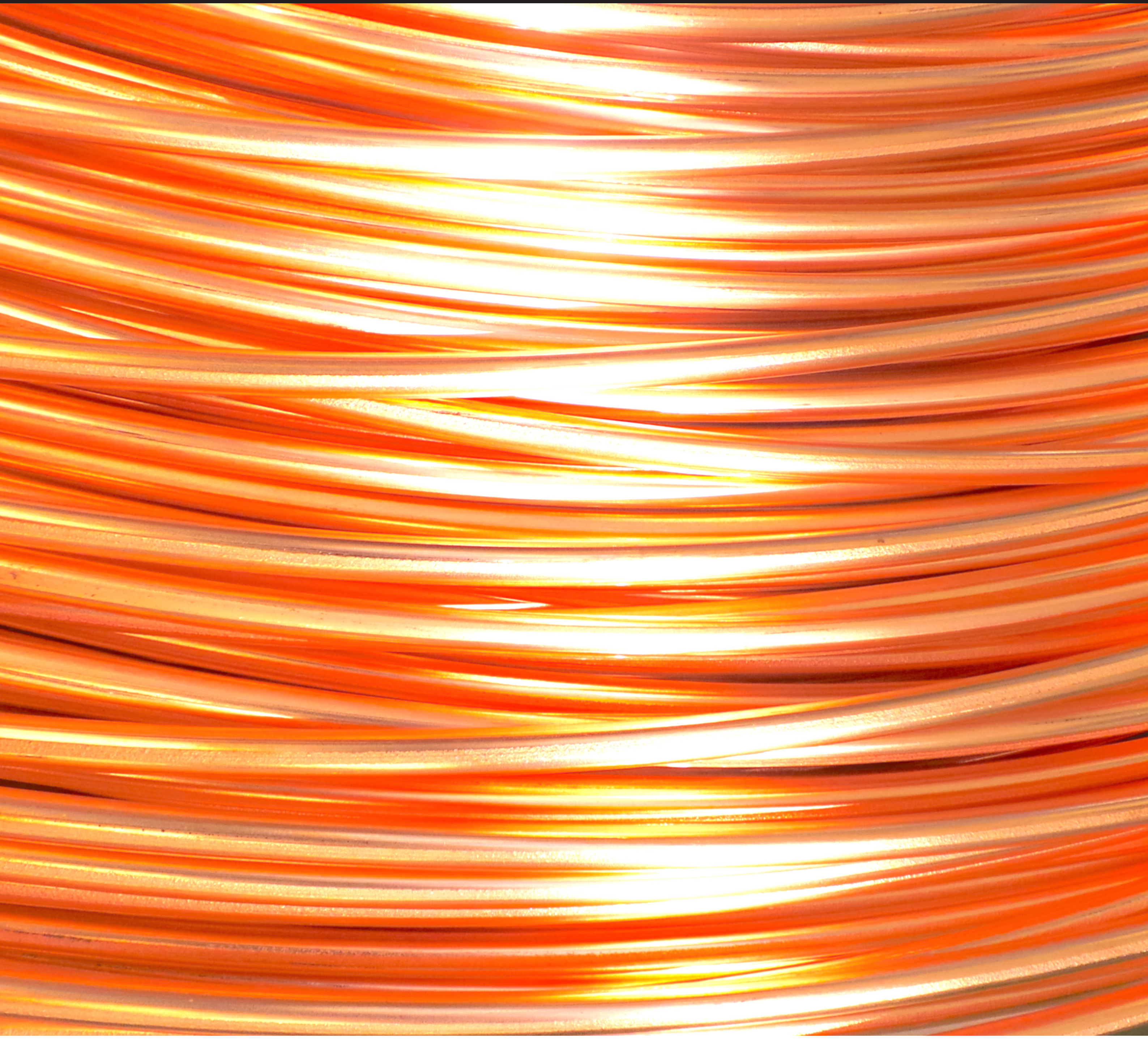
Copper and Aluminium Magnet Wire



powering ideas

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Copper and Aluminuim Magnet Wire

With a solid technical background, the CMP Group offers a comprehensive range of insulated winding wire, which provides a solution for every electric motor, transformer and coil manufacturer.

The magnet winding wire is at the heart of any such product and its quality greatly influences the reliability and performance. With extensive international technical and manufacturing associations, the CMP Group offers its customers the benefit of over thirty years' experience in know-how, development and production in the ferromagnetic and electrical industries.

CMP's reputation for quality and competitive product pricing is due to its highly experienced and qualified management and staff and to its utilisation of high technology product development and advanced manufacturing technology.

The CMP range of magnet winding wire, for both domestic and export markets, is presented in this catalogue complete with full technical details.

The CMP Group of companies is engaged in the manufacture of electro technology products. It trades internationally providing products and services of the highest quality for the electrical industry.

CMP Controls Pty. Ltd. is a manufacturer of high performance copper and aluminium winding wire, through the use of advanced manufacturing technology and insulation materials.

The CMP magnet wire manufacturing capacity range covers specialised manufacturing of bare and insulated wires for electrical engineering purposes as follows:

Enamelled copper and aluminium round wire from diameters 0.05mm to 5.00mm

Bare copper and aluminium rectangular strip, finished section from 1.00mm to 5.00mm thickness to width 3.00mm to 20.00mm.

Enamelled copper and aluminium rectangular strip, finished section from 1.00mm to 5.00mm diameter, width 3.00mm to 20.00mm

The production experience, continuous investment in Research and Development, advanced manufacturing technology and commitment to assured Quality allows CMP Controls Pty. Ltd. to offer services and solutions to its customers.

AUSTRALIAN MADE

Quality Endorsed Company
ISO 9001:2000
Lic QEC 1497
Standards Australia

ATCO220PAI

Choice of Conductor

Copper wire is the most common choice as conductor used throughout the Electrical Industry. Electrical conductivity is the most important characteristic of any conductor. Choices are usually restricted to unalloyed pure metals rather than to alloys.

For equal diameters, aluminium, the second choice of conductor, has about 61% greater resistance than copper. Furthermore, aluminium has a lower thermal conductivity, which reduces the efficiency of cooling by thermal conduction to heat sinks or by convection of moving air.

When considering volume, particularly in small sealed motors, copper is a more efficient material.

A comparison between copper and aluminium

POSITIVE

Copper	Aluminum
High electrical conductivity	Lower density
High thermal conductivity	Lower costs
Low cost	Higher temperature
Volume Efficient	Enamelled rating
Easy to solder	Weight efficient
Easy to work	
Good corrosion resistance	
Easy to coat	

NEGATIVE

Copper	Aluminum
Low strength	Lower strength
Low oxidation resistance	Lower conductivity
Difficult to machine	Lower corrosion resistance
Some brazing problems	Poor stress relaxation
Gas diffusion	Poor solderability
High temperature creep	

A comparison between copper and aluminium

Characteristics	Copper	Aluminum
Specific Weight (g/cm^3)	8.89	2.70
Melting Point (°C)	1,083	658
Specific Heat (cal/g °C)	0.093	0.0220
Coefficient of linear expansion (1/°C)	0.000017	0.000023
Tensile Strength (MPa)	262	82.7
Elongation at break (%)	15–35	10–30
Conductivity IACS at 20°C (%)	101	61.5
Resistivity at 20°C (Ω mm^2/m)	0.01707	0.02803
Temperature coefficient of resis-tivity at 20°C (1/°K)	0.00397	0.00406

For the Same Voltage Drop

Diameters ratio	1	1.27
Cross section ratio	1	1.63
Weight ratio	1	0.50

For the Same Intensity of Current (thermal exchange)

Diameters ratio	1	1.19
Cross section ratio	1	1.42
Weight ratio	1	0.40

Magnet Wire Characteristics

The characteristics of magnet wire can be divided broadly into the categories of mechanical, electrical, thermal and chemical.

Most thermal and chemical behaviours are related closely to the enamel formulations used.

Mechanical and electrical parameters are more closely related to possible causes for failure of the wire to withstand the rigours of winding.

The following are considered to be the most important characteristics for general coil winding:

Mechanical

- Conductor diameter
- Overall diameter
- Springiness
- Flexibility and adherence
- Coefficient of friction
- Bond strength

Electrical

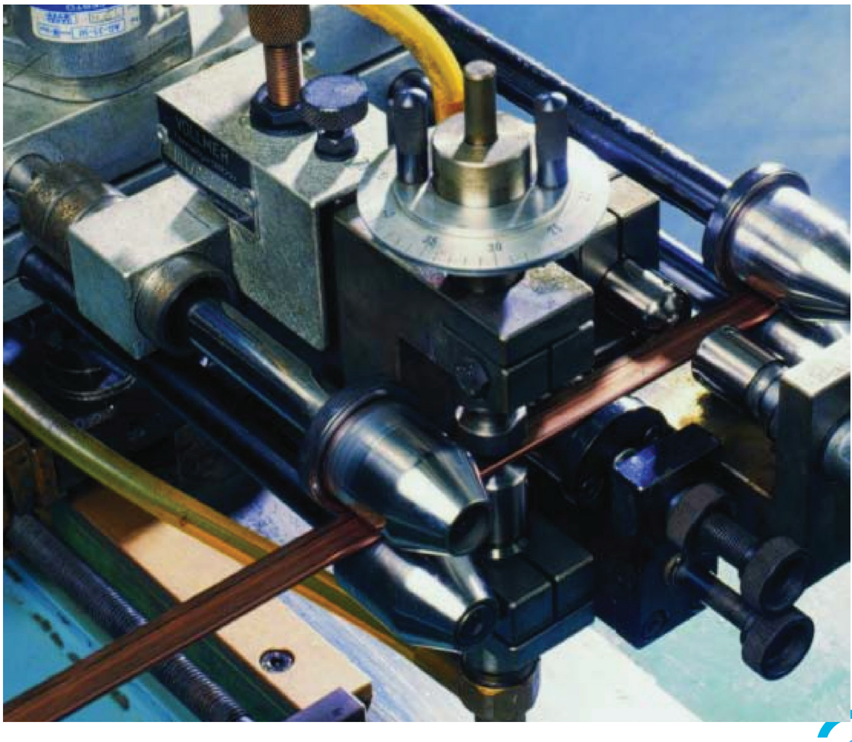
- Continuity of covering
- Breakdown voltage
- Resistance

Thermal

- Heat shock
- Tan delta

There are many types of winding wire each having its own features, properties and performances. Common requirements of all however, are;

- Good electrical performance
- Low yield strength
- Insulation uniformity
- Low springback
- Good flexibility
- High electrical conductivity
- High coating strength
- High thermal rating
- High elastic modulus
- Chemical resistance
- High low stress elongation
- High purity copper and aluminium
- Good conformability
- Stability at high temperature



Our Raw Materials

The high quality and reliability of insulated conductors is dependent not only on the production process, but also on the choice of raw materials.

Many years of experience, both as a user and manufacturer of enamelled winding wire has given CMP the knowledge and expertise to select the best raw materials from internationally approved suppliers.

The copper is high conductivity hot rolled copper rod for redraw and complies with the chemical composition limits and resistivity requirements of International Registered Alloy Designation 110.

For certain uses, the electrical industry requires the conductor to be aluminium and to satisfy this need, we source High Purity Aluminium redraw rod for electrical purposes, complying with the International Registered Alloy Designation 1350.

Critical attention is paid to the enamel as the material utilised to insulate the conductor. Choice of enamel is a key factor and is linked both to the enamelling system as well as the electrical, mechanical and technical characteristics of the finished product.

The insulation enamels sourced by CMP Controls Pty. Ltd. are supplied by internationally approved manufacturers specialising within this field.

Manufacturing Processes

Drawing process

Before being coated, the conductor, copper or aluminium is reduced in dimension through drawing (round wire) or flattening (rectangular wire).

