Ferrites and accessories

Processing notes

Date: September 2006

1 Gapped and ungapped ferrite cores

Even with the best grinding methods known today, a certain degree of roughness on ground surfaces cannot be avoided, so that the usual term “without air gap” or “ungapped” does not imply no air gap at all. The A_L values quoted allow for a certain amount of roughness of the ground faces. The tolerance of the A_L value for ungapped cores is –20 to +30% or –30 to +40%. Closer tolerances are not available for several reasons. The spread in the A_L values of ungapped cores practically equal the spread in ring core permeability (±20% … ±30%), and the A_L value largely depends on the grinding quality of the matching surfaces.

The following are normally defined:

precision-ground/lapped cores	s_{resid}	≈ 1 µm
normally ground cores	s_{resid}	≈ 10 µm
gapped cores	s	≥ 10 µm

The residual air gap s_{resid} here is the total of the residual air gaps at the leg or centerpost contact surfaces.

With increasing material permeability the influence of the inevitable residual air gap grows larger. The spreads in the A_L value may also be increased by the mode of core assembly. Effects of mounting and gluing can result in a reduction of the A_L value. An appropriate wringing of cores with polished surface is used to improve reproducibility of the measurement (it is recommended to rub the mating surfaces themselves six times in a circular or elliptic arc that matches the core profile before measuring A_L).

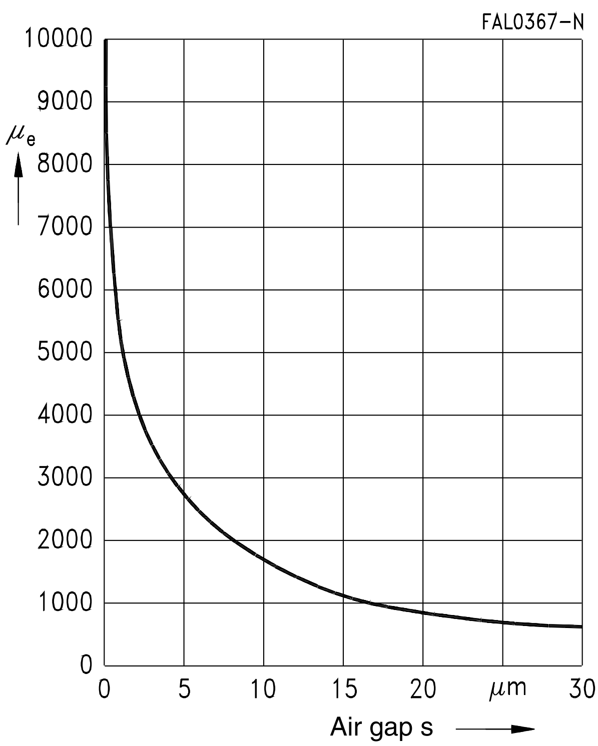


Figure 25
Relationship between permeability μ_e and air gap s for an RM 4/T38 ferrite core

2 Processing notes for the manufacture of wound products for small-signal and power applications

2.1 Winding design

For the most common core types the maximum number of turns for the individual coil formers can be seen from the following nomograms. The curves have been derived from the equation

$$N = \frac{A_N}{A_{wire}} \cdot f_{Cu}$$

where

N	Max. number of turns
A_N	Winding cross section in mm^2
A_{wire}	Wire cross section in mm^2
f_{Cu}	Copper space factor versus wire diameter (f_{Cu} approx. 0.55 for wire diameter 0.05)

Common wires and litz wires are specified in the pertinent standards (IEC 60317).

As can be seen from Figure 26, as high a winding level as possible should be employed because at low μ_e values in particular a low winding level (h/H ratio) can cause an A_L drop of up to 10% compared to the maximum value with full winding. (By our standards, the A_L values are always related to fully wound 100-turn coils.)

