MARECHAL electric

1 - Historical Overview

2 - Fundamental Principles

3 - Advantages of Butt Contacts

3 - DECONTACTOR™ Principle

4 - Explosion-proof Products

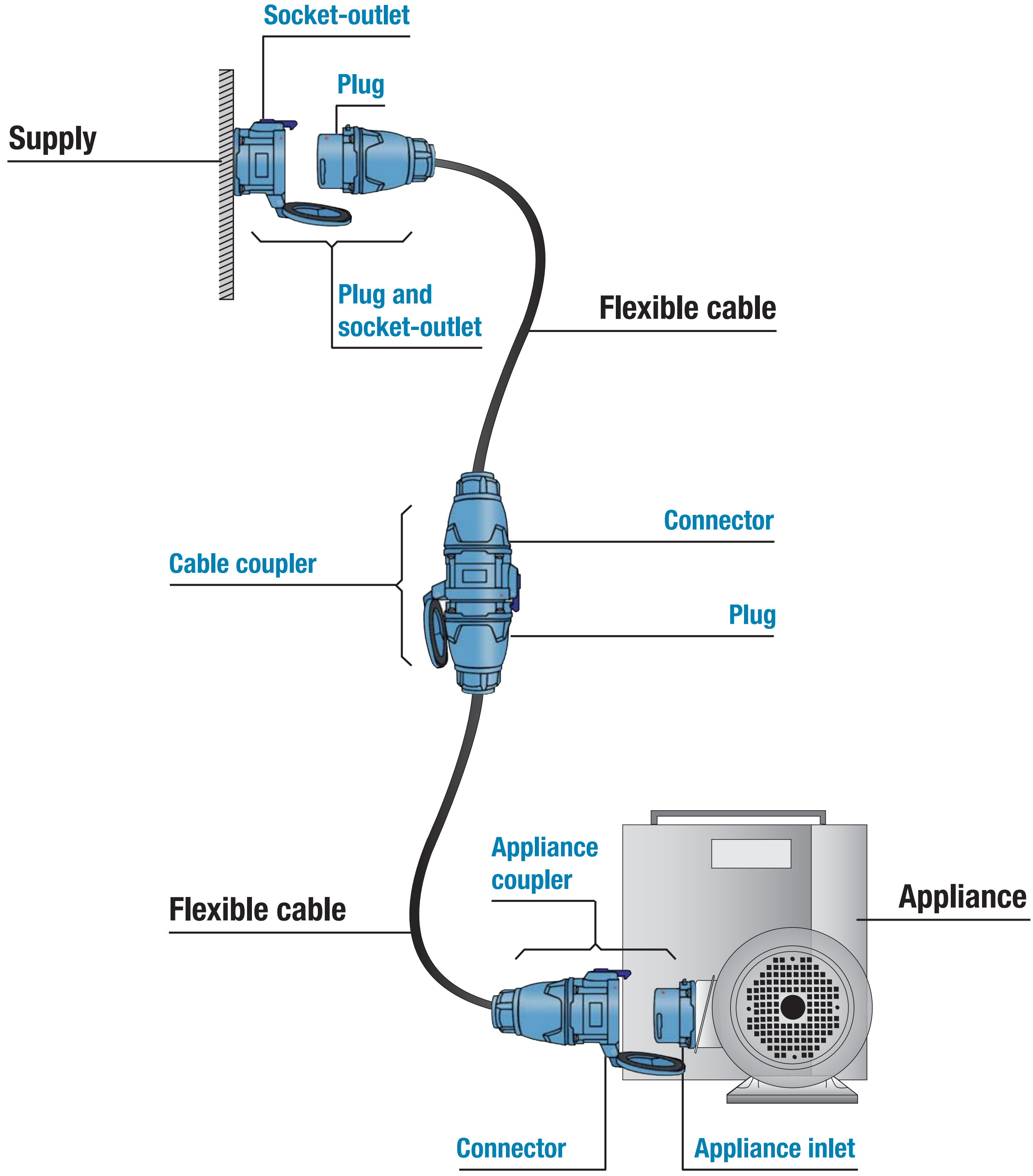
5 - Applicable Standards

Technical Training Manual

2009 - Part 1

English Version

TERMINOLOGY



HISTORICAL OVERVIEW ON PLUG AND SOCKET-OUTLET CONTACT TECHNOLOGY

The need for temporary connection of electrical appliances is as old as the invention of electricity and its expansion throughout human activities, particularly in industry.