The following steps are involved in the basic drawing process:

- A rod of large diameter, for example 8mm, is drawn to a diameter of around 3mm and is continually inline annealed
- The annealed wire is then drawn to its final diameter and in the process is annealed for a second time. During this phase, the drawing is usually combined with the enamelling.
- The drawing processes are dependent on die preparation and maintenance which are undertaken in our own die laboratory.

Rolling process

The procedure involved in the production of rectangular wire begins with the drawing phase to approach the desired size. The wire is then flattened to the exact profile and dimensions, including the desired corner radius.

The round drawn wire is passed between a set of rolls which effectively widens the round wire and reduces the thickness.

The flattening of round wire generates a natural edge which has to be reshaped to a round edge of various radii or a semi circular profile.

To effectively reshape the edges and obtain excellent blending of the corner radii, the flattened wire is then passed through a precision driven pair of powered edges, which act as an effective reducer to obtain the required width and forming of the corner radii.

The final profile, corner radii and control of finished dimension is achieved by the finishing rolls.

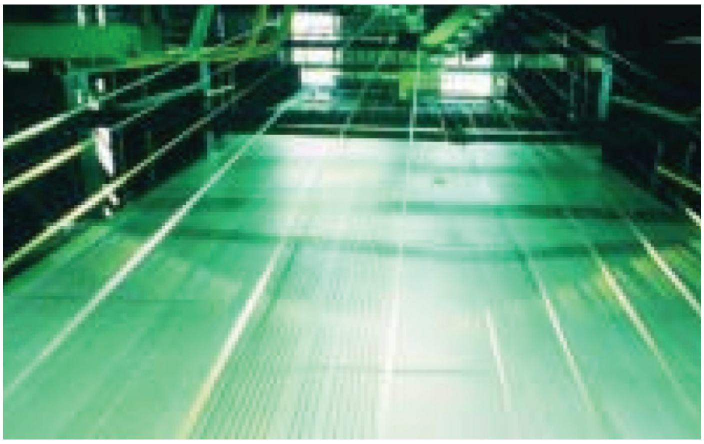
Enamelling process

Enamelling is the process involving the application on to the conductor of numerous thin layers of enamel through calibrated dies.

The conductors' characteristics change according to the type and thickness of the coating. To obtain the best possible characteristics, we often utilise combinations of various enamels, each with its own specific function.

The most important example is the wire "Polyester-imide with Amide-imide Top Coat (PEI-AI)", coated with a very flexible insulating layer with high dielectric characteristics, and a thinner top-coat of harder and smoother enamel with very high chemical and thermal resistance.

Another wire example is the "Polyester-imide with Bondable Top-coat (PEI-B)", on which, over a base coat of polyester-imide, is applied a thermoplastic top-coat. Once the windings are completed, the thermoplastic top- coat is melted, generally by resistance heating, to obtain a solid winding with a strong bond, thus eliminating the need for impregnation.



Manufacturing Processes

In-Line production process

The CMP magnet wire plant takes advantage of in-line processing. This is a composite production method in which the wire is drawn to its final size, annealed and enamel coated in one operation to produce magnet wire of paramount quality.

Drawing immediately precedes the enamelling process, eliminating oxidation and mechanical damage to the wire.

Mechanical properties and winding ability of the enamelled wire are enhanced through tightly controlled area reduction following annealing.

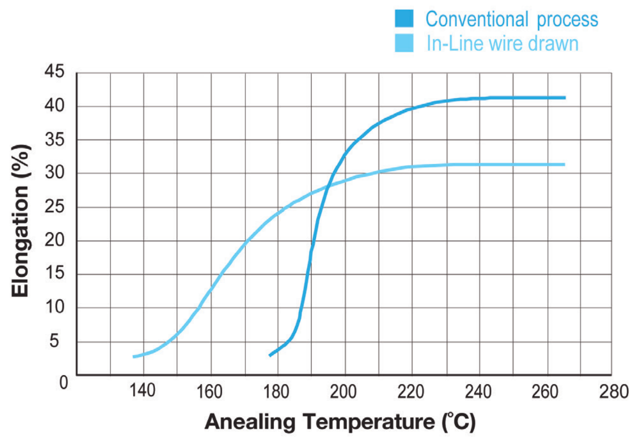
Enamelled wire manufactured by the in-line method is notable for its good workability. The ductility is ensured by the relatively small deformation of the copper conductor which takes place between two annealing treatments.

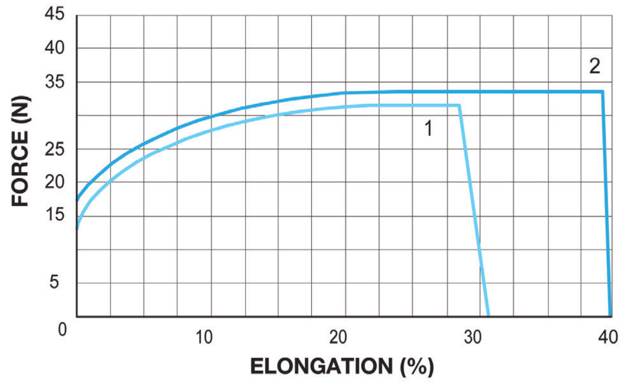
A comparison of stress-strain diagrams illustrates the difference in the ductile qualities of wire produced in the traditionally separated drawing-enamelling method and the in-line method. The curves show yield point, breaking strength and elongation at rupture.

The wire's improved elongation and breaking strength reduces the rate at which the wire breaks, particularly on high-speed winding machines.

In electrical terms enamelled wire produced by the in-line method has a higher electric strength due to the wire being drawn, annealed and coated in a continuous operation.

The cold rolling of copper and aluminium wire into rectangular sections as required in motors and transformers, is a standard practice to obtain the correct wire profile with particular reference to the rounded





edge blending required by the magnet wire design.

The above curve details annealing characteristics for 0.5mm copper wire drawn by the conventional and in-line processes. Because of the smaller area reduction of the in-line process, the driving force for annealing is reduced and the annealing temperature increased

1. Stress-strain diagram for wire manufactured by the conventional method. The wire's diameter is 0.4mm and is elongated 30%.
   Breaking strength 254 N/mm²
2. Stress-strain diagram for wire manufactured by the inline method. The wire's diameter is 0.4mm and is elongated 40%.
   Breaking strength 274 N/mm²

Manufacturing Processes

Rectangular Conductor Corner Radii		Rectangular Conductor Tolerance on Nominal Dimensions		Rectangular Conductor Increase in Dimensions Due to Enamel		
Nominal Thickness (mm)	**Corner Radii**	**Dimensions Width or Thickness (mm)**	**Tolerance (mm)**	**Increase in Dimensions Due to Enamel**		
≤ 1.00	Semicircular	≤ 3.15	± 0.030		Max (mm)	Min (mm)
> 1.00 to 1.60	0.50	> 3.15 to 6.30	± 0.050	Grade 1	0.110	0.060
> 1.60 to 2.24	0.65	> 6.30 to 12.50	± 0.670	Grade 2	0.160	0.110
> 2.24 to 3.55	0.80	> 12.50 to 16.00	± 0.100			
> 3.55	1.00	> 16.00	± 0.100			

CMP manufactures rectangular strip with corner radii complying with the latest relevant Australian and International Standards.

Width and thickness of rectangular profile are continuously computer monitored during manufacturing to ensure that quality standards are maintained, with tolerances on nominal dimensions not exceeding the values as prescribed by the latest Australian and International Standards.

The enamelling process includes the latest advanced manufacturing technology, coupled with computer controlled high insulation continuity testing, to produce a finished product of paramount quality.

Quality First

Assured quality of winding wire is first and foremost and cannot be compromised. CMP uses accepted IEC Standards and the Australian Standard AS1194 as the minimum measure of quality.

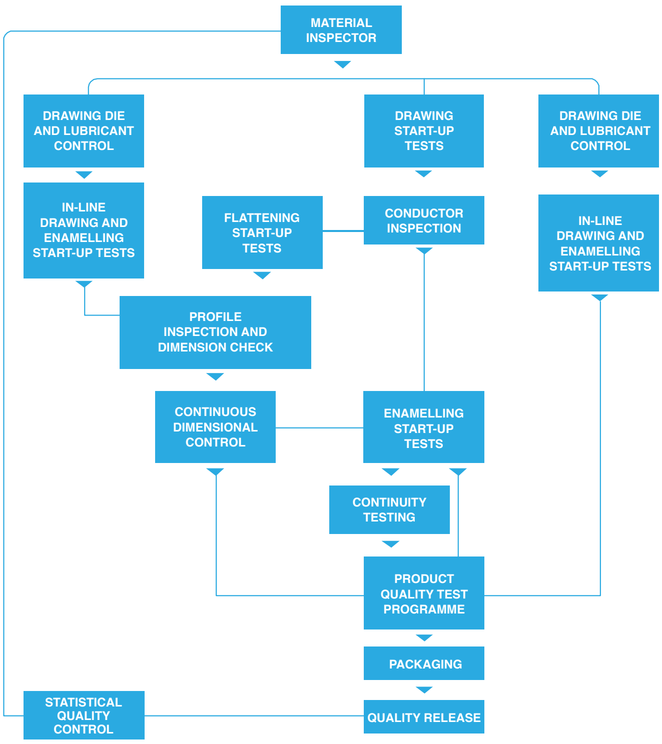
These Standards establish, through quality checks of mechanical, electrical and thermal characteristics, a magnet wire that retains its insulation and integrity under the required conditions of operation.

CMP magnet wire also manufactures product to conform to a client's own winding wire specification, should that be required.

Production is integrated with an audited Quality Control system supported by a trained technical team and fully equipped laboratory facilities.

Comprehensive Quality Test Programme includes:

- Conductor diameter check
- Enamel build
- Enamel cure test
- Breakdown voltage
- Cut-through test
- Continuity of covering
- Electrical resistance
- Tangent-delta enamel cure
- Elongation test
- Springiness test
- Flexibility and adherence test
- Heat shock test
- Enamel scrape test
- Heat bonding test
- Solderability test
- Coefficient of friction test
- Resistance to solvents
- Resistance to refrigerants and other tests specifically required by a client



Choosing Magnet Wire Enamels

The properties and performance of magnet wire are continually improving, due principally to advances in chemical engineering technology and the result of enamels available for magnet wire application.

The selection of one enamel over another in an application is based on a number of factors. The factors are defined by the end use application of the magnet wire as well as the wire production processes. Although the end uses of enamelled magnet wire are varied they can generally be grouped into three categories as follows:

- Motors,
- Transformers and Open Coils, and
- Encapsulated Coils.

Motors

Motors are built in varying size for different applications. They can range in size from sub-fraction horsepower to multiple horsepower.

This variation in size requires a difference in build and size or gauge of the magnet wire used.

In addition, motors by design may have hot spot operating temperatures in excess of 180°C. The magnet wire may be subjected to mechanical stresses and abrasion. These stresses and abrasions come from winding process and or from the final shaping of the wound magnet wire.

Finally, the magnet wire may be subjected to chemical exposure after it is in the motor.

The chemicals may be part of its operating environment. Often, to enhance the motor's resistance to its operating environment it will be coated with an insulating varnish.

The enamel must be compatible with the varnish.

Transformers and Open Coils

Transformers and open coils, like motors, are made in varying size and electrical requirements, thereby the magnet wire will vary in size.

Transformers may also operate in temperatures ranging from less than 105°C up to 220°C and may be immersed in a cooling oil or gas.

Again, the magnet wire is subjected to winding stresses and abrasions. They may not be as severe as the stresses seen in a motor but they still exist.

The magnet wire coil is often shaped to conform to size requirements. It is likely a transformer is coated with an insulating resin to aid in noise reduction and heat dissipation.