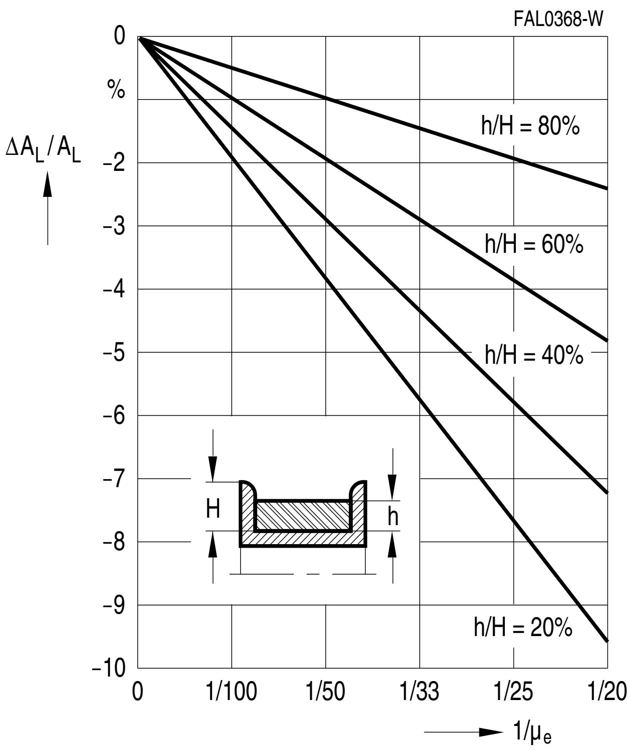
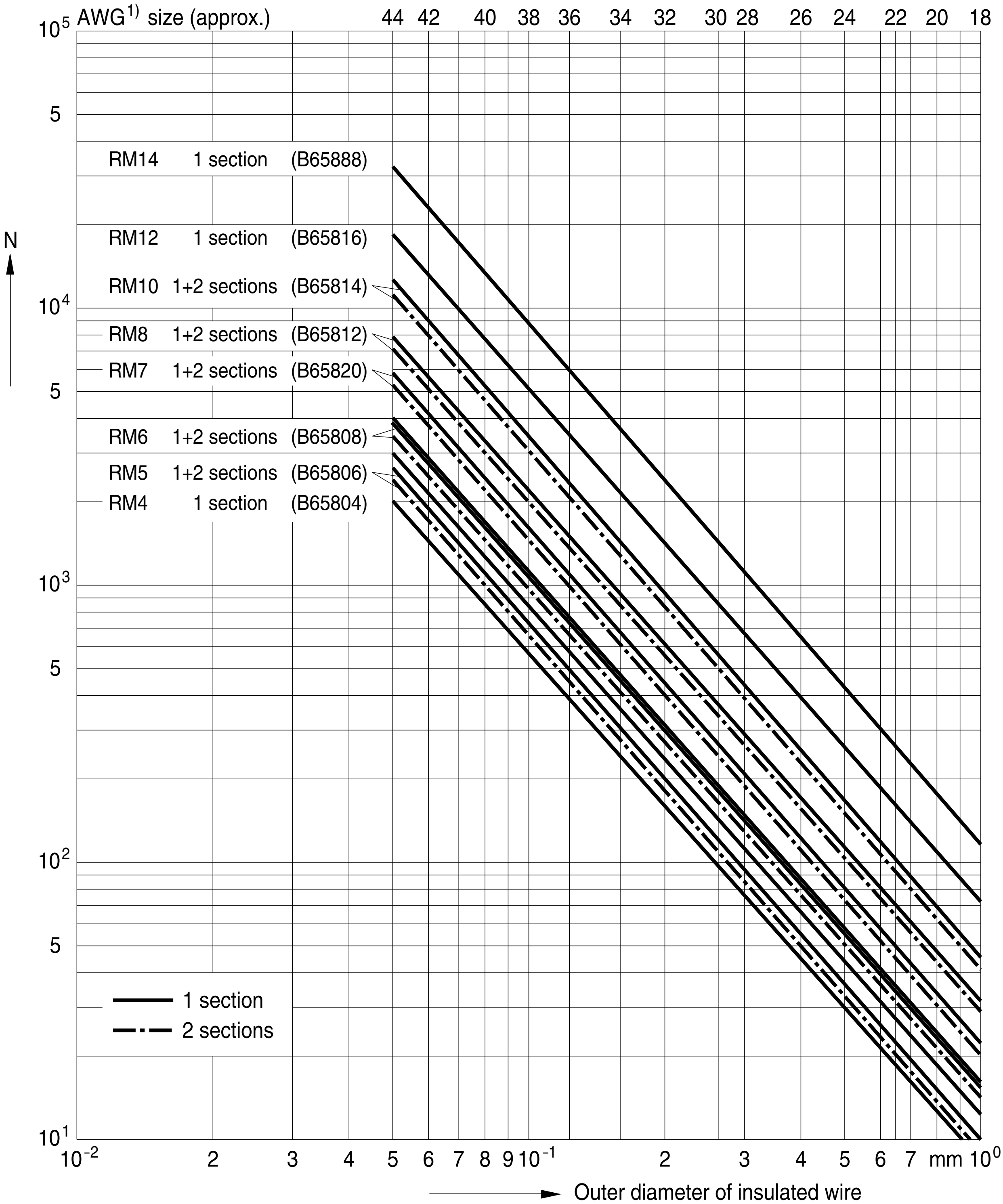


Figure 26
Percentage change in A_L value versus relative winding height h/H

RM cores

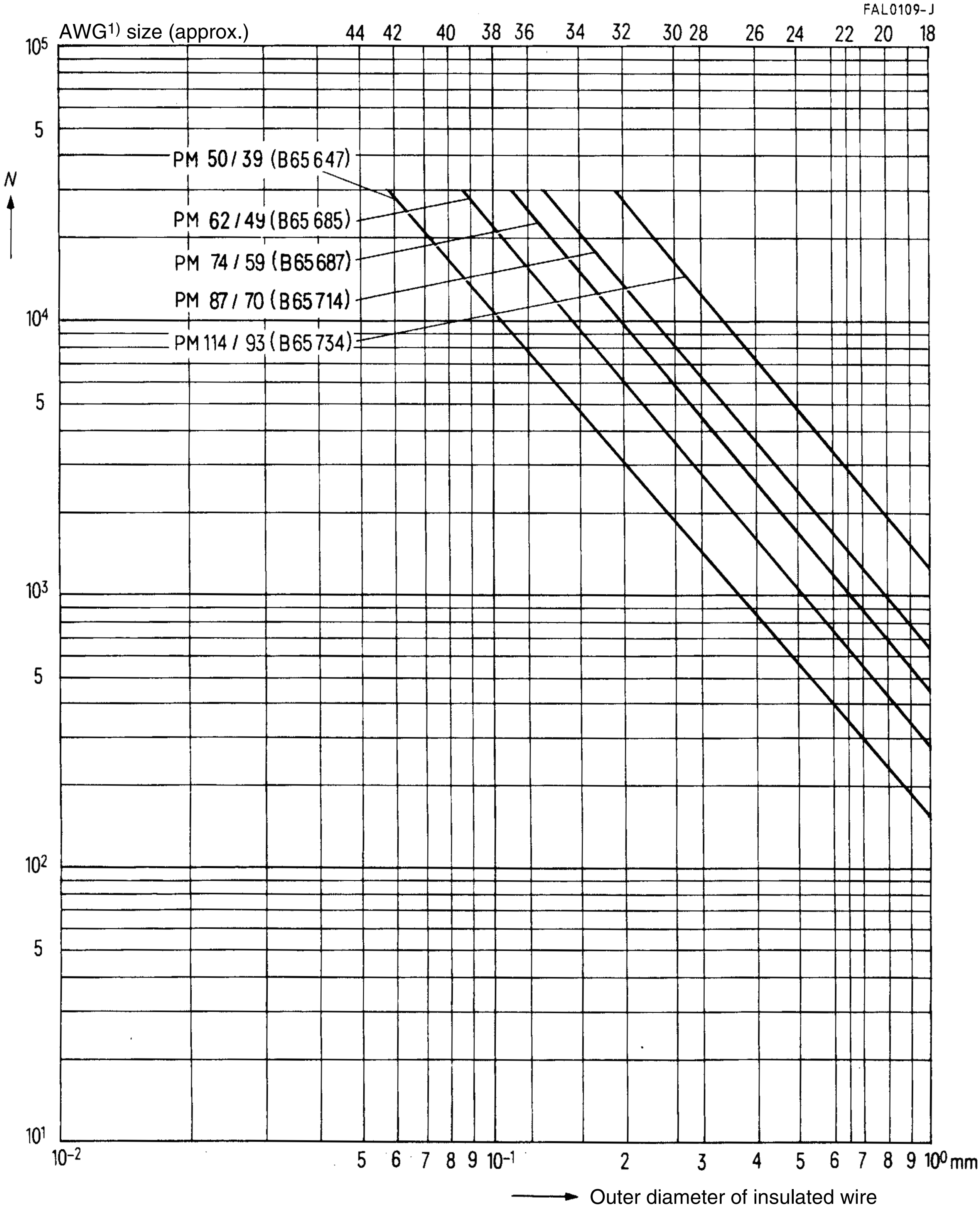
Maximum number of turns N for coil formers



