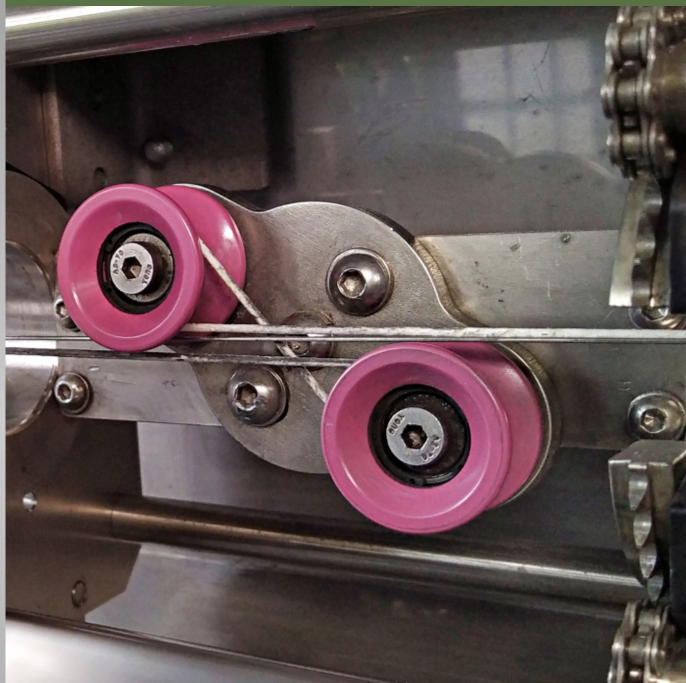
Boockmann
Engineering GmbH

2024



HELILUB®

Made in Germany

www.boockmann.com

HELILUB®

HELICORD®

THE ORIGINAL

Table of Contents

I. HELILUB®

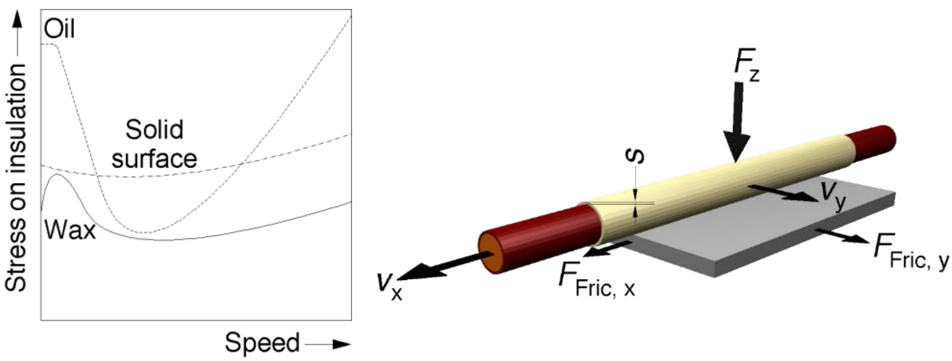
1 Basics of Magnet Wire Lubrication

Magnet wire processing requires lubrication for the following reasons:

- Protecting wire and insulation
- Increasing production speed
- Protecting winding tools
- Increasing density of windings

1.1 Mechanics of Magnet Wire Handling

Imagining an enameled wire which is pressed to a plane with a load F_z, the friction force to overcome in order to move the wire is a function of F_z. For dry, solid sliding surfaces, the friction force is independent of the speed *v* of the movement (fig. 1), which is also true for wires lubricated with wax or wax-like materials. Lubrication with oil or grease results in viscous floating which is dependent on the speed of movement.



Sliding on solid surface: $F_{Fric} = f(F_z)$

Floating on viscous oil: $F_{Fric} = f(1/s; v)$

$s = f(1/F_z; v)$

Fig. 1: Lubrication and friction force

For high winding speeds and winding density, often a solid dry sliding surface is required. This can be achieved, with limited success, by self-sliding enamels or, more successfully, by polishing with solid sliding agents, mainly paraffin and waxes.

Oily lubricants tend to drain out of the delivery spool. Like grease or high amounts of relatively low melting wax, oil absorbs dust, and coatings with these materials cannot withstand the high specific pressures between crossing wires due to their viscous behavior. Thus their application is mainly preferred for the insertion technique in motor production etc..

The coefficient of friction, as well as the sliding properties, windability, and insertability each show optima depending on lubricant quantity. Unfortunately, these optima often are not located in the same range of quantity and thus must be determined by experience.

Wire insulation		Coeff. of friction with ester wax lubrication	Coeff. of friction with paraffin lubrication
Ester-Imide	-	0.11	0.13
Ester-Imide	Amide-Imide	0.09	0.11
Ester-Imide	Amide-Imide with internal lubrication	0.07	0.09
Various, PUR included	PA-6.6 Overcoat	0.06	0.08
Self-bonding varnish	-	0.14	0.16

Table 1: Dynamic coefficient of friction for different combinations of insulating and lubricating materials determined according to Parussel [4]

The dynamic coefficient of friction, measured between a wire and a steel plate (Parussel [4]), is indicated in table 1 for different enamel materials and waxes. It is a material property of the applied lubricant, influenced by the wire insulation material.