Brass pins and contact tubes

Today's plugs and socket-outlets using pins and contact tubes are not much different from those of the 19th century. Conversely, if the need of connecting mobile appliances has not changed, voltages, currents, frequencies and the number of people involved have increased a lot.

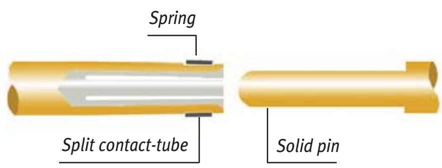
The need for intermateability of accessories from different manufacturers led to the laying down of a dimensional standard after World War II (CEE 17 publication, followed by IEC/EN 60309-2 standard). Unfortunately, and conversely to other electrical apparatuses, this led to the freezing of the contact technology.

The cylindrical pin and contact-tube design that was selected is the most cost-effective but the growing demand for reliability and safety combined with growing voltages and current reached rapidly the limits of this technology:

- Brass has a poor contact resistance, which increases over time due to the tarnishing of its surface. In addition, the passage of current generates a temperature rise which contributes to its oxidisation.
- Brass pins and contact-tubes are not suitable to make or break under load: their material is not arc resistant. Under arcing, brass pits and oxidises, which increases contact resistance and temperature rise in a vicious circle.
- Portable tools or domestic appliances seldom require the 13 A or 16 A their plugs are rated for. But as the current increases or when environmental factors (salt fog, moisture, chemicals) contribute to the tarnishing of the contacts, their overall performance deteriorates rapidly, even in absence of arcing. Occasionally, brass contacts get welded.

Problems between accessories of different origins

Conductivity of a contact requires a minimum applied pressure. With pins and contact tubes, contact pressure is generated by the resilience of the split contact-tube, often completed by a spring around the tube. This spring cannot be rated in a cost-effective way, and it is impossible to control the minimum value of the applied force, particularly when you insert the plug from one manufacturer into the socket-outlet from another.



Besides the difficult manual operation, contact resistance varies according to manufacturing tolerances and a constant performance is not guaranteed.

Importance of tolerances

The critical tolerances are those associated with:

- the overall diameter of the pin,
- the internal diameter of the sleeve,
- their conical shape and roundness.

Of course, there is no chance of honing them together like engine valves or to set very strict tolerances, for cost reasons and because of their nomadic nature.

- Productions using the whole tolerance band may be either too tight or too loose. Too loose a fit and the resistance increases, too tight a fit makes it difficult to operate. In the first case, contact pressure is low and the temperature rises. In the second case, it is difficult to insert the plug into the socket and this may create deformations beyond the resilience of the material.
- Wear associated to the friction between the contacts is likely to change its performances: as brass oxidises, its friction and abrasion deteriorate rapidly, increasing the wear of the material.

- The force fit between two cylinders where one is resilient generates a conical deformation. The contact between the two cylinders is then geometrically established on a circle, or more precisely on a series of points along this circle.

- Rotating tools used to machine contacts generate small undulations on the surface of the metal. These undulations are not visible to the naked eye, but when two pieces are in contact, from a microscopic point of view, only the high spots on this circle are in contact.

Limits of interchangeability

The dimensions laid in the 50-year-old CEE 17 publication followed by the IEC/EN 60309-2 standard are strictly limited to the interface. Fixing centres, internal parts and components are not covered. When a panel is drilled to accommodate a particular brand, this cannot be directly replaced by another brand.

As regards spare parts, in most instances, they are not available. Any damage imposes the replacement of the complete unit.

Improvements

Difficulties linked to the design, on both electrical and mechanical fronts, forced pin and contact-tube manufacturers to tentatively improve their accessories with respect to:

- contact material,
- difficult manual operation,
- inability to make or break the load.

Contact Material

A major weakness of brass pins and contact tubes is their material. Brass (a copper and zinc alloy) is cheap and very suitable to machine parts to the required shape. Anyhow, brass tarnishes (oxidises) at ambient temperature, which increases its contact resistance. Under an arc, it pits, leading to in-depth oxidisation. In addition, brass does not help a quick extinction of the arc.

Plating

Silver plating on both the pin and the contact tube reduces the contact resistance. Anyhow, plating cannot be compared to a solid material due to its softness and porosity. This softness is acceptable for connectors that are seldom disconnected but cannot withstand number of cycles expected from an industrial product: friction wears the plating and contact is then made on the underlying material. Silver- or gold-plated contacts cannot be exposed to an arc as the plating would vaporise.