1) American Wire Gauge (AWG)

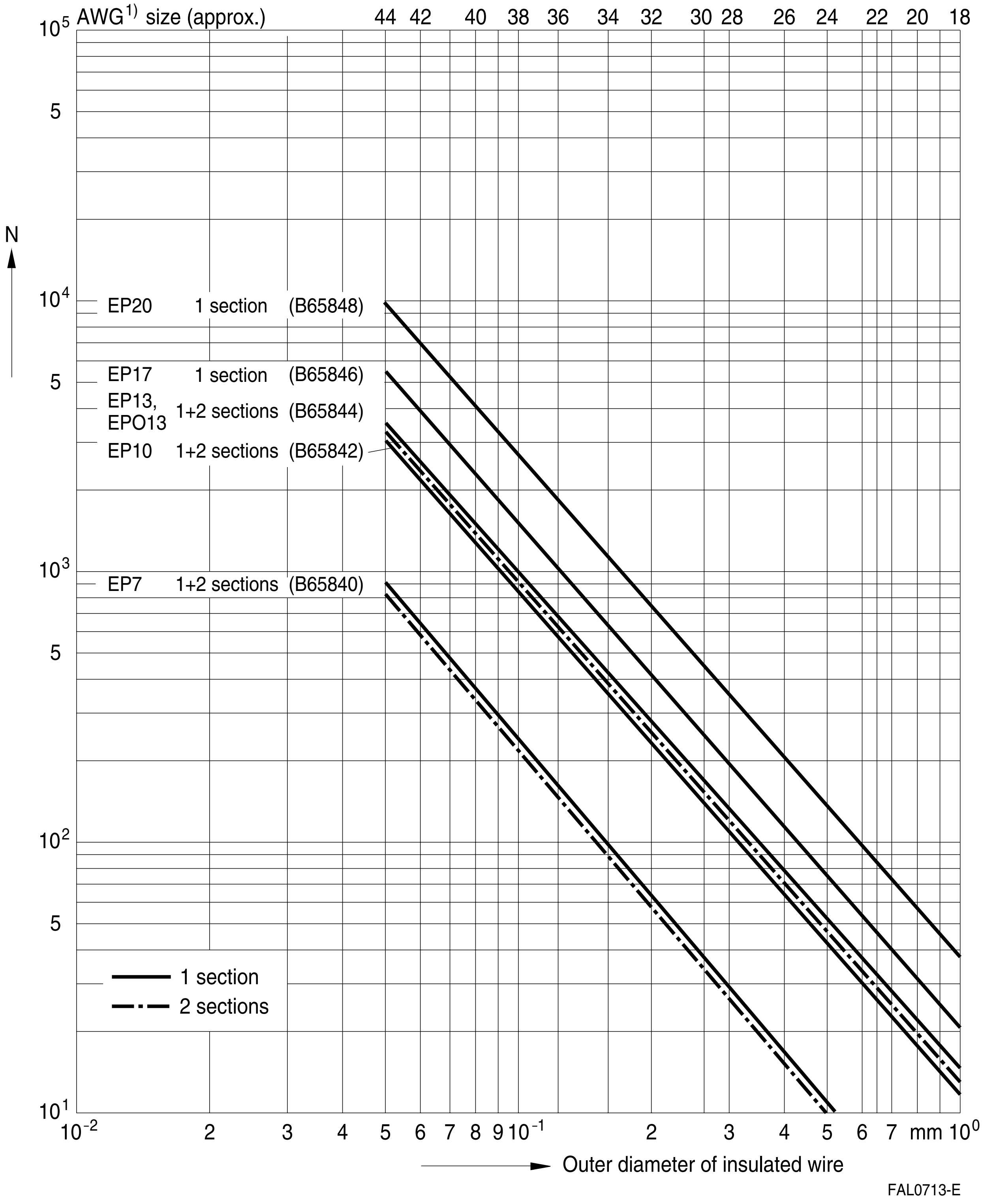
PM cores

Maximum number of turns N for coil formers



1) American Wire Gauge (AWG)