In this coating process the magnet wire will be submerged in an insulating resin.

Encapsulated Coils

While encapsulated coils receive the same stresses as transformers and open coils they will receive the additional stress of simultaneous heat and pressure.

The wound magnet wire coil will be placed in a mould and hot thermoplastic will be introduced into the mould under pressure.

Enamels

CMP magnet wire incorporates leading edge enamel technology from the world's most respected suppliers of insulating materials. The broad range of performance characteristics ensures a choice of magnet wire that technically best suits an application.

Polyurethane (PUR)
Insulation class: F (155°C)

A tough and flexible coating with good dielectric strength which offers solderability at low temperatures without prior removal of the enamel. The dissipation factor of PUR enamelled wire is low and changes little, even at high frequencies or in humid conditions.

However, it should be noted that PUR is not compatible with all impregnating varnishes and it does have a limited shelf life.

The common applications for PUR enamelled wire are in low power motors and transformers operating at low temperatures, telecommunication coils and meters.

Solderable Polyester-imide (PEI-S)
Insulation class: H (180°C)

This enamel offers the high thermal and solvent resistance advantages of polyester-imide with the additional benefit of solderability without the requirement of stripping.

First class electrical and mechanical characteristics plus compatibility with impregnating varnishes make the PEI-S the preferred choice in most traditional PUR applications, such as low and medium power motors, transformers and relays.

Polyester-imide (PEI) Insulation class: H (180°C)

A high performance coating, having a broad, almost universal application. PEI not only offers good dielectric strength, flexibility and abrasion resistance, but also high thermal resistance, improved aging resistance and increased production speed.

State-of-the-art PEI enamels are suitable for use in hermetic motors and oil cooled transformers.

Applications for PEI enamelled wire include motors, ballasts, chokes, transformers and general electrical assemblies working at high temperatures.

Polyester-imide with Amide-imide Top Coat (PEI-AI)
Insulation class: H+ (200°C)

An amide-imide coating on top of a polyester-imide (PEI) base enamel offers high abrasion resistance and better relative friction so that the processing capability (windability) is improved. Also, it offers excellent dielectric strength along with significantly better thermal and chemical resistance.

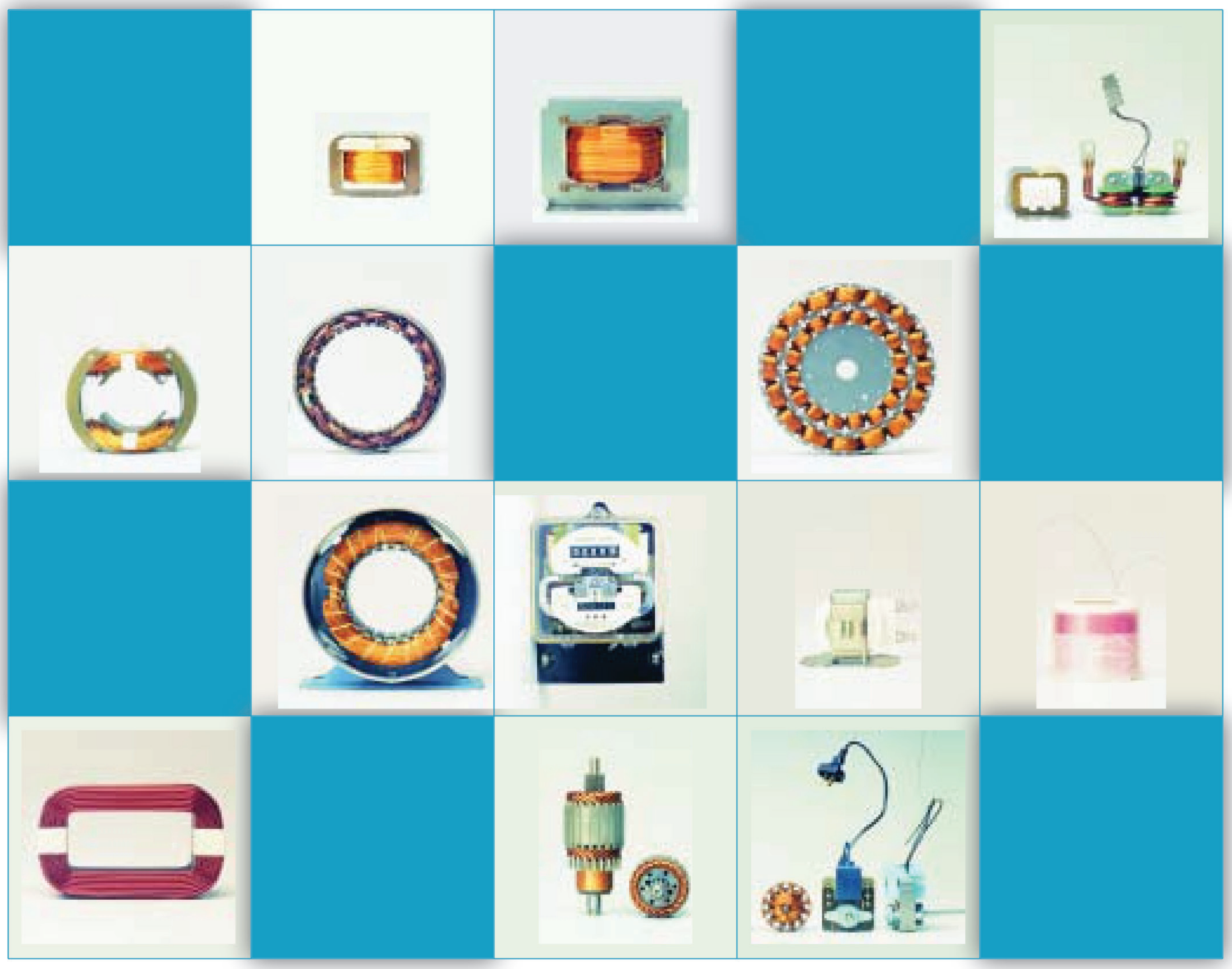
PEI-AI is well suited to high speed and abrasive winding processes and in electrical assemblies that are stressed both mechanically and thermally during normal operation. Applications include high temperature hermetically sealed motors, special transformers, chokes and ballasts.

Polyester-imide with Bondable Top-coat (PEI-B)

A thermoplastic coating on top of a polyester-imide base enamel offers self-bonding hardening.

Resistance heating is the best method for bonding coils using this enamel. To maintain good bond strength it is recommended that windings do not operate at temperatures exceeding 155°C.

Initially for use in the communication industry, PEI-B is applicable where no support or former is used in the construction of coils. Also suitable in relay coils, yoke coils, solenoids and in open motors.



Magnet Wire Tests

The most decisive way to test the magnet wire enamel is in its end use in a motor, transformer or coil, however this is impractical. Testing of enamelled magnet wire is accomplished with laboratory bench tests designed to simulate usage stresses. Magnet wire is tested beyond its operating limits to ensure a significant safety factor.

Adhesion

During the winding process, enamelled magnet wire is subjected to extreme tension such that it may actually elongate the magnet wire. In order to evaluate this stress, magnet wire is subjected to a rapid elongation or "snap" test. This tests the ability of the enamel to elongate with the conductor. The test requires that the enamel does not crack after elongation.

Flexibility

As magnet wire is wound or shaped it may be bent at sharp angles. Therefore after elongation the magnet wire must be able to withstand sharp angles. This is simulated by winding previously snapped magnet wire around mandrels. A mandrel is defined as a multiple of the bare wire diameter. For example, if the snapped magnet wire is wrapped around a mandrel which is two times the diameter of the uncoated wire and the enamel coating did not crack, it will be said to have passed "2X" after snap. This is how the criteria of flexibility of the enamel is defined.

Heat Shock

Heat Shock testing is a thermal test designed to approximate application stresses. The testing is conducted by taking a section of snapped magnet wire and making mandrels as outlined in the flexibility testing. These mandrels are subjected to an elevated temperature for one half hour, removed and examined for cracking of the enamel.

This testing simulates cold start-ups of electrical devices. A cold start-up is when a device is at ambient temperature and then the unit is put into operation. Operation involves the flow of currents through the magnet wire which generates heat from the inherent resistance of the conductor. Also the wire may see elevated temperatures from the curing cycle of an insulating varnish. If those processes are viewed in terms of magnet wire stresses, it is seen that the magnet wire which may have been previously elongated and bent at a severe angle is subjected to additional thermal stress.

Solderability

Solderability is defined as the time it takes for a self-fluxing enamelled magnet wire to be covered with a continuous film of solder.

To test solderability a length of magnet wire is submerged into molten solder which is at a specified temperature. The purpose of the test is simply to measure the length of time it takes to solder a given type of enamel at a specific temperature. This test is important for automated processes.

Thermoplastic Flow or Cut-Through Temperature

Although magnet wire enamels are generally thermosetting there is a temperature at which they will soften and flow if subjected to pressure. This is the basis of thermoplastic flow testing, or as it is often referred to, as "cut-through".

Testing involves arranging two straight lengths of magnet wire, one on top of the other at a right angle. One length has a voltage applied to it. The other length is at ground potential. Perpendicular force is applied at the point of contact. The specimens are heated until a current is detected, flowing between the two lengths. This testing is designed to simulate the combined stresses of heat and pressure that can occur in various applications.

Thermal Class

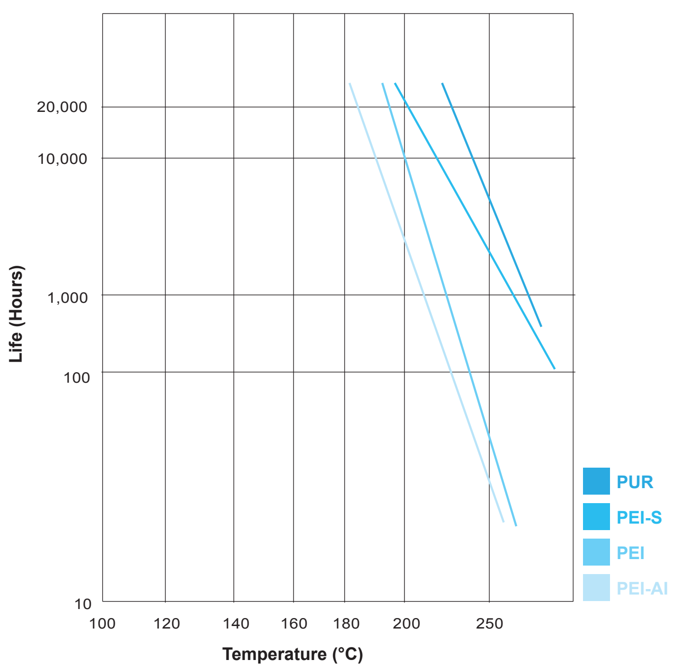
Thermal Class determinations are made by testing at least ten (10) twisted pair samples of enamelled magnet wire to a series of elevated temperatures. Samples are removed periodically and subjected to a non-destructive proof voltage test. If complete failure is not detected the samples are returned to the oven after noting the number of failures. The individual failures at a given temperature define the average life at that temperature.

The lives at a temperature are plotted and the best fit line is determined. The temperature intercept at 20 thousand hours is defined as the temperature index.