Due to the inherent porosity of plating, oxides of the underlying material migrate at the surface of the contact.

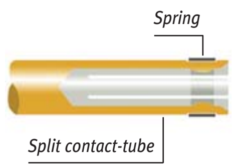
Although very stable over time due to its hardness, **nickel** has a far better resistance to both wear and arcing. Unfortunately, nickel has a high contact resistance and its use is then restricted to limited currents. It is usually used as hard plating on one of the sides only, to eliminate the high friction of brass on itself, but the overall performance, electrically, remains close to that of the weakest side.

Difficult Manual Operation

Several designs have been developed to overcome another major drawback of the pin and contact-tube technology: its difficult manual operation.

"Soft" contacts

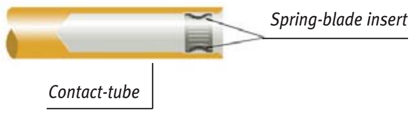
The split contact-tube has an inner protrusion under the spring. The friction between the pin and the contact-tube is then limited to a controlled number of spots on a circle, thus diminishing the friction area and making insertion and withdrawal of the plug easier.



This does not bring any improvement on the electrical side, as the design and materials remain the same.

Inserts

A groove is machined inside the contact tube and fitted with a strip of beryllium-copper spring blades. The number of contact spots is precisely controlled, and the forces applied by the blades on the pin are far less dependent on very stringent tolerances, due to the high resilience, hardness and low friction of the material. At the same time, this design provides an ease of operation similar to the soft contact above.



The little vanes that establish the contact are extremely sensitive to dust and foreign particles can just stop the insertion of a plug. Like any other pin and sleeve design, they are unable to close on a fault current, or even to make and break under full load.

This design also involves two contacts in series, one between the pin and the blade barrel, and the other between the barrel and the contact tube.

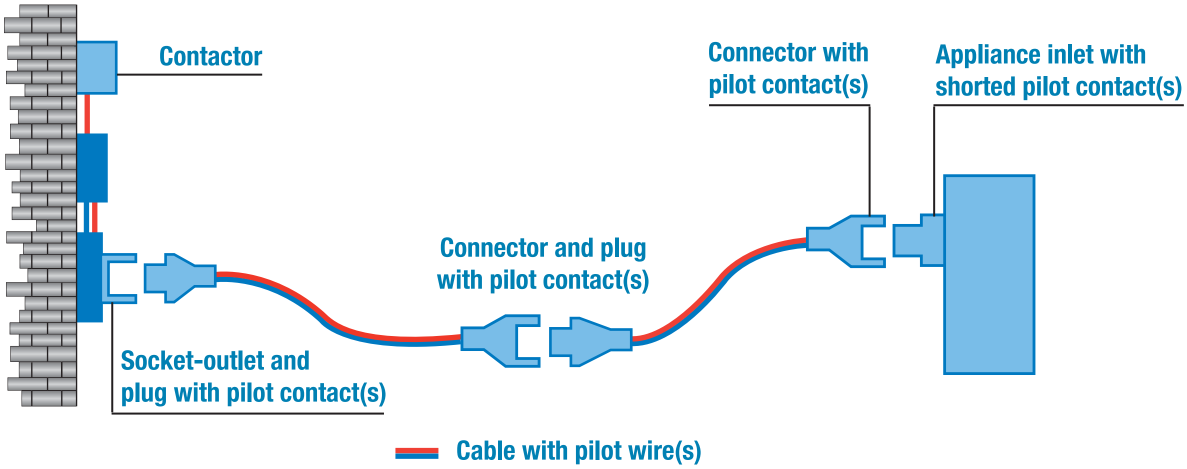
Inability to Break the Load

Whatever their improvements, pins and contact-tubes are, by design, unable to make or break in overload conditions (locked rotor, short-circuit, etc), or even under their nominal load, in complete safety. To provide users with a minimum level of protection, they need to be mechanically or electrically interlocked with a switching device, to prevent operators from withdrawing a "live" plug from its socket-outlet or plugging-in on a fault.

Mechanical interlock means that a mechanical lock does not allow to close the switch associated to the socket-outlet before a plug has been fully engaged. The plug is then physically locked into the socket-outlet until the switch is opened again.