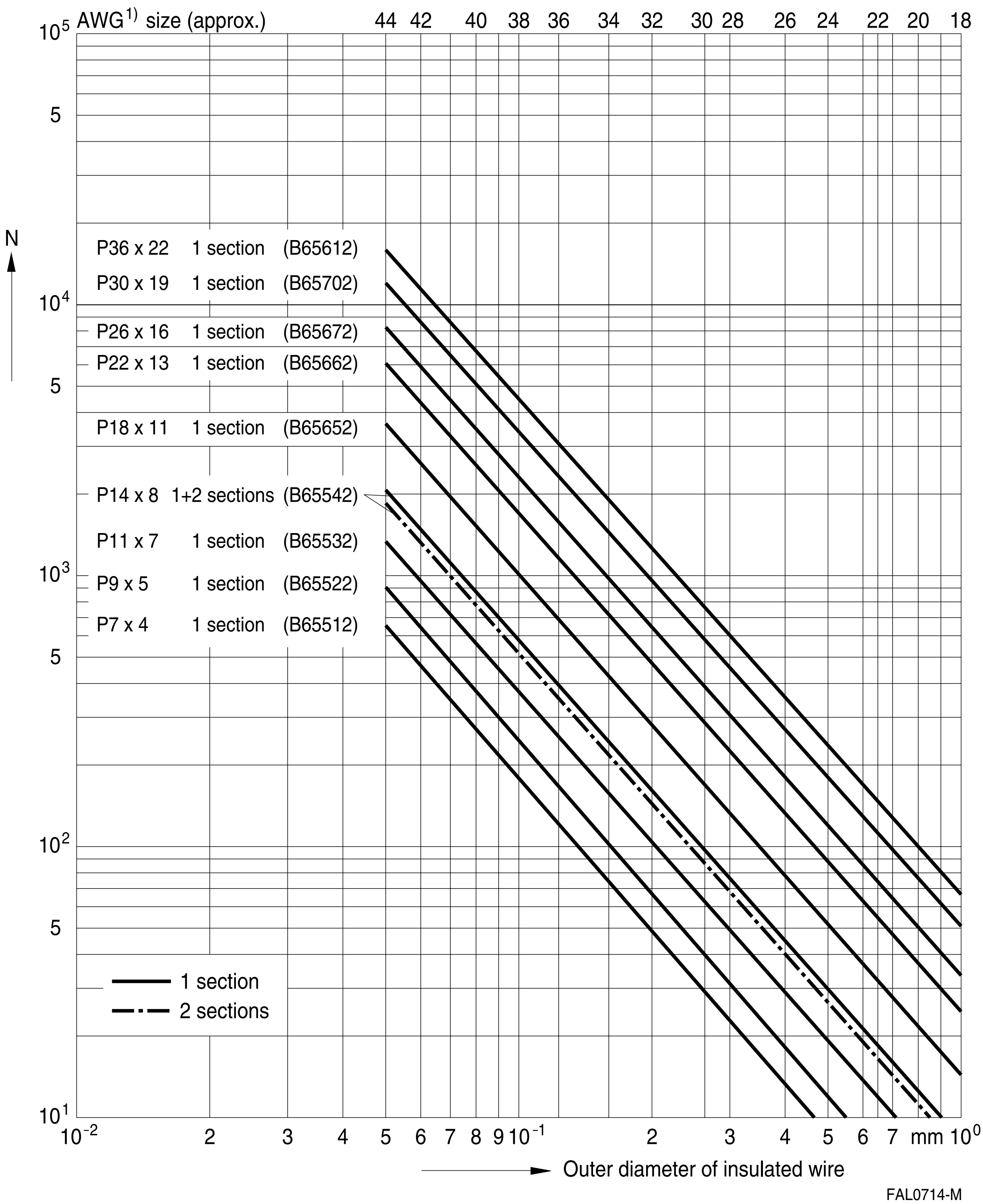
EP cores
Maximum number of turns N for coil formers



1) American Wire Gauge (AWG)