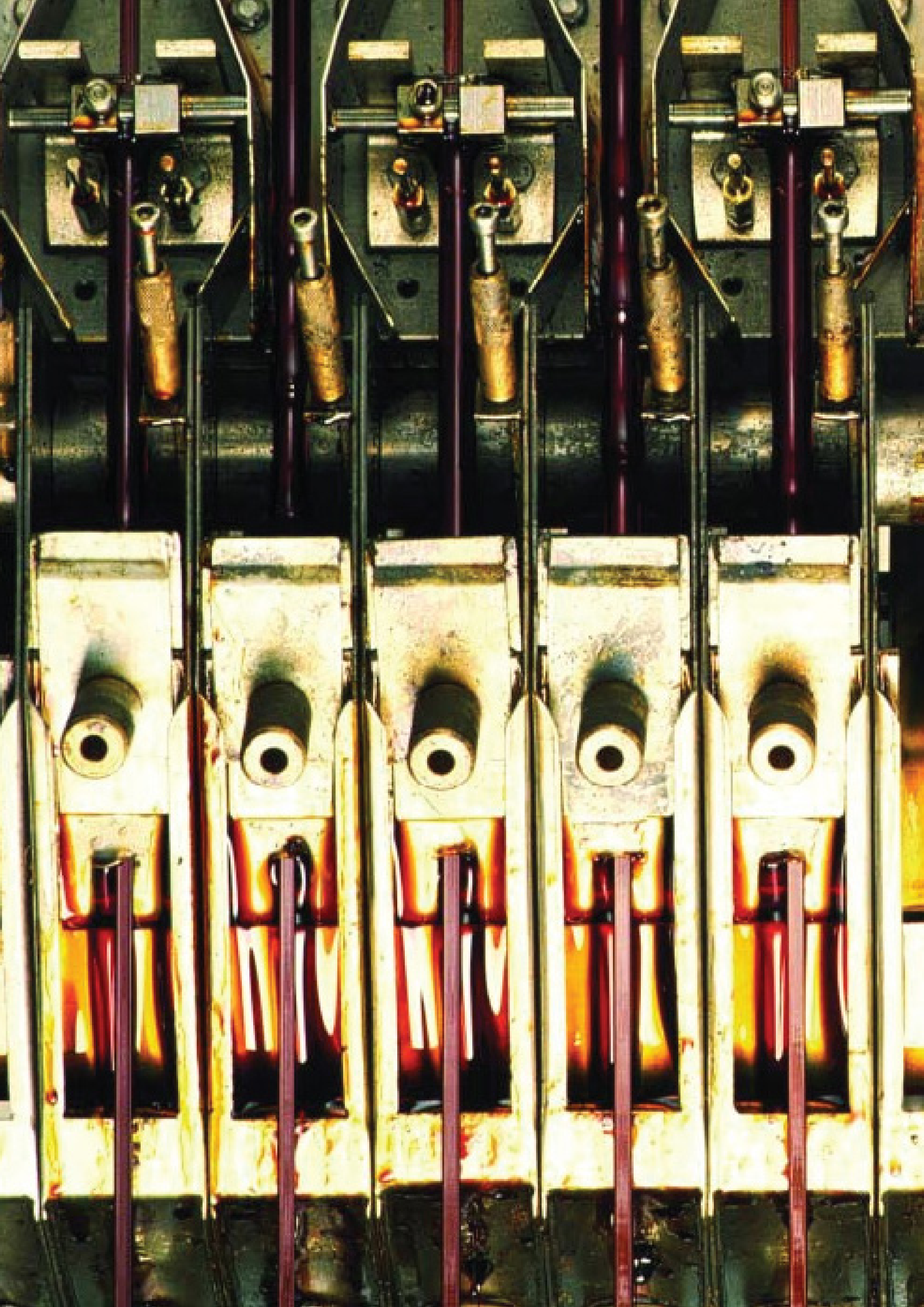
Indices are grouped into thermal classes and insulation classes.

	Polyurethane	Polyester-Imide Solderable	Polyester-Imide	Polyester-Imide Amide-Imide Top-Coat	Polyester-Imide With Bondable Top-Coat
Type of Enamelled Wire	**(PUR)**	**(PEI-S)**	**(PEI)**	**(PEI-AI)**	**(PEI-B)**
Thermal class	155°C	180°C	180°C	200°C	-
Temperature index (IEC)	>170°C	>200°C	>200°C	>220°C	>200°C
Undirectional scrape	11 to 12N	9N	10 to 11N	12 to 13N	10 to 11N
Resistance (IEC)	(0.71mm)	(0.71mm)	(0.71mm)	(1.00mm)	(0.60mm)
Heat shock (IEC)	180°C	200°C	200°C	250°C	200°C
Cut-Through temperature (IEC)	240 to 250°C	330 to 340°C	380 to 400°C	380 to 400°C	380 to 400°C
Temperature of soldering	370 to 380°C	470°C	-	-	-
Resistance to humidity	Good	Very Good	Very Good	Excellent	Good
Resistance to Freon 12	-	-	Good	Very Good	-
Resistance to Freon 22	-	Good	Good	Very Good	-

NOTE: This information is intended only for general guidance in the application for our products. It has been obtained by careful investigation and represents the present state of our knowledge and experience. Because of the large number of possible methods of application and processing we are unable to assume responsibility for technical results.



Thermal	Thermal	Insulation
Index °CI	**IClass °C**	**Class**
105-119.9	105	A
120-129.9	120	E
130-154.9	130	B
155-179.9	155	F
180-199.9	180	H
200-219.9	200	H+
>220	220	C



Surface Lubrication

Surface Lubrication

In winding applications the surface of the enamelled wire must be lubricated. This is particularly important in high speed winding machines to reduce frictions and elongation. CMP magnet wire offers either CMP Magnaslip wax or oil lubrication according to a customer's specified requirement.

Magnaslip

CMP Magnaslip is a natural wax based lubricant developed especially to reduce coefficient of friction to less than 0.06 and to be compatible with all insulation materials and systems.

Oil

Mineral oil lubrication typically reduces the coefficient of friction to less than 0.10 and minimises residue deposit in wire feed systems.

Gauge System		Diameter		Cross-Section Area		Current Rating
B&S (A.W.G)	**SWG**	**mm**	**mil**	**mm²**	**in²**	**Based on 2.565A/mm² A**
	6	4.8770	192.0	18.6808	0.028955	47.9162
5	-	4.6230	182.0	16.7856	0.026018	43.0551
-	7	4.4700	176.0	15.6930	0.024324	40.2524
6	-	4.1150	162.0	13.2993	0.020614	34.1128
-	8	4.0650	160.0	12.9781	0.020116	33.2888
-	-	3.7590	148.0	11.0977	0.017202	28.4657
7	9	3.6580	144.0	10.5094	0.016290	26.9566
-	-	3.4040	134.0	9.1006	0.014106	23.3430
8	10	3.2510	128.0	8.3009	0.012866	21.2917
-	-	3.0480	120.0	7.2966	0.011310	18.7157
-	11	2.9480	116.1	6.8257	0.010580	17.5078
9	-	2.8960	114.0	6.5870	0.010210	16.8956
-	12	2.6420	104.0	5.4822	0.008497	14.0619
10	-	2.5910	102.0	5.2726	0.008173	13.5242
-	13	2.3370	92.0	4.2895	0.006649	11.0026
11	-	2.3110	91.0	4.1946	0.006502	10.7591
12	-	2.0570	81.0	3.3232	0.005151	8.5240
-	14	2.0320	80.0	3.2429	0.005027	8.3181
13	15	1.8280	72.0	2.6245	0.004068	6.7318
14	16	1.6260	64.0	2.0765	0.003219	5.3262
15	-	1.4480	57.0	1.6467	0.002552	4.2239
-	17	1.4220	56.0	1.5881	0.002462	4.0736
16	-	1.2950	51.0	1.3171	0.002042	3.3784
-	18	1.2190	48.0	1.1671	0.001809	2.9935
17	-	1.1430	45.0	1.0261	0.001590	2.6319
18	19	1.0160	40.0	0.8107	0.001257	2.0795
19	20	0.9144	36.0	0.6567	0.001018	1.6844
20	21	0.8128	32.0	0.5189	0.000804	1.3309
21	-	0.7239	28.5	0.4116	0.000638	1.0557
-	22	0.7112	28.0	0.3973	0.000616	1.0190
22	-	0.6428	25.3	0.3245	0.000503	0.8324
-	23	0.6096	24.0	0.2919	0.000452	0.7486
23	-	0.5740	22.6	0.2588	0.000401	0.6637
-	24	0.5588	22.0	0.2452	0.000380	0.6291
24	-	0.5105	20.1	0.2047	0.000317	0.5250
-	25	0.5080	20.0	0.2027	0.000314	0.5199
-	26	0.4580	18.0	0.1647	0.000255	0.4226
25	-	0.4547	17.9	0.1624	0.000252	0.4165
-	27	0.4166	16.4	0.1363	0.000211	0.3496
26	-	0.4039	15.9	0.1281	0.000199	0.3286
-	28	0.3759	14.8	0.1110	0.000172	0.2847
27	-	0.3607	14.2	0.1022	0.000158	0.2621
-	29	0.3454	13.6	0.0937	0.000145	0.2403
-	-	0.3302	13.0	0.0856	0.000133	0.2197
28	-	0.3200	12.6	0.0804	0.000125	0.2063
-	30	0.3150	12.4	0.0779	0.000121	0.1999
-	31	0.2946	11.6	0.0682	0.000106	0.1748
29	-	0.2870	11.3	0.0647	0.000100	0.1659
-	32	0.2743	10.8	0.0591	0.000092	0.1516
30	33	0.2540	10.0	0.0507	0.000079	0.1300

Gauge System		Diameter		Cross-Section Area		Current Rating
B&S (A.W.G)	SWG	mm	mil	mm^2	in^2	Based on $2.565A/mm^2$ A
-	34	0.2337	9.2	0.0429	0.000066	0.1100
31	-	0.2261	8.9	0.0402	0.000062	0.1030
-	35	0.2134	8.4	0.0358	0.000055	0.0917
32	-	0.2019	7.9	0.0320	0.000050	0.0821
-	36	0.1930	7.6	0.0293	0.000045	0.0750
33	-	0.1803	7.1	0.0255	0.000040	0.0655
-	37	0.1727	6.8	0.0234	0.000036	0.0601
34	-	0.1600	6.3	0.0201	0.000031	0.0516
-	38	0.1524	6.0	0.0182	0.000028	0.0468
35	-	0.1422	5.6	0.0159	0.000025	0.0407
-	39	0.1321	5.2	0.0137	0.000021	0.0352
36	-	0.1270	5.0	0.0127	0.000020	0.0325
-	40	0.1219	4.8	0.0117	0.000018	0.0299
37	-	0.1131	4.5	0.0100	0.000016	0.0258
-	41	0.1118	4.4	0.0098	0.000015	0.0252
38	42	0.1016	4.0	0.0081	0.000013	0.0208
-	43	0.0914	3.6	0.0066	0.000010	0.0168
39	-	0.0889	3.5	0.0062	0.000010	0.0159
-	44	0.0813	3.2	0.0052	0.000008	0.0133
40	-	0.0787	3.1	0.0049	0.000008	0.0125
41	45	0.0711	2.8	0.0040	0.000006	0.0102
42	-	0.0635	2.5	0.0032	0.000005	0.0081
-	46	0.0610	2.4	0.0029	0.000005	0.0075
43	-	0.0559	2.2	0.0025	0.000004	0.0063
44	47	0.0508	2.0	0.0020	0.000003	0.0052

