Types of Conductors 導體類型

Many materials are used to transmit electrical energy, but those most frequently specified for types of conductors are copper, copper-covered steel, high strength copper alloys, and aluminium. For more unusual applications, conductors are fabricated from pure nickel, pure silver, copper-covered aluminium, and a host of metals, metal alloys, and metal combinations.
許多材料用於傳輸電能，但最常用於導電類型的材料是銅，銅包鋼，高強度銅合金和鋁。 對於更多不尋常的應用，導體由純鎳，純銀，銅覆蓋的鋁以及許多金屬，金屬合金和金屬組合製成。

These metals may be coated with rubber, polyethylene, asbestos, thermoplastic, or varnished cambric material, which are called insulators as they have very low electron mobility (few or no free electrons), all of which depend on the voltage of the circuit, the temperature, and whether the circuit is exposed to water or chemicals.
這些金屬可以塗有橡膠，聚乙烯，石棉，熱塑性塑料或塗漆的 cambric 材料，它們被稱為絕緣體，因為它們具有非常低的電子遷移率（很少或沒有自由電子），所有這些都取決於電路的電壓， 溫度，以及電路是否暴露在水或化學品中。

Not all conductive metals have the same level of conductivity – some obviously being better than others – and not all insulators are equally resistant to electron motion. Additionally, it’s also useful to know that some materials experience changes in their electrical properties under different conditions. The following section will go over some of these differences.
並非所有導電金屬都具有相同的導電水平 - 有些明顯優於其他導電金屬 - 並非所有絕緣體都能同樣抵抗電子運動。 此外，知道某些材料在不同條件下的電性能發生變化也很有用。 以下部分將介紹其中一些差異。

Metals Used 金屬的使用

Copper 銅

Copper is by far the most widely used conductor material. Among its physical properties are high electrical and thermal conductivity, ductility, malleability and solder ability, high melting point, and high resistance to corrosion, wear, and fatigue.
銅是迄今為止使用最廣泛的導體材料。 其物理性質包括高導電性和導熱性，延展性，可塑性和可焊性，高熔點，以及高耐腐蝕性，耐磨性和抗疲勞性。

Copper-covered steel 銅包鋼

Copper-covered steel combines the conductivity and corrosion resistance of copper with the strength of steel. Three types are presently available, differing primarily in method of producing the composite metal. In one type, molten welding permanently bonds the two components; in another, a copper layer is electroplated over a steel rod; and in the third, the copper and steel are metallurgically bonded.
銅包鋼將銅的導電性和耐腐蝕性與鋼的強度相結合。 目前有三種類型，主要區別在於製備複合金屬的方法。 在一種類型中，熔融焊接永久地粘合兩個部件; 另一方面，在鋼棒上電鍍銅層; 第三，是以冶金結合的方式結合銅和鋼。

High Strength Alloys 高強度合金

Though more expensive than copper-covered steel wires, copper alloy conductors are specified because they permit significant size and/or weight reductions especially important in computer and aerospace cable and wire applications. They offer high breaking strength and greater flex life with only a small increase in DC resistance. Cadmium-chromium copper, cadmium copper, chromium copper, and zirconium copper are most frequently used.

雖然比銅包鋼線更昂貴，但是銅合金導體是特定的，因為它們允許顯著的尺寸和/或重量減輕，這在電腦和航空航天電纜和電線應用中尤為重要。 它們具有高斷裂強度和更長的彎曲壽命，而直流電阻只有很小的增加。 最常使用鎘 - 鉻銅，鎘銅，鉻銅和鋯銅。

Stainless Steel 不銹鋼

Stainless steel is used for medical lead wires and cables. Stainless steel has poor conductivity compared to copper and may have to be gold plated to improve the conductivity.

不銹鋼用於醫用引線和電纜。 與銅相比，不銹鋼具有差的導電性，並且可能必須鍍金以改善導電性。

Conductor Coatings 導體塗層

Bare Copper 裸銅

Bare copper slowly combines with oxygen at room temperatures to form copper oxide. Raising the temperature accelerates this reaction, and at about 180°C and higher, bright copper wire turns black in just a few minutes. Oxide film is a poor conductor of electricity and must be either removed or prevented from forming in order to assure reliability of connections. This is usually accomplished by coating the copper wire with another metal which oxidizes more slowly at operating and processing temperatures. Thus, a coating is sometimes used to facilitate termination (soldering); sometimes as a processing aid (preventing oxidation of the copper at Teflon® TFE extrusion temperatures); and sometimes to offer a lower-resistance connection ("Wire-Wrap" termination). Bare copper is satisfactory at temperatures up to about 100°C.