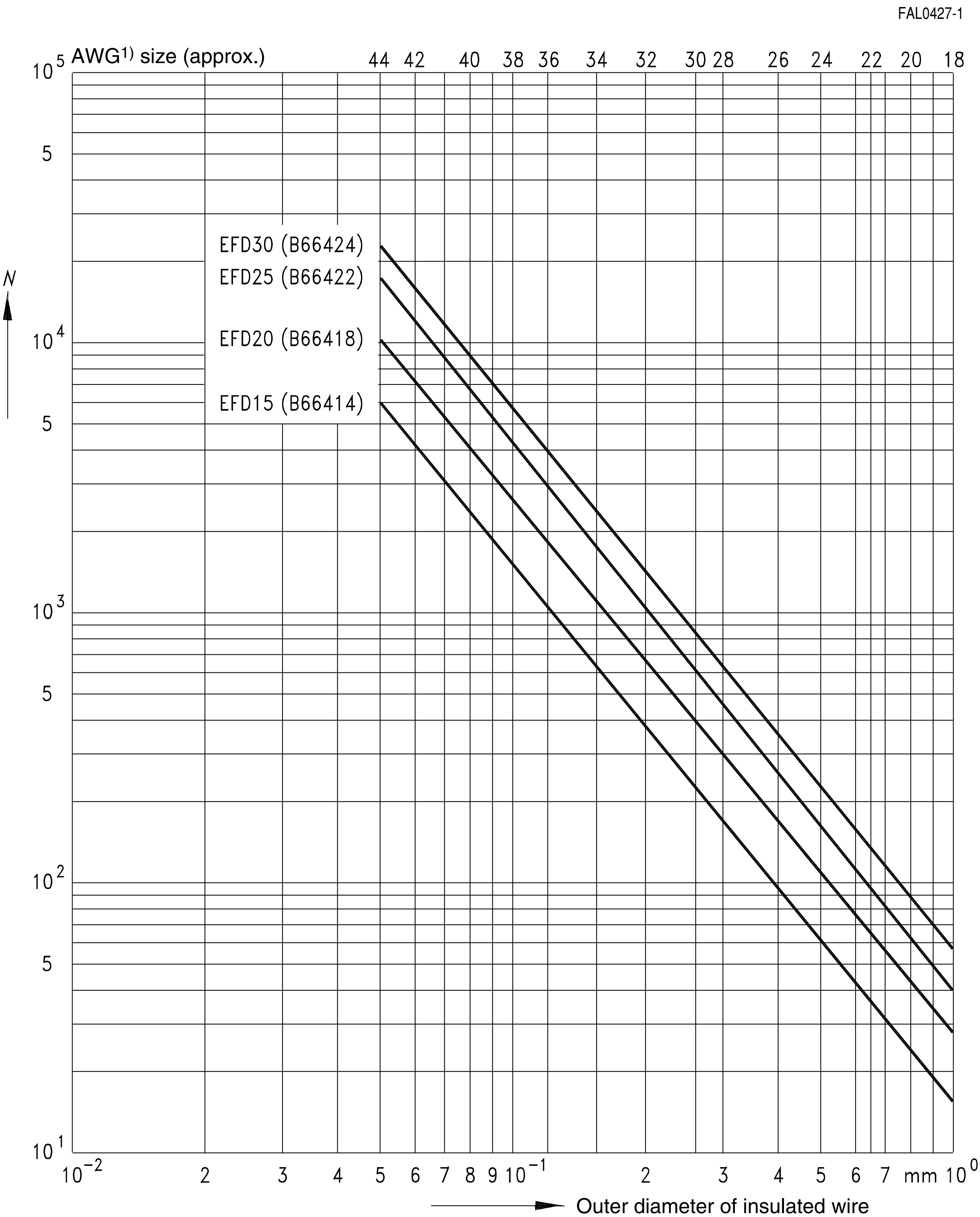
P cores

Maximum number of turns N for coil formers



1) American Wire Gauge (AWG)

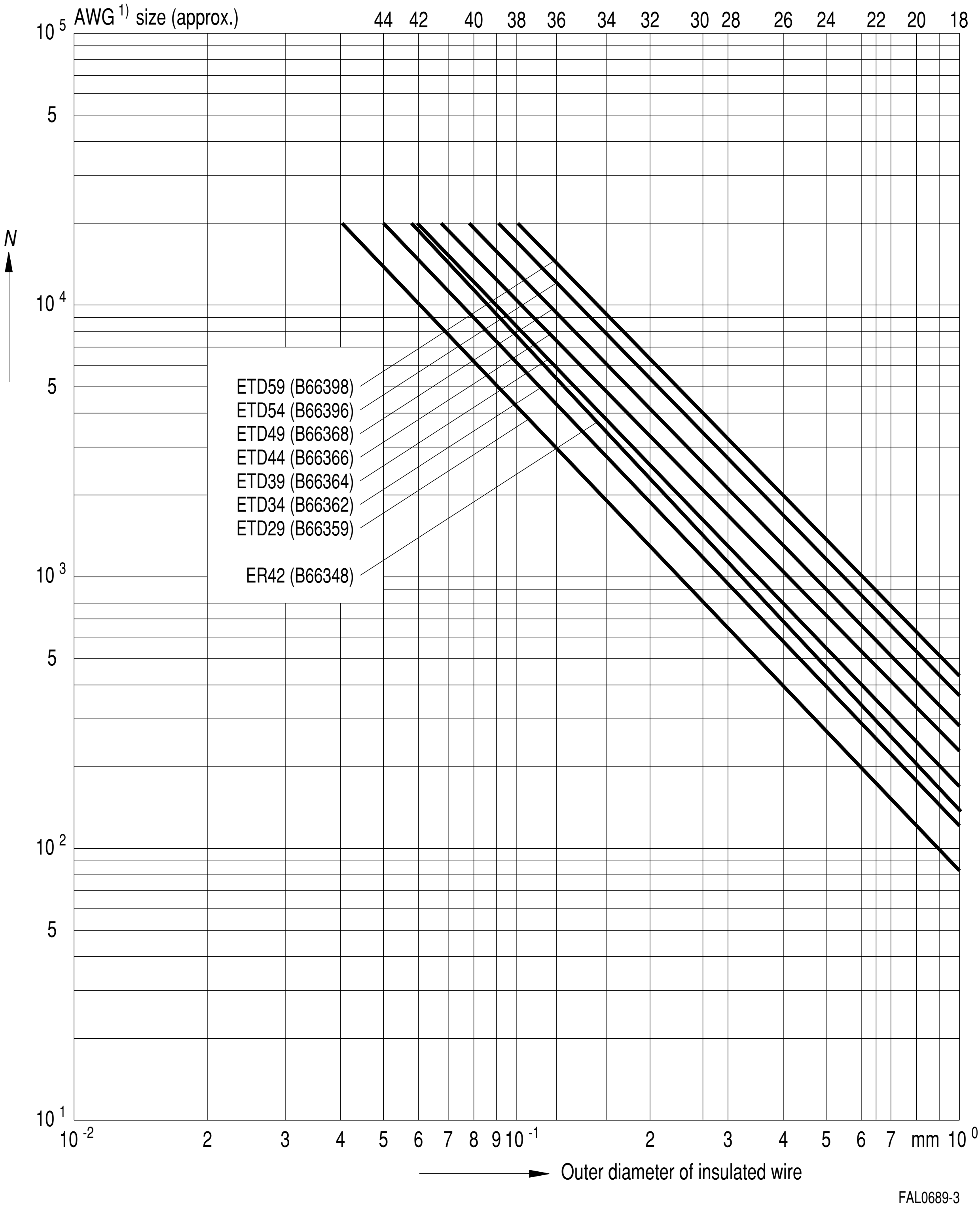
EFD cores
Maximum number of turns N for coil formers