Conductor Diameter			Cross-Section Area	Maximum Resistance at 20°C		Current Rating
Nominal (mm)	Maximum (mm)	Minimum (mm)	(mm)	CU ΩΩ/1,000mm²	AL Ω/1,000m	2.565A/mm² A
0.050	0.052	0.048	0.00196	9,528	15,492	0.0050
0.063	0.065	0.061	0.00312	5,899	9,593	0.0080
0.071	0.074	0.068	0.00396	4,747	7,719	0.0102
0.080	0.083	0.077	0.00503	3,702	6,020	0.0129
0.090	0.093	0.087	0.00636	2,900	4,716	0.0163
0.100	0.103	0.097	0.00785	2,333	3,794	0.0201
0.112	0.115	0.109	0.00985	1,848	3,004	0.0253
0.125	0.128	0.122	0.01227	1,475	2,398	0.0315
0.140	0.143	0.137	0.01539	1,170	1,902	0.0395
0.160	0.163	0.157	0.02011	890.6	1,448	0.0516
0.180	0.183	0.177	0.02545	700.7	1,139	0.0653
0.200	0.203	0.197	0.03142	565.6	919.7	0.0806
0.224	0.227	0.221	0.03941	449.5	730.8	0.1011
0.250	0.254	0.246	0.04909	362.7	589.8	0.1259
0.280	0.284	0.276	0.06158	288.2	468.6	0.1579
0.315	0.319	0.311	0.07793	227.0	369.0	0.1999
0.355	0.359	0.351	0.09898	178.2	289.7	0.2539
0.400	0.405	0.395	0.12566	140.7	228.8	0.3223
0.450	0.455	0.445	0.15904	110.9	180.3	0.4079
0.500	0.505	0.495	0.19635	89.59	145.7	0.5036
0.560	0.566	0.554	0.24630	71.52	116.3	0.6318
0.630	0.636	0.624	0.31172	56.38	91.67	0.7996
0.710	0.717	0.703	0.39592	44.42	72.22	1.0155
0.750	0.758	0.742	0.44179	39.87	64.83	1.1332
0.800	0.808	0.792	0.50265	35.00	56.90	1.2893
0.850	0.859	0.841	0.56745	31.04	50.47	1.4555
0.900	0.909	0.891	0.63617	27.65	44.96	1.6318
0.950	0.960	0.940	0.70882	24.84	40.40	1.8181
1.000	1.010	0.990	0.78540	22.40	36.42	2.0145
1.060	1.071	1.049	0.88247	19.95	32.44	2.2635
1.120	1.131	1.109	0.98520	17.85	29.02	2.5270
1.180	1.192	1.168	1.09359	16.09	26.16	2.8051
1.250	1.263	1.237	1.22718	14.35	23.33	3.1477
1.320	1.333	1.307	1.36848	12.85	20.90	3.5101
1.400	1.414	1.386	1.53938	11.43	18.58	3.9485
1.500	1.515	1.485	1.76715	9.955	16.19	4.5327
1.600	1.616	1.584	2.01062	8.749	14.23	5.1572
1.700	1.717	1.683	2.26980	7.750	12.60	5.8220
1.800	1.818	1.782	2.54469	6.913	11.24	6.5271
1.900	1.919	1.881	2.83529	6.204	10.09	7.2725
2.000	2.020	1.980	3.14159	5.599	9.105	8.0582
2.120	2.141	2.099	3.52989	4.983	8.102	9.0542
2.240	2.262	2.218	3.94081	4.462	7.256	10.1082
2.360	2.384	2.336	4.37435	4.023	6.541	11.2202
2.500	2.525	2.475	4.90874	3.584	5.827	12.5909
2.650	2.677	2.623	5.51546	3.191	5.188	14.1472
2.800	2.282	2.772	6.15752	2.857	4.645	15.7940
3.000	3.030	3.970	7.06858	1.393	2.265	18.1309
3.150	3.182	3.118	7.79311	2.258	3.672	19.9893
3.350	3.384	3.316	8.81413	1.996	3.246	22.6082
3.550	3.586	3.514	9.89798	1.778	2.891	25.3883
3.750	3.788	3.712	11.04466	1.593	2.590	28.3296
4.000	4.040	3.960	12.56637	1.400	2.276	32.2327
4.250	4.293	4.207	14.18625	1.240	2.017	36.3877
4.500	4.545	4.455	15.90431	1.106	1.798	40.7946
4.750	4.798	4.702	17.72055	0.9929	1.614	45.4532
5.000	5.050	4.950	19.63495	0.8959	1.457	50.3637

	Grade 1 Enamel		Grade 2 Enamel		Grade 2 Enamel	
Nominal Conductor Diameter (mm)	**Maximum Overall Diameter (mm)**	**Minimum Enamel Increase (mm)**	**Maximum Overall Diameter (mm)**	**Minimum Enamel Increase (mm)**	**Maximum Overall Diameter (mm)**	**Minimum Enamel Increase (mm)**
0.050	0.060	-	0.066	-	-	-
0.063	0.076	-	0.083	-	-	-
0.071	0.084	0.007	0.091	0.012	0.097	0.018
0.080	0.094	0.007	0.101	0.014	0.108	0.020
0.090	0.105	0.008	0.113	0.015	0.120	0.022
0.100	0.117	0.008	0.125	0.016	0.132	0.023
0.112	0.130	0.009	0.139	0.017	0.147	0.026
0.125	0.144	0.010	0.154	0.019	0.163	0.028
0.140	0.160	0.011	0.171	0.021	0.181	0.030
0.160	0.182	0.012	0.194	0.023	0.205	0.033
0.180	0.204	0.013	0.217	0.025	0.229	0.036
0.200	0.226	0.014	0.239	0.027	0.252	0.039
0.224	0.252	0.015	0.266	0.029	0.280	0.043
0.250	0.281	0.017	0.297	0.032	0.312	0.048
0.280	0.312	0.018	0.329	0.033	0.345	0.050
0.315	0.349	0.019	0.367	0.035	0.384	0.053
0.355	0.392	0.020	0.411	0.038	0.428	0.057
0.400	0.439	0.021	0.459	0.040	0.478	0.060
0.450	0.491	0.022	0.513	0.042	0.533	0.064
0.500	0.544	0.024	0.566	0.045	0.587	0.067
0.560	0.606	0.025	0.630	0.047	0.653	0.071
0.630	0.679	0.027	0.704	0.050	0.728	0.075
0.710	0.762	0.028	0.789	0.053	0.814	0.080
0.750	0.805	0.030	0.834	0.056	0.861	0.085
0.800	0.855	0.030	0.884	0.056	0.911	0.085
0.850	0.909	0.032	0.939	0.060	0.968	0.090
0.900	0.959	0.032	0.989	0.060	1.018	0.090
0.950	1.012	0.034	1.044	0.063	1.074	0.095
1.000	1.062	0.034	1.094	0.063	1.124	0.095
1.060	1.124	0.034	1.157	0.065	1.188	0.098
1.120	1.184	0.034	1.217	0.065	1.248	0.098
1.180	1.246	0.035	1.279	0.067	1.311	0.100
1.250	1.316	0.035	1.349	0.067	1.381	0.100
1.320	1.388	0.036	1.422	0.069	1.455	0.103
1.400	1.468	0.036	1.502	0.069	1.535	0.103
1.500	1.570	0.038	1.606	0.071	1.640	0.107
1.600	1.670	0.038	1.706	0.071	1.740	0.113
1.700	1.772	0.039	1.809	0.073	1.844	0.116
1.800	1.872	0.039	1.909	0.073	1.944	0.116
1.900	1.974	0.040	2.012	0.075	2.048	0.119
2.000	2.074	0.040	2.112	0.075	2.148	0.119
2.120	2.196	0.041	2.235	0.077	2.272	0.123
2.240	2.316	0.041	2.355	0.077	2.392	0.123
2.360	2.438	0.042	2.478	0.079	2.516	0.113
2.500	2.587	0.042	2.618	0.079	2.656	0.127
2.650	2.730	0.043	2.772	0.081	2.811	0.130
2.800	2.880	0.043	2.922	0.081	2.961	0.130
3.000	3.083	0.045	3.126	0.084	3.166	0.134
3.150	3.233	0.045	3.276	0.084	3.316	0.134
3.350	3.435	0.046	3.479	0.086	3.521	0.138
3.550	3.635	0.046	3.679	0.086	3.721	0.138
3.750	3.838	0.047	3.833	0.089	3.926	0.142
4.000	4.088	0.047	4.133	0.089	4.176	0.142
4.250	4.341	0.049	4.387	0.092	4.431	36.3877
4.500	4.591	0.049	4.637	0.092	4.681	40.7946
4.750	4.843	0.050	4.891	0.094	4.936	45.4532
5.000	5.093	0.050	5.141	0.094	5.186	50.3637

	Nominal Weight per 1,000 Metres Round							
Nominal Conductor Diameter (mm)	Bare Copper (kg)	Bare Aluminium (kg)	Grade 1 Copper (kg)	Grade 1 Aluminium kg	Grade 2 Copper kg	Grade 2 Aluminium kg	Grade 3 Copper kg	Grade 3 Aluminium kg
0.050	0.0175	0.0053	0.0184	0.0063	0.0190	0.0069	-	-
0.063	0.0277	0.0084	0.0292	0.0099	0.0302	0.0109	-	-
0.071	0.0352	0.0107	0.0370	0.0125	0.0382	0.0137	0.0394	0.0149
0.080	0.0447	0.0136	0.0468	0.0157	0.0483	0.0172	0.0499	0.0188
0.090	0.0566	0.0172	0.0592	0.0198	0.0610	0.0216	0.0629	0.0235
0.100	0.0698	0.0212	0.0730	0.0243	0.0751	0.0265	0.0772	0.0286
0.112	0.0876	0.0266	0.09164	0.0304	0.0940	0.0330	0.0967	0.0357
0.125	0.1091	0.0331	0.1136	0.0377	0.1168	0.0409	0.1201	0.0441
0.140	0.1369	0.0416	0.1422	0.0470	0.1462	0.0509	0.1500	0.0548
0.160	0.1787	0.0543	0.1855	0.0610	0.1904	0.0660	0.1952	0.0708
0.180	0.2262	0.0687	0.2345	0.0770	0.2405	0.0830	0.2464	0.0889
0.200	0.2793	0.0848	0.2892	0.0947	0.2961	0.1017	0.3032	0.1087
0.224	0.3503	0.1064	0.3622	0.1183	0.3706	0.1266	0.3794	0.1354
0.250	0.4364	0.1325	0.4512	0.1474	0.4615	0.1576	0.4732	0.1685
0.280	0.5474	0.1663	0.5646	0.1835	0.5764	0.1953	0.5892	0.2081
0.315	0.6928	0.2104	0.7133	0.2309	0.7273	0.2449	0.7425	0.2601
0.355	0.8799	0.2672	0.9047	0.2920	0.9218	0.3092	0.9393	0.3266
0.400	1.1172	0.3393	1.1465	0.3686	1.1667	0.3888	1.1878	0.4099
0.450	1.4139	0.4294	1.4485	0.4640	1.4728	0.4883	1.4982	0.5137
0.500	1.7455	0.5301	1.7870	0.5716	1.8146	0.5992	1.8432	0.6278
0.560	2.1896	0.6650	2.2379	0.7133	2.2708	0.7462	2.3057	0.7811
0.630	2.7712	0.8417	2.8293	0.8998	2.8678	0.9382	2.9084	0.9789
0.710	3.5197	1.0690	3.5885	1.1378	3.6353	1.1845	3.6836	1.2329
0.750	3.9275	1.1928	4.0047	1.2701	4.0570	1.3223	4.1120	1.3773
0.800	4.4686	1.3572	4.5508	1.4394	4.6063	1.4949	4.6646	1.5532
0.850	5.0446	1.5321	5.1382	1.6257	5.2004	1.6879	5.2657	1.7531
0.900	5.6556	1.7177	5.7545	1.8166	5.8201	1.8822	5.8889	1.9509
0.950	6.3014	1.9138	6.4116	2.0240	6.4844	2.0968	6.5607	2.1730
1.000	6.9822	2.1206	7.0980	2.2364	7.1744	2.3128	7.2543	2.3927
1.060	7.8452	2.3827	7.9704	2.5079	8.0552	2.5927	8.1425	2.6799
1.120	8.7585	2.6600	8.8906	2.7922	8.9799	2.8815	9.0717	2.9733
1.180	9.7220	2.9527	9.8654	3.0961	9.9609	3.19316	10.0588	3.2895
1.250	10.9097	3.3134	11.0614	3.4651	11.1622	3.5660	11.2656	3.6693
1.320	12.1658	3.6949	12.3307	3.8598	12.4403	3.9694	12.5526	4.0817
1.400	13.6851	4.1563	13.8598	4.3310	13.9757	4.4470	14.0943	4.5656
1.500	15.7099	4.7713	15.9042	4.9656	16.0319	5.0933	16.1644	5.2257
1.600	17.8744	5.4287	18.0814	5.6357	18.2173	5.7715	18.3580	5.9122
1.700	20.1785	6.1285	20.4045	6.3544	20.5528	6.5027	20.7062	6.6562
1.800	22.6223	6.8707	22.8613	7.1097	23.0180	7.2664	23.1799	7.4283
1.900	25.2057	7.6553	25.4647	7.9143	25.6346	8.0842	25.8100	8.2596
2.000	27.9288	8.4823	28.2012	8.7547	28.3797	8.9332	28.5638	9.1173
2.120	31.3808	9.5307	31.6770	9.8270	31.8711	10.0211	32.0713	10.2212
2.240	35.0338	10.6402	35.3466	10.9530	35.5514	11.1577	35.7622	11.3686
2.360	38.8880	11.8108	39.2259	12.1486	39.4472	12.3699	39.6749	12.5976
2.500	43.6387	13.2536	43.9964	13.6113	44.2303	13.8452	44.4709	14.0858
2.650	49.0324	14.8917	49.4209	15.2802	49.6783	15.58376	49.9428	15.8027
2.800	54.7404	16.6253	55.1506	17.0355	55.4221	17.3071	55.7009	17.5859
3.000	62.8397	19.0852	63.2969	19.5424	63.5949	19.8404	63.9005	20.1460
3.150	69.2808	21.0414	69.7606	21.5212	70.0731	21.8337	70.3934	22.1540
3.350	78.3576	23.7982	78.8797	24.3202	79.2189	24.6603	79.5722	25.0128
3.550	87.9930	26.7245	88.5460	27.2775	88.9058	27.6373	89.2786	28.0101
3.750	98.1870	29.8206	98.7888	30.4224	98.9556	30.5892	99.5849	31.2184
4.000	111.7150	33.9292	112.3566	34.5707	112.7759	34.9899	113.2042	35.4183
4.250	126.1158	38.3029	126.8225	39.0096	127.2778	39.4649	127.7430	39.9301
4.500	141.3893	42.9416	142.1373	43.6896	142.6188	44.1711	143.1105	44.6628
4.750	157.5357	47.8455	158.3419	48.6517	158.8670	49.1768	159.4028	49.7126
5.000	174.5547	53.0144	175.4031	53.8627	175.9553	54.4149	176.5185	54.9781

