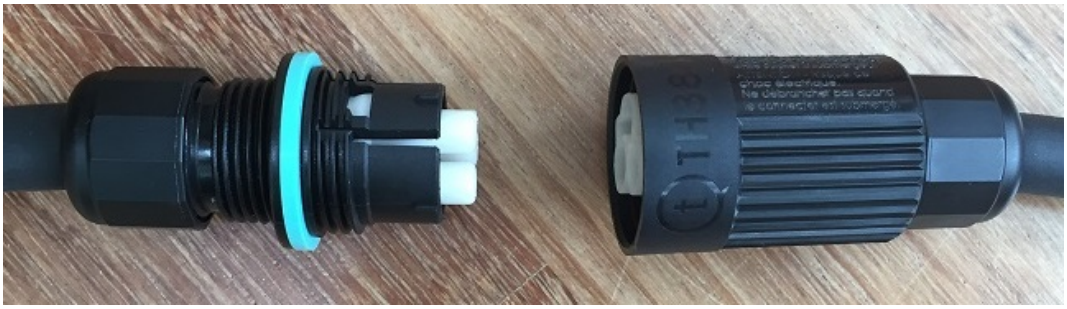


Figure 51 – Lining up of connectors

Ready to screw together.

Figure 52 – Fully connected Hylec single-phase connector

Complete.

8.2 The Three-Phase Connector

Figure 53 – Part of the Hylec three-phase connector

Similar in design to the single-phase connector, except the main joint is a bayonet design rather than screwed. Again, only the outer turquoise sleeve is needed with 5G2.5 cable.

Figure 54 – Female end of the Hylec three-phase connector

Figure 54 shows the socket side which should be connected to the 16A red plug. A tool is supplied in the kit which is used to rotate the white connectors' halves and lock them into the body.

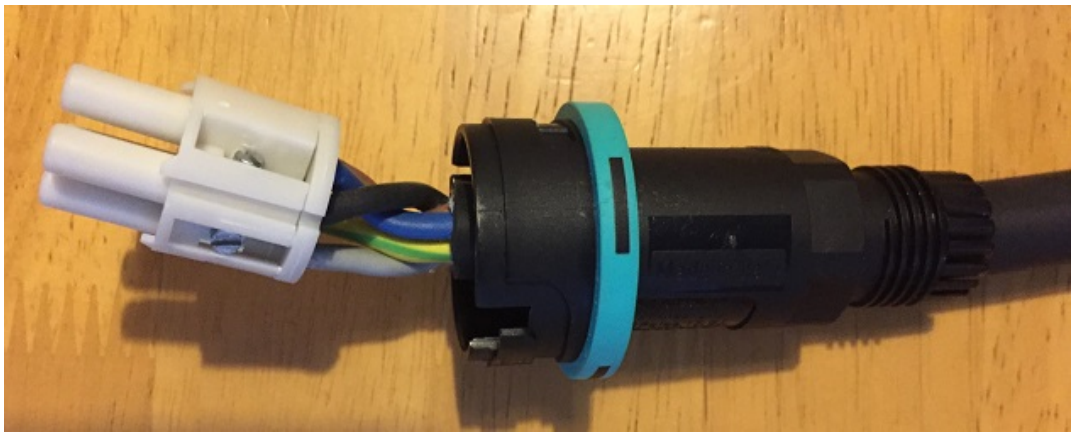


Figure 55 – Exploded view of assembled socket end of the Hylec three-phase connector

It's all a tight fit and there is no room for the ferrules' plastic insulation which must be cut off with side cutters. As with the single-phase connector the terminal markings are difficult to see. Wiring up the plug side (which is wired to the 16A red socket) is similarly tight and the markings can also be difficult to see.

Figure 56 – Terminal markings of plug side of the Hylec three-phase connector

Figure 57 – Exploded view of assembled plug end of the Hylec three-phase connector

The kit includes a plastic tool for tightening the end nuts.

8.3 Material Sources

Single-phase connector
Solely available from http://www.screwfix.com
Teeplug, part number: 38456
Imported by www.hylec-apl.com code: THK-384.03-SF, but not listed on their website.

Three-phase connector
Solely available from http://uk.farnell.com
Part number: 1521775 (often out of stock)
Imported by www.hylec-apl.com code: THR.405.S5A

9 Temperature Monitoring

Overheating is the greatest risk when charging, as mentioned in Section 2. In particular, the overheating of a 13A plug or socket, or Schuko socket, particularly in older properties.

One way to monitor temperatures whilst charging is to use an infra-red pyrometer. This is basically a non-contact thermometer which measures the infra-red radiation given off by a warm body and estimates the temperature from that.

The important thing to remember is that an infrared pyrometer will only give a correct reading from a matt black body, such as a black plug or the UMC. If used on a shiny coloured item, such as a white or metallic socket, the reading will be hugely inaccurate. The simple solution is to put a couple of strips of black insulating tape on the socket and measure the temperature of the black surface.

Although most pyrometers are fitted with a laser, it is only an aiming guide and is not used in the measurement process. Put the large hole in the front of the pyrometer over the item to be measured.

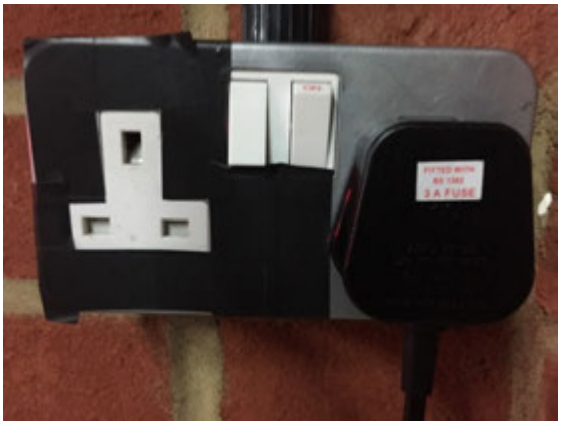


Figure 58 – Insulating tape on the socket face to allow accurate temperature measurement

Figure 59 – Initial temperatures of the plug's back and the socket's surface

The plug had previously been in a warm room.

Figure 60 – Temperatures after 30 minutes charging at 13A showing the expected modest increases

9.1 Material Sources

A suitable pyrometer can be found on Amazon for less than £10.

Figure 61 – Pyrometer

https://www.amazon.co.uk/Benetech-Non-Contact-Infrared-Digital-Thermometer/dp/B007Q87J3U/ref=sr_1_1?ie=UTF8&qid=1483550976&sr=8-1&keywords=pyrometer

10 Portable Appliance Testing

Portable Appliance Testing is basic electrical safety testing for portable equipment. It includes an earth continuity test and a high voltage insulation test of all the conductors to the earth lead. Some businesses and hotels may be unwilling to let you use charging equipment that has not been tested. Testing is easily done by a suitably qualified electrician and each piece of equipment (extension lead, adaptor etc.) has a sticker applied with the date of the test and details of the tester. It is recommended that all extension leads and adaptors are PA Tested.

For more information see https://en.wikipedia.org/wiki/Portable_appliance_testing

Figure 62 – PAT sticker clearly visible on the red socket