1) American Wire Gauge (AWG)

ETD and ER cores

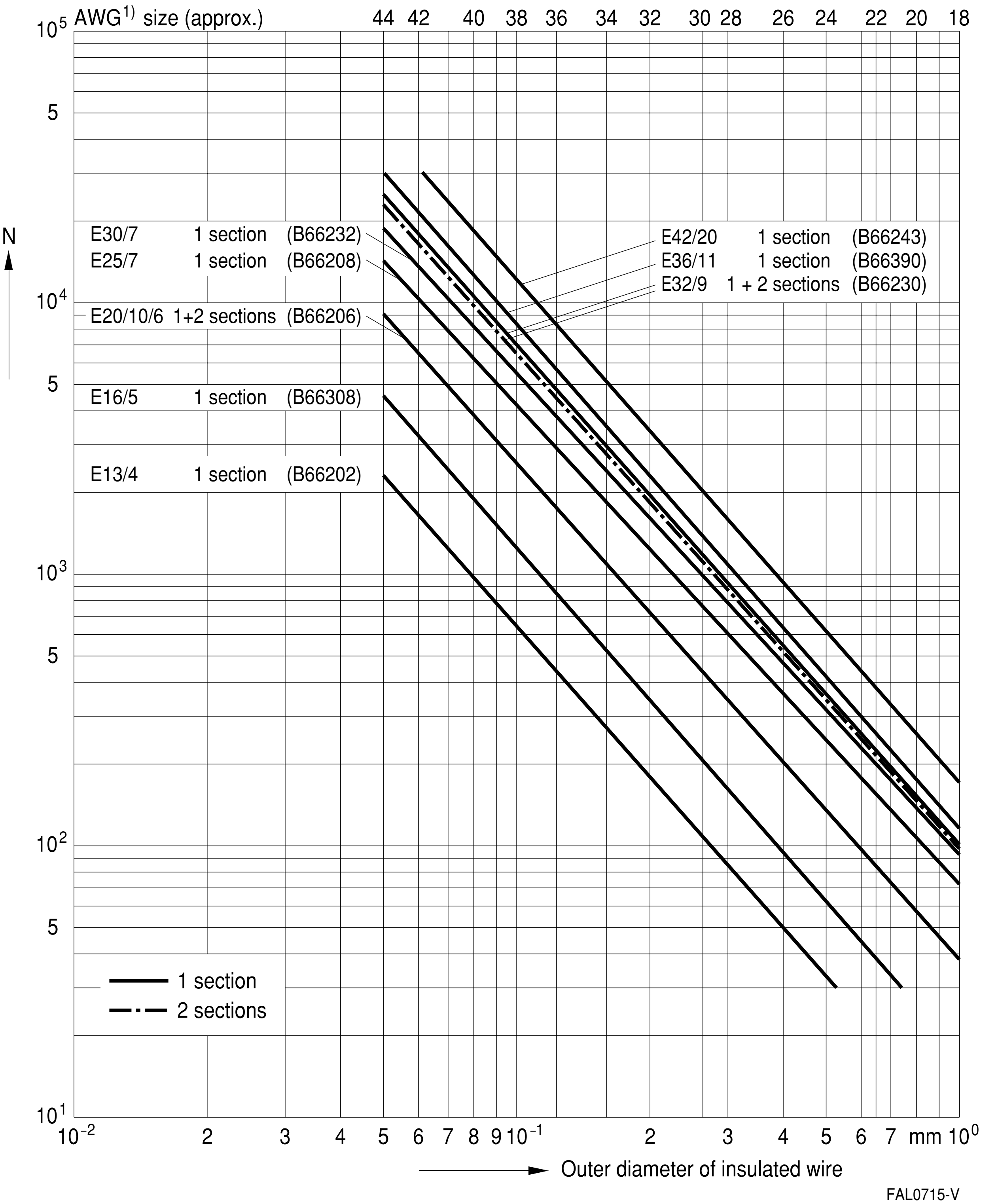
Maximum number of turns N for coil formers



1) American Wire Gauge (AWG)