Nominal Cross Sectional Area (mm²)

Width

	0.80	0.90	1.00	1.12	1.25	1.40	1.60	1.80	2.00	2.24	2.50	2.80	3.15	3.55	4.00	4.50	5.00	5.60
2.00	1.46	1.63	1.79	2.03	2.29	2.59												
2.24	1.65	1.84	2.03	2.29	2.59	2.92	3.37											
2.50	1.86	2.08	2.29	2.59	2.91	3.29	3.79	4.14										
2.80	2.10	2.35	2.59	2.92	3.29	3.71	4.27	4.68	5.24									
3.15	2.38	2.66	2.94	3.31	3.72	4.20	4.83	5.31	5.94	6.69								
3.55	2.70	3.02	3.34	3.76	4.22	4.76	5.47	6.03	6.74	7.59	8.33							
4.00	3.06	3.43	3.79	4.27	4.79	5.39	6.19	6.84	7.64	8.60	9.45	10.65						
4.50	3.46	3.88	4.29	4.83	5.41	6.09	6.99	7.74	8.64	9.72	10.70	12.05	13.63					
5.00	3.86	4.33	4.79	5.39	6.04	6.79	7.79	8.64	9.64	10.84	11.95	13.45	15.20	17.20				
5.60	4.34	4.87	5.39	6.06	6.79	7.63	8.75	9.72	10.84	12.18	13.45	15.13	17.09	19.33	21.54			
6.30	4.90	5.50	6.09	6.84	7.66	8.61	9.87	10.98	12.24	13.75	15.20	17.09	19.30	21.82	24.34	27.49		
7.10		6.22	6.89	7.74	8.66	9.73	11.15	12.42	13.84	15.54	17.20	19.33	21.82	24.66	27.54	31.09	34.64	
8.00			7.79	8.75	9.79	10.99	12.59	14.04	15.64	17.56	19.45	21.85	24.65	27.85	31.14	35.14	39.14	43.94
9.00				9.87	11.04	12.39	14.19	15.84	17.64	19.78	21.95	24.65	27.80	31.40	35.14	39.64	44.14	49.54
10.00					12.29	13.79	15.79	17.64	19.64	22.04	24.45	27.45	30.95	34.95	39.14	44.14	49.14	55.14
11.20						15.47	17.71	19.80	22.04	24.73	27.45	30.81	34.73	39.21	43.94	49.54	55.14	61.86
12.50							19.79	22.14	24.64	27.64	30.70	34.45	38.83	43.83	49.14	55.39	61.64	69.14
14.00								24.84	27.64	31.00	34.45	38.65	43.55	49.15	55.14	62.14	69.14	77.54
16.00									31.64	35.48	39.45	44.25	49.85	56.25	63.14	71.14	79.14	88.74

Current Rating Based on 2.565/mm2 (A)

Thickness

Width

mm	0.80	0.90	1.00	1.12	1.25	1.40	1.60	1.80	2.00	2.24	2.50	2.80	3.15	3.55	4.00	4.50	5.00	5.60
2.00	3.75	4.17	4.58	5.20	5.86	6.63												
2.24	4.24	4.73	5.20	5.88	6.63	7.49	8.64											
2.50	4.78	5.33	5.86	6.63	7.47	8.43	9.71	10.61										
2.80	5.39	6.02	6.63	7.49	8.43	9.50	10.94	12.00	13.43									
3.15	6.11	6.83	7.53	8.50	9.55	10.76	12.38	13.61	15.23	17.17								
3.55	6.93	7.75	8.56	9.65	10.83	12.20	14.02	15.46	17.28	19.47	21.36							
4.00	7.86	8.79	9.71	10.94	12.27	13.81	15.87	17.54	19.59	22.05	24.24	27.32						
4.50	8.88	9.94	10.99	12.38	13.88	15.61	17.92	19.85	22.15	24.92	27.45	30.91	34.95					
5.00	9.91	11.10	12.27	13.81	15.48	17.40	19.97	22.15	24.72	27.80	30.65	34.50	38.99	44.12				
5.60	11.14	12.48	13.81	15.54	17.40	19.56	22.43	24.92	27.80	31.25	34.50	38.81	43.84	49.58	55.25			
6.30	12.58	14.10	15.61	17.55	19.65	22.07	25.30	28.16	31.39	35.27	38.99	43.84	49.49	55.96	62.44	70.52		
7.10		15.94	17.66	19.85	22.21	24.95	28.59	31.85	35.49	39.86	44.12	49.58	55.96	63.24	70.64	79.75	88.86	
8.00			19.97	22.43	25.10	28.18	32.28	36.01	40.11	45.03	49.89	56.05	63.23	71.44	79.88	90.14	100.40	112.71
9.00				25.30	28.31	31.77	36.39	40.62	45.24	50.78	56.30	63.23	71.31	80.54	90.14	101.68	113.22	127.07
10.00					31.51	35.36	40.49	45.24	50.37	56.53	62.72	70.41	79.39	89.65	100.40	113.22	126.05	141.44
11.20						39.67	45.41	50.78	56.53	63.42	70.41	79.03	89.08	100.58	112.71	127.07	141.44	158.67
12.50							50.75	56.78	63.19	70.89	78.75	88.37	99.59	112.41	126.05	142.08	158.11	177.35
14.00								63.71	70.89	79.51	88.37	99.14	111.71	126.07	141.44	159.39	177.35	198.89
16.00									81.15	91.00	101.19	113.50	127.87	144.28	161.96	182.48	203.00	227.62

Copper, Maximum Resistance at 20°C (Ω/1,000m)

Thickness

Width

mm	0.80	0.90	1.00	1.12	1.25	1.40	1.60	1.80	2.00	2.24	2.50	2.80	3.15	3.55	4.00	4.50	5.00	5.60
2.00	11.7877	10.6024	9.6569	8.5126	7.5441	6.6688												
2.24	10.4199	9.3593	8.5126	7.5152	6.6688	5.9018	5.1171											
2.50	9.2563	8.3044	7.5441	6.6688	5.9241	5.2479	4.5547	4.1673										
2.80	8.1998	7.3487	6.6688	5.9081	5.2479	4.6530	4.0422	3.6862	3.2920									
3.15	7.2362	6.4789	5.8736	5.2035	4.6312	4.1096	3.5730	3.2486	2.9039	2.5759								
3.55	6.3794	5.0769	5.1692	4.5838	4.0828	3.6256	3.1546	2.8605	2.5591	2.2718	2.0709							
4.00	5.6296	5.0323	4.5547	4.0422	3.6029	3.2015	2.7874	2.5217	2.2575	2.0054	1.8244	1.6188						
4.50	4.9792	4.4480	4.0233	3.5730	3.1867	2.8332	2.4682	2.2283	1.9961	1.7743	1.6113	1.4307	1.2654					
5.00	4.4636	3.9854	3.6029	3.2015	2.8567	2.5410	1.9715	1.9961	1.7890	1.5909	1.4427	1.2818	1.1343	1.0024				
5.60	3.9702	3.5431	3.2015	2.8463	2.5410	2.2610	1.9715	1.7743	1.5909	1.4154	1.2818	1.1395	1.0088	0.8919	0.8004			
6.30	3.5167	3.1370	2.8332	2.5202	2.2507	2.0036	1.7477	1.5706	1.4089	1.2540	1.1343	1.0088	0.8935	0.7903	0.7083	0.6272		
7.10		2.7736	2.5040	2.2283	1.9908	1.7728	1.5470	1.3885	1.2460	1.1094	1.0024	0.8919	0.7903	0.6993	0.6260	0.5545	0.4977	
8.00			2.2146	1.9715	1.7619	1.5695	1.3700	1.2283	1.1026	0.9820	0.8864	0.7891	0.6994	0.6191	0.5536	0.4906	0.4405	0.3924
9.00				1.7477	1.5624	1.3921	1.2154	1.0887	0.9776	0.8709	0.7855	0.6994	0.6202	0.5491	0.4906	0.4349	0.3906	0.3480
10.00					1.4034	1.2507	1.0922	0.9776	0.8780	0.7824	0.7052	0.6281	0.5571	0.4933	0.4405	0.3906	0.3509	0.3127
11.20						1.1148	0.9738	0.8709	0.7824	0.6973	0.6281	0.5596	0.4964	0.4397	0.3924	0.3480	0.3127	0.2787
12.50							0.8714	0.7788	0.6998	0.6238	0.5616	0.5005	0.4441	0.3934	0.3509	0.3113	0.2797	0.2494
14.00								0.6942	0.6238	0.5562	0.5005	0.4461	0.3959	0.3508	0.3127	0.2775	0.2494	0.2224
16.00									0.5450	0.4860	0.4370	0.3896	0.3459	0.3065	0.2731	0.2424	0.2179	0.1943

Aluminium, Maximum Resistance at 20°C (Ω/1,000m)