裸銅在室溫下與氧氣緩慢結合形成氧化銅。 升高溫度會加速這種反應，在約180°C 或更高溫度下，亮銅線在幾分鐘內變黑。 氧化膜是一種不良的電導體，必須將其移除或防止形成，以確保連接的可靠性。 這通常通過用另一種金屬塗覆銅線來實現，該金屬在操作和加工溫度下更慢地氧化。 因此，有時使用塗層來促進終止（焊接）; 有時作為加工助劑（防止 Teflon®TFE 擠出溫度下的銅氧化）; 有時提供低電阻連接（"繞線"端接）。 裸銅在高達約100°C的溫度下是令人滿意的。

Tinned Copper 鍍錫銅

Tinned copper conductors are a soldering aid and are usually specified where this terminating method is to be used. Suitable for conductors continually exposed to temperatures not exceeding 150°C, tinned copper conductors are slightly more expensive than bare copper wires. However, the labour savings gained by using tinned copper more than offset the additional expense, especially when manual twisting and solder dipping of the stripped lead is required.

鍍錫銅導體是焊接助劑，通常指定使用這種終止方法。 適用於連續暴露在不超過150°C 的溫度下的導體，鍍錫銅導線比裸銅導線略貴。 然而，使用鍍錫銅所節省的勞動力大大抵消了額外的費用，特別是當需要手工加撚和焊接浸漬剝離的鉛時。

Silver Coated Copper 鍍銀銅

Silver plated copper is made by electro-plating pure silver on 18 AWG wire which then is cold drawn to size and finally annealed. Minimum silver thickness is 40 micro-inches. Though higher in cost than tinned copper, silver-coated conductors are recommended for wires operating from above 150°C to about 200°C and in high frequency applications where, because of skin effect, higher conductivity of silver is desirable. They are readily wet by solder, permitting rapid soldering with hand irons. Care must be taken, however, to prevent solder wicking under the insulation, which may reduce conductor flex life. Silver coated copper will oxidize after a few hundred hours at 250°C.

鍍銀銅是通過在18 AWG 電線上電鍍純銀製成的，然後冷拉成一定尺寸並最終退火。 最小銀厚度為40微英寸。 雖然成本高於鍍錫銅，但建議在150°C 至200°C 以上的導線上使用鍍銀導體，在高頻應用中，由於集膚效應，需要更高的銀導電性。 它們很容易被焊料弄濕，允許用手工熨斗快速焊接。 但是，必須注意防止絕緣層下的焊料芯吸，這可能會縮短導體的彎曲壽命。 在250°C下，銀塗覆的銅將在幾百小時後氧化。

Nickel Coated Copper 鍍鎳銅

Nickel plated conductor (50 micro-inches minimum nickel thickness) is recommended for Teflon® TFE hook-up wire operating for prolonged periods at temperatures of from 200° to 260°C, and where silver coating is objectionable because of possible solder wicking. Ordinary soft solder does not wet nickel as readily as it does tin or silver. It adheres well enough to make a good termination, but will not wick into the stranded conductor beyond the joint, thereby leaving flexibility unimpaired. Connections exposed to temperatures above the melting point of soft solder require special soldering techniques. The term "nickel clad" refers to a much thicker coating – 10% to 30% of the radius of the strand.

對於在200°C 至260°C 的溫度下長時間運行的 Teflon®TFE 連接線，建議使用鍍鎳導體（最小鎳厚度為50微英寸），並且因為可能存在焊料芯吸而導致銀塗層不合適。 普通的軟焊料不像錫或銀那樣容易潤濕鎳。 它粘附良好，足以形成良好的終止，但不會芯吸到接頭外的絞合導體，從而使靈活性不受損害。 暴露於高於軟焊料熔點的溫度的連接需要特殊的焊接技術。 術語“鎳包層”是指厚度更厚的塗層 - 鏈的半徑的10％至30％。

COMPARISON OF CONDUCTOR COATINGS

Characteristic	Tin Plate	Silver Plate	Nickel Plate
Life Stability	Conductivity and solderability deteriorate with heat aging at rated temperature due to migration of tin and copper and tin oxidation.	Excellent – no loss of conductivity with heat aging at rated temperature. Solderability shelf-life remains good.	Conductivity remains stable with heat aging at rated temperature.
Crimp Terminability	Good – but contact resistance increases with time and can be variable.	Excellent - contact resistance remains low.	Good – but contact resistance may vary with time. Use plated steel terminal in some cases.
Solder	Good originally. Deteriorates with shelf life.	Excellent.	Requires active flux.
Service Temperature	150°C	200°C	250°C

CONDUCTOR PROPERTIES COMPARISON CHART

Material	Maximum Continuous Operating Temperature	Corrosion Resistance	Solderability	Relative Weight	%IACS (% Conductivity by conductivity relative to standard)	Tensile psi	Flex Life	Formability	Price
Bare Copper	150°C	Good (poor oxidation resistance)	Fair	1.000	100%	35	**	**	$
Tin Plated Copper	150°C	Good	Good	1.000	100%	35	**	**	$
Silver Plated Copper	200°C	Poor	Good	1.000	100-103%	35	**	**	$$$
Nickel Plated Copper	260°C	Good	Poor	1.000	96%	35	**	**	$$
Copper Covered Steel	200°C	Good	Fair	0.925	19-40%	120-200	**	***	$$
High Strength Alloy	200°C	Poor	Good	0.980	65-95%	60-95	***	***	$$$$
Stainless Steel	870°C	Good	Poor	0.905	10-30%	70-300	***	***	$$$

*International Annealed Copper Standard