E cores

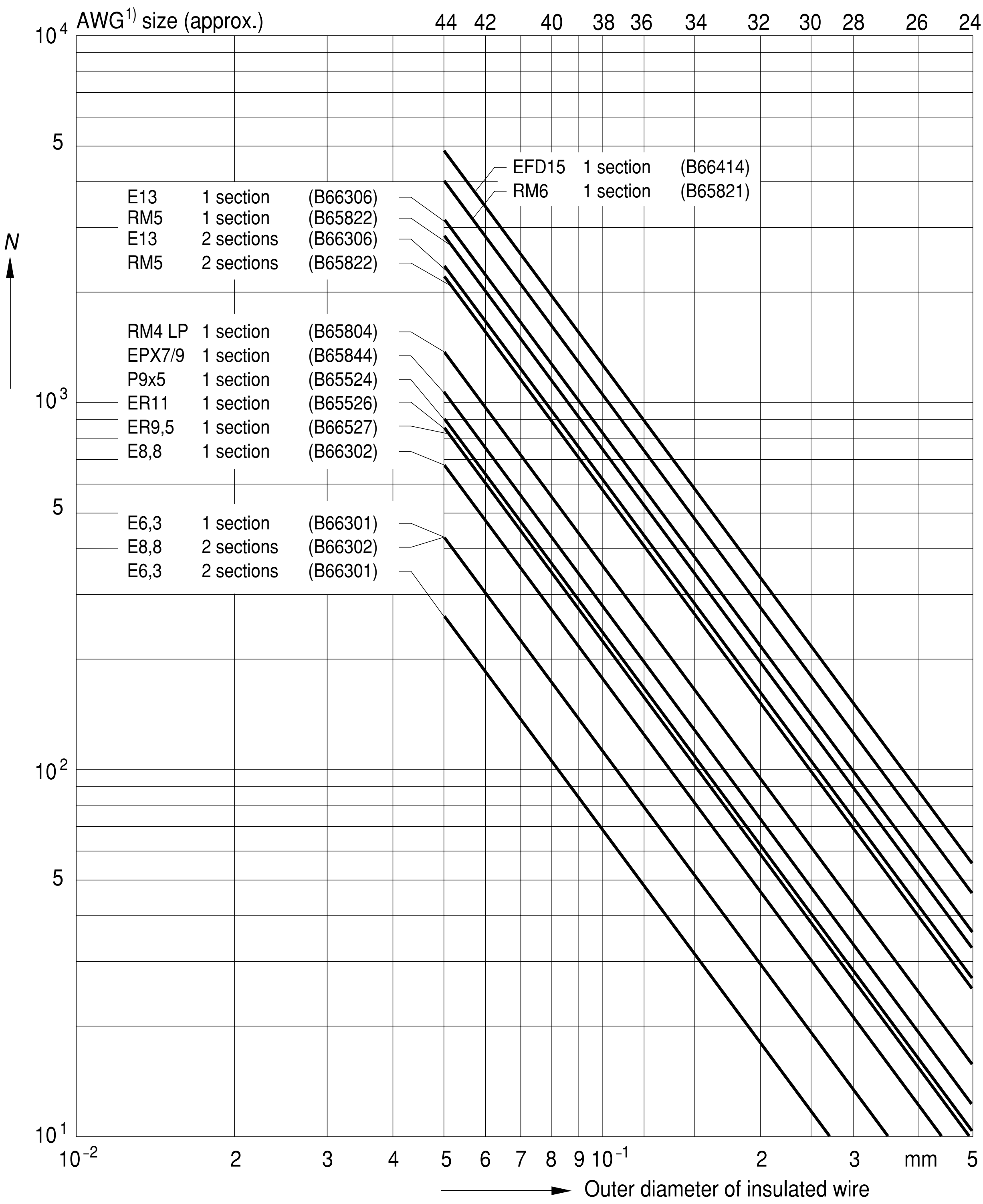
Maximum number of turns N for coil formers



1) American Wire Gauge (AWG)

SMD types

Maximum number of turns N for coil formers



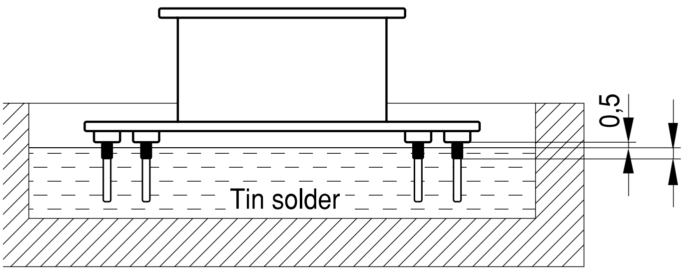
1) American Wire Gauge (AWG)

2.2 Soldering/Inductor assembly

The winding wires are preferably connected to the pins by dip soldering. Note the following when soldering:

– Prior to every dip soldering process the oxide film must be removed from the surface of the solder bath.
– 2 to 3 turns of the wire are dipped into the solder bath; the coil former must not be allowed to come too close to the solder or remain there for too long (see diagram).
– Typical values are: Bath temperature: 400 °C, soldering time: 1 s.

Soldering of PTH (pin through hole)



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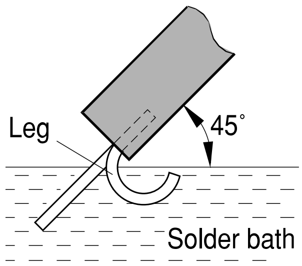
Soldering of J-leg



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For inductor assembly, it is advisable to clamp the cores with the associated relevant mounting assemblies for the coil formers and cores. In this way it is possible to avoid the effects of external mechanical stress.

2.3 Design and processing information for SMD components

2.3.1 Automatic placement

EPCOS ferrite accessories are suitable for automatic placement. Many automatic placement machines pick up the components with suction probes and pliers, so the inductive components should have simple and clear contours as well as a sufficiently large and flat surface. Ferrite cores with a perpendicular magnetic axis, e.g. RM and ER cores, have a smooth surface and the flange for the coil former is styled right for the purpose. For cores with a horizontal magnetic axis, e.g. E cores and toroids, we provide cover caps to meet these requirements.

2.3.2 Coplanarity

Coplanarity means the maximum spacing between a terminal and a plane surface. If inductive components are fabricated with coplanarity of <0.2 mm for example, then one or more terminals may be spaced maximally 0.2 mm from a plane surface.
Inductive components are fabricated to standard with coplanarity of <0.2 mm. Coplanarity is influenced by a number of factors:

a) Coil former specification
The coplanarity of the coil former is <0.1 mm for manufacturing reasons.