Thickness

Width

mm	0.80	0.90	1.00	1.12	1.25	1.40	1.60	1.80	2.00	2.24	2.50	2.80	3.15	3.55	4.00	4.50	5.00	5.60
2.00	19.1638	17.2368	15.6996	13.8393	12.2648	10.8417												
2.24	16.9401	15.2157	13.8393	12.2178	10.8417	9.5947	8.3190											
2.50	15.0484	13.5008	12.2648	10.8417	9.6310	8.5317	7.4048	6.7749										
2.80	13.3308	11.9471	10.8417	9.5947	8.5317	7.5646	6.5715	5.9927	5.3520									
3.15	11.7642	10.5330	9.5490	8.4596	7.5291	6.6811	5.8088	5.2814	4.7210	4.1878								
3.55	10.3713	9.2779	8.4038	7.4520	6.6376	5.8944	5.1286	4.6505	4.1604	3.6933	3.3667							
4.00	9.1522	8.1811	7.4048	6.5715	5.8574	5.2048	4.5316	4.0996	3.6701	3.2603	2.9659	2.6318						
4.50	8.0949	7.2314	6.5408	5.8088	5.1808	4.6061	4.0127	3.6227	3.2452	2.8845	2.6195	2.3260	2.0572					
5.00	7.2567	6.4792	5.8574	5.2048	4.6443	4.1309	3.6003	3.2452	2.9085	2.5864	2.3455	2.0839	1.8440	1.6296				
5.60	6.4546	5.7602	5.2048	4.6274	4.1309	3.6759	3.2051	2.8845	2.5864	2.3011	2.0839	1.8525	1.6401	1.4500	1.3012			
6.30	5.7173	5.0999	4.6061	4.0971	3.6591	3.2573	2.8412	2.5534	2.2905	2.0386	1.8440	1.6401	1.4527	1.2849	1.1515	1.0196		
7.10		4.5092	4.0709	3.6227	3.2366	2.8821	2.5149	2.2573	2.0257	1.8036	1.6296	1.4500	1.2849	1.1369	1.0177	0.9015	0.8091	
8.00			3.6003	3.2051	2.8645	2.5516	2.2272	1.9968	1.7925	1.5965	1.4411	1.2828	1.1371	1.0064	0.9001	0.7976	0.7161	0.6379
9.00				2.8412	2.5400	2.2631	1.9760	1.7699	1.5892	1.4158	1.2770	1.1371	1.0083	0.8927	0.7976	0.7071	0.6350	0.5658
10.00					2.2816	2.0333	1.7757	1.5892	1.4274	1.2719	1.1464	1.0211	0.9056	0.8020	0.7161	0.6350	0.5704	0.5083
11.20						1.8124	1.5831	1.4158	1.2719	1.1337	1.0211	0.9098	0.8071	0.7149	0.6379	0.5658	0.5083	0.4531
12.50							1.4167	1.2662	1.1377	1.0142	0.9130	0.8136	0.7219	0.6396	0.5704	0.5060	0.4547	0.4054
14.00								1.1285	1.0142	0.9043	0.8136	0.7252	0.6436	0.5703	0.5083	0.4511	0.4054	0.3615
16.00									0.8860	0.7901	0.7105	0.6334	0.5623	0.4983	0.4439	0.3940	0.3542	0.3159

Bare Copper Conductor, Nominal Weight per 1,000 Metres (kg)

Thickness

Width

mm	0.80	0.90	1.00	1.12	1.25	1.40	1.60	1.80	2.00	2.24	2.50	2.80	3.15	3.55	4.00	4.50	5.00	5.60
2.00	13.00	14.46	15.87	18.01	20.32	22.98												
2.24	14.71	16.38	18.01	20.40	22.98	25.97	29.95											
2.50	16.56	18.46	20.32	22.98	25.87	29.21	33.65	36.78										
2.80	18.69	20.86	22.98	25.97	29.21	32.94	37.92	41.58	46.56									
3.15	21.18	23.66	26.10	29.46	33.10	37.30	42.90	47.18	52.78	59.50								
3.55	24.03	26.86	29.65	33.44	37.54	42.28	48.59	53.58	59.89	67.47	74.01							
4.00	27.23	30.46	33.65	37.92	42.54	47.88	54.99	60.78	67.90	76.43	84.02	94.68						
4.50	30.78	34.46	38.10	42.90	48.10	54.10	62.10	68.78	76.79	86.39	95.13	107.13	121.13					
5.00	34.34	38.46	42.54	47.88	53.65	60.32	69.21	76.79	85.68	96.34	106.24	119.58	135.13	152.91				
5.60	38.61	43.26	47.88	53.85	60.32	67.79	77.75	86.39	96.34	108.29	119.58	134.51	151.94	171.85	191.50			
6.30	43.58	48.86	54.10	60.82	68.10	76.50	87.70	97.59	108.79	122.23	135.13	151.94	171.54	193.94	216.40	244.40		
7.10		55.26	61.21	68.79	76.99	86.46	99.08	110.39	123.01	138.16	152.91	171.85	193.94	219.19	244.84	276.40	307.96	
8.00			69.21	77.75	86.99	97.66	111.88	124.79	139.02	156.08	172.92	194.25	219.14	247.59	276.85	312.41	347.97	390.64
9.00				87.70	98.10	110.11	126.11	140.79	156.80	176.00	195.14	219.14	247.15	279.15	312.41	352.41	392.42	440.42
10.00					109.22	122.55	140.33	156.80	174.58	195.91	217.37	244.04	275.15	310.71	347.97	392.42	436.87	490.21
11.20						137.49	157.40	176.00	195.91	219.81	244.04	273.91	308.76	348.58	390.64	440.42	490.21	549.95
12.50							175.89	196.80	219.03	245.70	272.93	306.27	345.16	389.61	436.87	492.43	547.99	614.67
14.00								220.80	245.70	275.57	306.27	343.60	387.17	436.95	490.21	552.44	614.67	689.34
16.00									281.26	315.39	350.72	393.39	443.17	500.07	561.33	632.45	703.57	788.91

Bare Aluminium Conductor, Nominal Weight per 1000 Metres (kg)

Thickness

Width

mm	0.80	0.90	1.00	1.12	1.25	1.40	1.60	1.80	2.00	2.24	2.50	2.80	3.15	3.55	4.00	4.50	5.00	5.60
2.00	3.95	4.39	4.82	5.47	6.17	6.98												
2.24	4.47	4.97	5.47	6.19	6.98	7.89	9.10											
2.50	5.03	5.61	6.17	6.98	7.86	8.87	10.22	11.17										
2.80	5.68	6.33	6.98	7.89	8.87	10.00	11.52	12.63	14.14									
3.15	6.43	7.19	7.93	8.95	10.05	11.33	13.03	14.33	16.03	18.07								
3.55	7.30	8.16	9.01	10.16	11.40	12.84	14.76	16.27	18.19	20.49	22.48							
4.00	8.27	9.25	10.22	11.52	12.92	14.54	16.70	18.46	20.62	23.21	25.52	28.76						
4.50	9.35	10.47	11.57	13.03	14.61	16.43	18.86	20.89	23.32	26.24	28.89	32.54	36.79					
5.00	10.43	11.68	12.92	14.54	16.30	18.32	21.02	23.32	26.02	29.26	32.27	36.32	41.04	46.44				
5.60	11.73	13.14	14.54	16.35	18.32	20.59	23.61	26.24	29.26	32.89	36.32	40.85	46.14	52.19	58.16			
6.30	13.24	14.84	16.43	18.47	20.68	23.23	26.64	29.64	33.04	37.12	41.04	46.14	52.10	58.90	65.72	74.23		
7.10		16.78	18.59	20.89	23.38	26.26	30.09	33.53	37.36	41.96	46.44	52.19	58.90	66.57	74.36	83.95	93.53	
8.00			21.02	23.61	26.42	29.66	33.98	37.90	42.22	47.40	52.52	59.00	66.56	75.20	84.08	94.88	105.68	118.64
9.00				26.64	29.80	33.44	38.30	42.76	47.62	53.45	59.27	66.56	75.06	84.78	94.88	107.03	119.18	133.76
10.00					33.17	37.22	42.62	47.62	53.02	59.50	66.02	74.12	83.57	94.37	105.68	119.18	132.68	148.88
11.20						41.76	47.80	53.45	59.50	66.76	74.12	83.19	93.77	105.87	118.64	133.76	148.88	167.03
12.50							53.42	59.77	66.52	74.62	82.89	93.02	104.83	118.33	132.68	149.56	166.43	186.68
14.00								67.06	74.62	83.69	93.02	104.36	117.59	132.71	148.88	167.78	186.68	209.36
16.00									85.42	95.79	106.52	119.48	134.60	151.88	170.48	192.08	213.68	239.60

Copper, Grade 2 Enamel, Nominal Weight per 1000 Metres (kg)

Thickness

Width

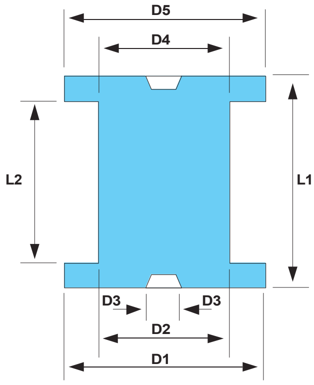
mm	0.80	0.90	1.00	1.12	1.25	1.40	1.60	1.80	2.00	2.24	2.50	2.80	3.15	3.55	4.00	4.50	5.00	5.60
2.00	13.64	15.12	16.56	18.72	21.06	23.76												
2.24	15.40	17.09	18.74	21.16	23.77	26.79	30.82											
2.50	17.31	19.23	21.11	23.80	26.72	30.09	34.58	37.75										
2.80	19.51	21.69	23.84	26.86	30.12	33.89	38.91	42.61	47.64									
3.15	22.07	24.57	27.03	30.42	34.09	38.32	43.96	48.29	53.93	60.71								
3.55	25.00	27.86	30.67	34.49	38.62	43.38	49.74	54.78	61.13	68.76	75.36							
4.00	28.30	31.56	34.77	39.06	43.72	49.08	56.24	62.08	69.23	77.82	85.46	96.19						
4.50	31.97	35.67	39.32	44.15	49.38	55.41	63.46	70.19	78.23	87.88	96.68	108.75	122.83					
5.00	35.63	39.77	43.88	49.24	55.05	61.75	70.68	78.30	87.23	97.95	107.90	121.30	136.94	154.80				
5.60	40.03	44.71	49.34	55.34	61.84	69.34	79.34	88.03	98.03	110.03	121.37	136.37	153.87	173.87	193.62			
6.30	45.16	50.46	55.72	62.47	69.77	78.21	89.45	99.38	110.63	124.12	137.08	153.95	173.62	196.11	218.67	246.78		
7.10		57.03	63.00	70.60	78.84	88.34	101.01	112.36	125.02	140.23	155.03	174.03	196.20	221.54	247.29	278.29	310.63	
8.00			71.20	79.76	89.04	99.74	114.00	126.95	141.22	158.34	175.23	196.63	221.60	250.14	279.49	315.16	350.83	393.63
9.00				89.94	100.37	112.40	128.45	143.17	159.22	178.47	197.67	221.74	249.82	281.91	315.27	355.38	395.50	443.63
10.00					111.70	125.06	142.89	159.39	177.22	198.61	220.12	246.85	278.04	313.69	351.05	395.60	440.16	493.63
11.20						140.26	160.22	178.86	198.81	222.76	247.05	276.98	311.91	351.82	393.98	443.87	493.76	553.64
12.50							178.99	199.94	222.21	248.93	276.22	309.63	348.60	393.13	440.49	496.16	551.83	618.64
14.00								224.27	249.21	279.13	309.89	347.29	390.93	440.80	494.16	556.49	618.83	693.64
16.00									285.20	319.39	354.77	397.51	447.37	504.35	565.71	636.94	708.17	793.64

Aluminium, Grade 2 Enamel, Nominal Weight per 1000 Metres (kg)