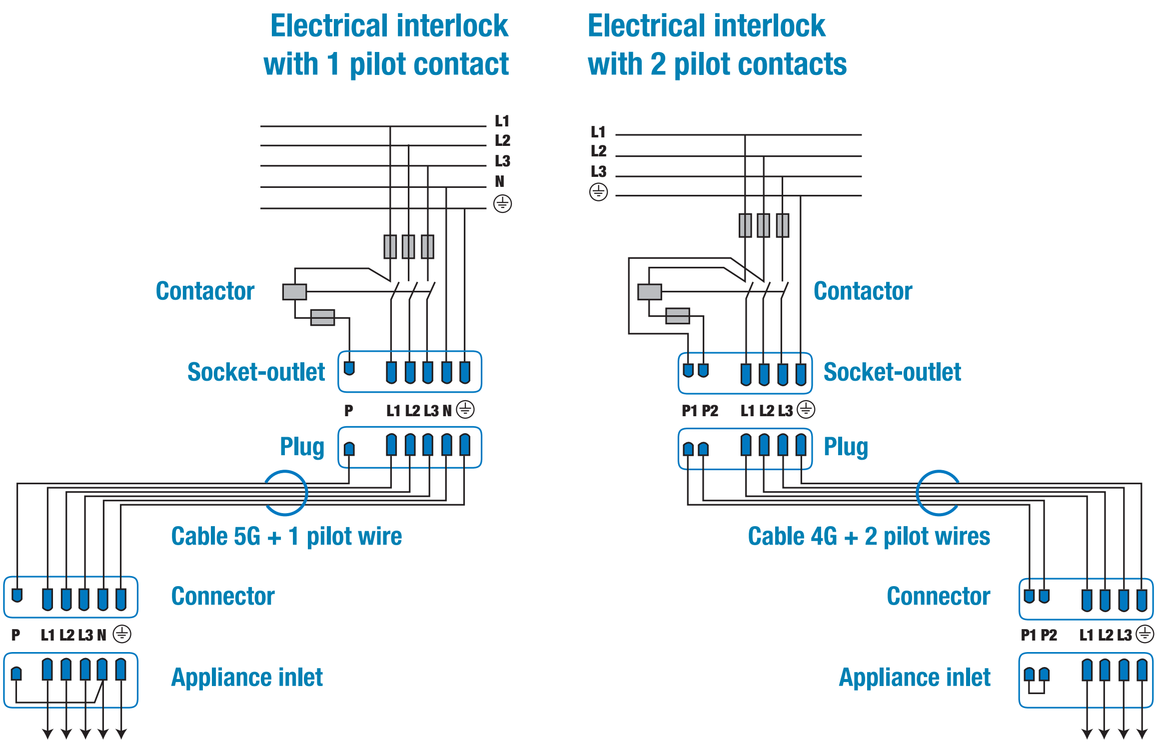
- This requirement can be easily achieved in the case of a surface mounted socket-outlet but is impractical for an in-line connection.
- Mechanically interlocked socket-outlets involve two sets of contacts in series: one in the plug and socket-outlet and one in the switch, which is one more chance to fail.
- Locking mechanisms are often damaged due to rough handling or abuse.
- A welded switch-contact may remain unnoticed.

Electrical interlock is achieved by supplying the coil of an upstream contactor by means of one or two additional wires and contacts (pilot pins), throughout the circuit, from the socket-outlet down to the appliance.



On the appliance, the two pilots are shorted together (or the single pilot is shorted together with a Phase or the Neutral). In other words, the coil of the contactor is not energised as long as one of the connections is not fully made.

- This provides a higher level of safety but requires a contactor, special cables and extra labour.
- A welded contact in the contactor may remain unnoticed.



Butt Contacts and Integral Switching

An ultimate improvement was achieved by the adaptation to plugs and socket-outlets of the silver-nickel butt-contact technology in confined arc chambers, commonly used in the switchgear industry.

They were first developed in the 1950's to overcome the shortcomings of pins and contact-tubes and to cater for the growing need for safety and reliability as well as increasing voltages and currents. They are now quite widespread in several industrial, professional or general public uses worldwide.

In 1996, butt-contact technology was selected by European and American electric car manufacturers as being the safest, most reliable and easiest design to use for the fast-conductive recharging at 250 A of electric vehicles by non-professional users.

As a plug and socket-outlet using silver-nickel butt contacts and confined arc chambers is significantly different from an ordinary pin and contact-tube accessory, it was called a DECONTACTOR™.

The advantages of the DECONTACTOR™ and of the butt-contact principle are described in:

Technical Training Manual – Part 3
The Advantages of Butt Contacts
The DECONTACTOR™ Principle