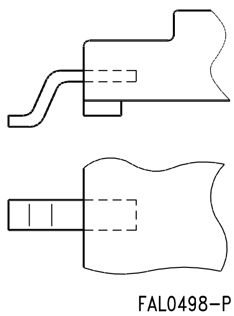
b) Winding wire
Use of thick winding wire (e.g. 0.25 mm diameter in model ER 11) leads to considerable mechanical strain on the terminal during winding, and this can degrade coplanarity.

c) Soldering temperature and duration
When winding wire is soldered to a terminal, the coil former is subjected to high thermal stress. If thick wires have to be soldered, the soldering temperature and/or duration increase and thus the thermal stress on the coil former too. This also degrades coplanarity.

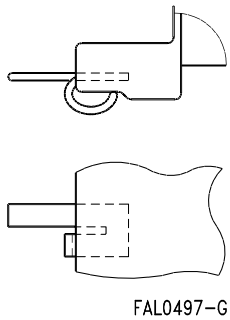
Consequently the use of thick wires degrades coplanarity in two ways: greater mechanical strain when winding, and greater thermal stress during soldering.

If electrical requirements call for the use of thick wires, either the manufacturing effort is greater (it takes longer and the costs are higher), or a terminal geometry has to be chosen that is suitable for the use of thick wires. EPCOS offers two different SMD lead geometries: gullwings and J terminals.

Gullwing terminals



Molded-in J terminals



With gullwings the wire is wound direct on the terminal, which is then soldered on the circuit board. With J terminals the wire is wound on a separate pin, and the J terminal is soldered to the circuit board.

So gullwings are suitable for applications with thin wire (up to approx. 0.18 mm in diameter), and J terminals for use with thick wire (upwards from 0.18 mm in diameter). These figures for wire diameter are only intended as guidelines. Depending on wire diameter, the winding arrangement, the pinning and electrical requirements, one has to decide from case to case which solution is best for the particular application.

2.3.3 Solder paste application

Coplanarity has to be considered when determining the thickness of the solder paste. If coplanarity is <0.2 mm for example, the solder paste has to be applied at least 0.2 mm thick to ensure proper soldering.

2.4 Gluing

The mating surfaces must be free of dust, grease and fibers. From the numerous adhesives available, epoxy resins with appropriate hardeners have proved particularly suitable. The following adhesives can be recommended:

a) for cores:
100 g Araldite AY 103
16 g hardener HY 956
Pot life 1 hour max.
Curing 3 hours at 60 °C
Thermal stability of the glued joint 60 °C
(for a short period 90 °C)

b) for cores:
100 g Araldite AY 103
40 g hardener HY 991
Pot life 1 hour
Curing 60 minutes at 80 °C
Thermal stability of the glued joint 80 °C

c) for cores:
100 g Araldite AY 105-1
50 g hardener HY 991
Pot life approx. 1 hour
Curing 45 minutes at 80 °C
Thermal stability of the glued joint 100 °C

d) for coil formers:
100 g adhesive a)
200 cm^3 filler Aerosil 200
Curing same as a)

e) for external gluing:
Single-component adhesive AV 118
Open pot life
Curing 10 minutes 180 °C
20 minutes 160 °C
45 minutes 140 °C
Thermal stability of the glued joint 120 °C

(Manufacturer of adhesives a) – e): Vantico (former Ciba Geigy)

2.5 Adhesive application and core mating

A quantity of adhesive appropriate to the area in question is applied to the cleaned surface of the core's side walls. The centerpost must remain free of adhesive. The two core halves without coil former are then placed on a mandrel and rotated against each other two or three times to spread the adhesive. A slight ring of adhesive exuding around the edges indicates that sufficient adhesive has been applied.

On porous, low-permeability SIFERRIT materials (K) the adhesive should be applied and spread twice.

The next step should follow immediately since the adhesive film easily attracts dust and absorbs moisture. Therefore, the core pair with adhesive already applied is opened for a short time and the wound coil is inserted without touching the mating surfaces.

The wound coil is then fixed into position. This can be done by using resilient spacers which must be inserted before applying the adhesive. Appropriate spacers are available on request.

The coil former can also be fixed by gluing, e.g. using adhesive d), but only at one spot on the core bottom to avoid any mechanical stress caused by the difference in thermal expansion of core and coil former.

Adhesive e) is suitable for external gluing, which implies only four dots of adhesive at the joints on both sides of the openings. Because of the somewhat lower torsional strength, it should be noted that this kind of gluing should only be used with mounted cores.

2.6 Holding jigs

The core assembly is cured under pressure in a centering jig. The core center hole – where present – is used for centering, and two to eight coils can be held in one jig with a pressure spring. Spacers will ensure that the pressure is only exerted on the side walls of the core.

Single jigs facilitate the coil inductance measurement, which has proved useful for checking cores with small air gaps before the adhesive has hardened. Small inductance corrections can be made by slightly turning the core halves relative to each other.

2.7 Final adjustment

(possible only with adjustable cores)

With all assembled ferrite cores, a magnetic activation takes place as a result of mounting influences such as clamping, gluing and soldering, i.e. a disaccommodation process commences. Therefore the final adjustment for high-precision inductors should take place no earlier than one day after assembly; preferably, one week should first elapse.

2.8 Hole arrangement

For drilling the through-holes into the PC board we recommend the dimensions given in the hole arrangement for each coil former, which depend on the distance of the pins on the pin outlet level.

2.9 Creepage and clearance

For telecom transformers the clearance and creepage distances and the thickness of insulation must be considered acc. EN 60950 subclause 2.9.