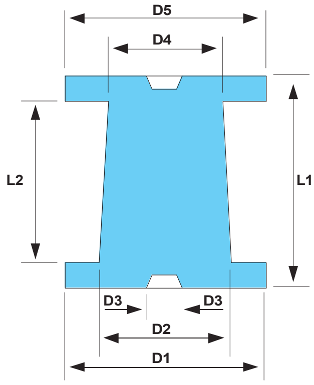
Thickness

Width

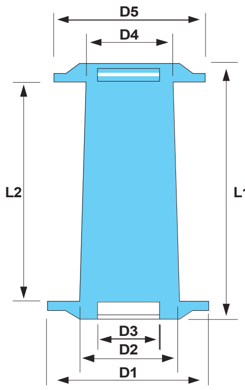
mm	0.80	0.90	1.00	1.12	1.25	1.40	1.60	1.80	2.00	2.24	2.50	2.80	3.15	3.55	4.00	4.50	5.00	5.60
2.00	4.59	5.05	5.50	6.18	6.91	7.75												
2.24	5.16	5.69	6.20	6.96	7.77	8.71	9.96											
2.50	5.78	6.38	6.96	7.80	8.71	9.75	11.14	12.14										
2.80	6.49	7.17	7.84	8.77	9.78	10.95	12.51	13.66	15.22									
3.15	7.32	8.10	8.86	9.91	11.04	12.35	14.09	15.44	17.18	19.28								
3.55	8.27	9.16	10.03	11.20	12.48	13.95	15.91	17.47	19.43	21.78	23.83							
4.00	9.34	10.35	11.34	12.66	14.09	15.75	17.95	19.75	21.96	24.60	26.96	30.27						
4.50	10.53	11.67	12.80	14.28	15.89	17.75	20.22	22.29	24.77	27.73	30.45	34.16	38.48					
5.00	11.72	13.00	14.26	15.90	17.69	19.74	22.49	24.83	27.57	30.87	33.93	38.04	42.85	48.33				
5.60	13.15	14.58	16.01	17.85	19.84	22.14	25.21	27.88	30.95	34.63	38.11	42.71	48.08	54.21	60.28			
6.30	14.81	16.44	18.05	20.12	22.36	24.94	28.39	31.43	34.88	39.01	42.99	48.16	54.19	61.08	67.99	76.61		
7.10		18.56	20.38	22.71	25.23	28.14	32.02	35.49	39.37	44.02	48.56	54.38	61.16	68.92	76.81	86.50	96.20	
8.00			23.01	25.63	28.46	31.74	36.10	40.06	44.43	49.66	54.83	61.38	69.01	77.74	86.72	97.63	108.54	121.63
9.00				28.87	32.06	35.73	40.64	45.14	50.04	55.93	61.80	69.15	77.74	87.54	97.74	110.00	122.26	136.97
10.00					35.65	39.73	45.18	50.22	55.66	62.19	68.77	76.93	86.46	97.35	108.76	122.37	135.98	152.31
11.20						44.53	50.62	56.31	62.40	69.71	77.13	86.27	96.93	109.11	122.98	137.21	152.44	170.71
12.50							56.52	62.91	69.71	77.86	86.19	96.38	108.26	121.85	136.30	153.29	170.27	190.65
14.00								70.53	78.13	87.26	96.64	108.04	121.35	136.56	152.83	171.84	190.85	213.66
16.00									89.37	99.79	110.57	123.60	138.79	156.16	174.86	196.57	218.28	244.33



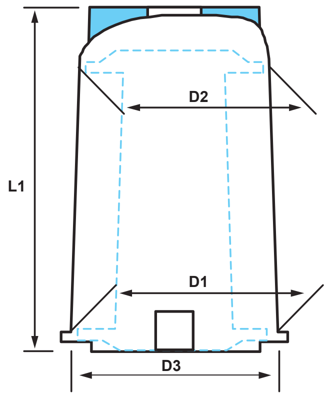
Horizontal Take Off Spools			Dimensions						
Type of Spool	**Payload Capacity CU**	**AL**	**D1**	**D2**	**D3**	**D4**	**D5**	**L1**	**L2**
HS 32	32	10	315	220	36	220	315	209	165
HS 48	48	15	339	220	36	220	339	269	225
HS 120	100	35	500	315	36	315	500	250	180
HS 150	150	50	500	220	36	220	500	265	225



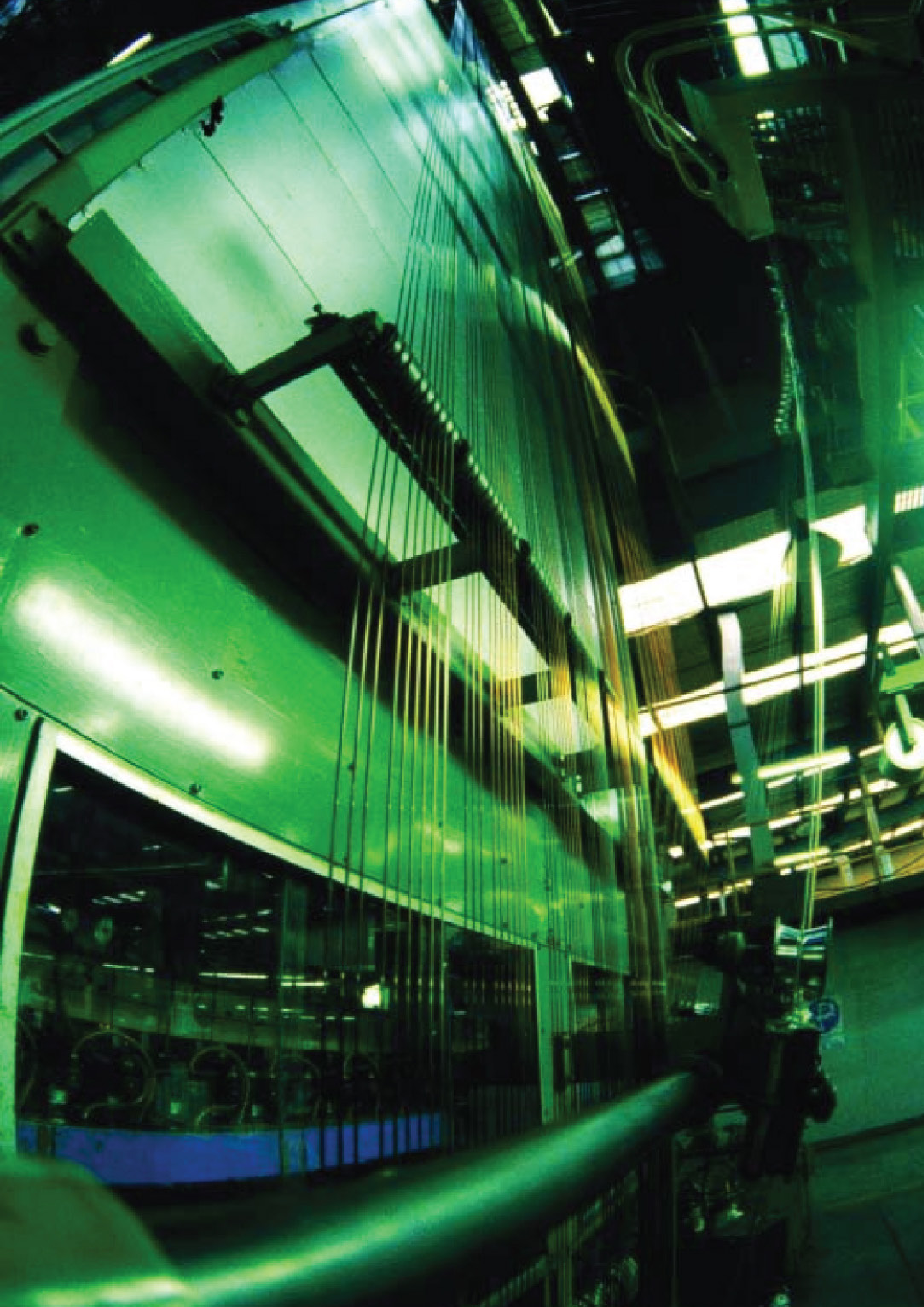
Vertical Take Off Spools			Dimensions						
Type of Spool	**Payload Capacity CU**	**AL**	**D1**	**D2**	**D3**	**D4**	**D5**	**L1**	**L2**
VS 15	15	5	200	110	35	96	180	230	200
VS 27	27	10	245	165	35	150	230	280	250
VS 70	60	20	315	220	100	200	300	414	370
VS 110	95	30	340	220	100	200	328	414	370



Vertical Din 46383 Take Off Spools			Dimensions						
Type of Spool	**Payload Capacity CU**	**AL**	**D1**	**D2**	**D3**	**D4**	**D5**	**L1**	**L2**
VS 45	45	15	250	160	100	140	236	400	335
VS 90	90	30	315	200	100	180	300	500	425
VS 180	180	60	400	250	100	224	375	630	530
VS 400	400	135	500	315	100	280	475	800	670



DIN 46383 Dome Cover		Dimensions			
Type of Dome	**Spool Accom.**	**D1**	**D2**	**D3**	**L1**
DM 45	VS 45	280	270	315	500
DM 90	VS 90	355	338	400	630
DM 180	VS 180	450	428	500	800
DM 400	VS 400	545	508	581	985



Maximum Winding Tension

The unwinding of the wire from the spool must be carried out properly in order not to damage the wire. Winding and unwinding tensions are of paramount importance. They must be constant during the entire manufacturing process. Wire tension measurements are usually performed by means of tensiometers which feature instantaneous tension readings.

Recommendations When Using Quality Magnet Wire
During Storage

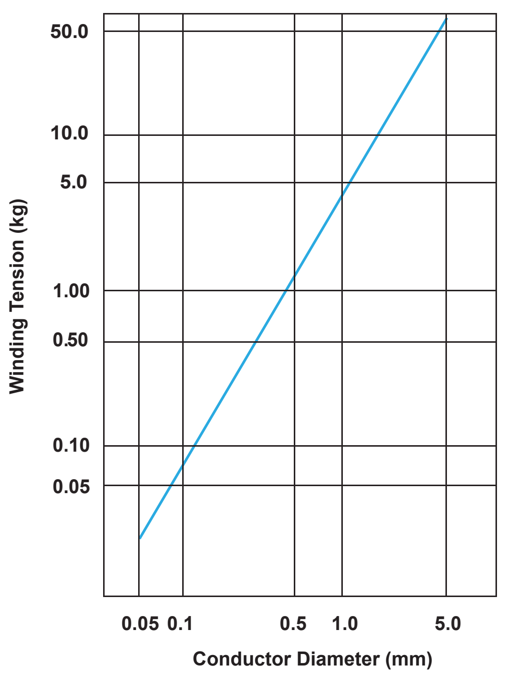
- Keep the wire well packed and dry.
- Keep the wire clean, especially free of metal based dust.
- Avoid exposure to direct sunlight.
- Do not store wire near solvents.
- Do not store in high temperature atmospheres.
- Avoid mechanical damage.

Enamel Removal

- Various methods can be applied to remove enamel from the conductor.
- Scrape off using sandpaper, a blade or mechanical stripper.
- Scrape off using stripper solution.
- Peel off after soaking in alkaline solution.
- Burn off provided it is quenched in 50% alcohol 50% water solution to prevent oxidation.

Coiling

- Minimise changes in direction of the wire path.
- Use large diameter sheaves rather than bushes.
- Use ceramic on wear surfaces.
- Winding tension should be regularly checked.
- Avoid tensions that cause high temperature friction or work hardening of the wire.
- Regularly check points of possible wear on the winding machines and in particular on the wire path.
- When a spool cover also serves as a take- off, use a polished steel collar in the top of the cover to ensure a perfectly smooth exit surface. Refer diagram.



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