Due to the strong dependence of the coefficient of friction from the lubricant amount on the wire surface (figure 2), the quantity applied to the surface must be controlled within narrow limits. Additionally the lubricating process influences reliability and uniformity of the lubrication.

1.2 Reasons for New Lubrication Methods

Solvent-based lubricants consist of nearly 99 % of volatile organic compounds (VOC), which are usually released by ventilation systems of factories (fig. 3).

Fig. 3: Fumes released during solvent-based wire lubrication

Since governmental regulations (e.g. the European VOC regulation 1999-13-EC [5]) limit the amount of VOC emissions also specifically from magnet wire production, manufacturers can eliminate an important emission source by using solvent-free lubrication.

Additionally, with respect to ISO 14000, customers increasingly require programs for environmental protection from their magnet wire suppliers.

Furthermore, applied liquids including solutions of solid lubricants get stripped off the wire surface due to increased centrifugal forces on fast-turning guide rolls in high VD enameling machines, with an impact on process reliability and quality.

Solvent-free magnet wire lubrication reduces worker's health concerns from fumes and prevents severe workplace accidents as well as fire hazard.

In addition solvent induced attack on the wire enamel as well as on plastic spools are avoided.

1.3 Comparison of Technologies for Metering and Application of Lubricants on Magnet Wire

Magnet wire manufacturers are trying to better meet enhanced lubrication requirements of their customers. Being influenced by e.g. ISO 9001 or IATF 16949, users of magnet wire have individual and very specific demands regarding the type and quantity of the lubricant as well as consistency of lubrication. Some customers even require the possibility of recorded constant supervision of the lubricating process for magnet wire production.

Numerous possibilities of machinery, process and materials for lubrication of winding wires exist. Table 2 provides a comparative overview on various technical solutions.

The HELILUB® method first reported in 1993 [1], using pre-impregnated yarns, overcomes the problems of all felt systems by providing high consistency and reliability of lubricant application, and allows to constantly supervise the lubrication. Due to the easy change of lubricant quantity and material, the magnet wire producer can adjust the lubrication exactly to very specific customer requirements and offer customized products.

		Materials						
Dosage Principle	Means of polishing	Solutions 0.1 - 2% solids, conventional	Concentrates 5 – 50 % solids, dispersions	Water dispersion	Self-sliding enamels	Melts of lubricants	HELILUB®, Impregnated Yarns	Lubricant vapors
Level/ Capillarity	Felts	+						
Rollers	Felts	+	○	+		○		
Rollers	Rollers	+	+(1)			+(1)		
Valves	Felts	+	+(1)	○		+(1)		
Pump	Felts	+	+(1)	+		+(1)		
Pin	Felts Future: Rollers	+	+(1)			+(1)		
Yarn speed	Yarn	+	+	+			+	
Vapor temperature	Not necessary							+
Dual coat enameling	Not applicable				+			
(1) If heated reservoir and felts available							+ Good ○ Possible	

Table 2: Materials and devices for dosage and polishing for magnet wire lubrication [2]

Most important with respect to the lubricating process are the principles of applying a metered quantity (dosage) and the principles of polishing. This may limit the selection of applicable materials and their embodiment or aggregate state, as listed in table 2.

In table 3 a selection of important characteristics (e.g. with respect to environmental and safety impact, lubrication process and cost) of the different magnet wire lubrication methods is listed and rated.

Generally, it turns out that the technical ranking of the HELILUB® process is equal or superior to all other methods. The higher investment costs for HELILUB® will be compensated by the advantages of high precision, reliability and supervision of the lubrication even for high V×D enameling machines.

	Conventional felt solution, level or roller dosage	Solution felt pump dosage	Water felt	Internal	Vapor	Melt felt magnetic valve or pneumatic pump dosage	Melt felt pin dosage	HELILUB® Yarn
Environmental protection	–	–	+	+	+	+	+	+
Fire hazard	–	–	+	+	○	○	○	+
Health risks	–	–	+	+	○	○	○	+
Easy change of lubricant	–	–	–	– –	–	– / ○(1)	–	+
Quantity supervision	–	–	–	n/a	–	– –	– –	+
Quantity adjustment	–	○	○	n/a	○	○	○	+
Fine and ultra-fine wires	○	○	–	?	+	–	–	+
Low wire temperature	○	○	–	+	+	○(2)	○(2)	+
High wire temperature	+	+	+	n/a	– –	+	+	+
High VD	–(5)	–(5)	–(3, 5)	○	– ?	○	○	+
Tolerance for particle contamination	○	○	○	n/a	?	–	○	+
Reliability of polishing	–	–	–	+	+	–	–	+
Investment cost calculated on 3 year return of investment per average kg of wire (US-cent/kg)	0.2	1	1	n/a(4)	2	1 - 3	1	2
Material per average kg of wire lubricant, polishing, energy (US-cent/kg)	1	1	0.1	0.3	0.3	0.2	0.2	1

(1) If single dosage and application
(2) With pre-heating or concentrates
(3) Wetting and drying problems
(4) Low if dual coat applicator available
(5) Spraying loss of lubricant due to fast turning rolls

+ Good
n/a Not applicable
○ Possible
? No information
– Difficult
– – Not possible

Table 3: Comparison of different lubrication methods [2]

2 Principle of the HELILUB® Process

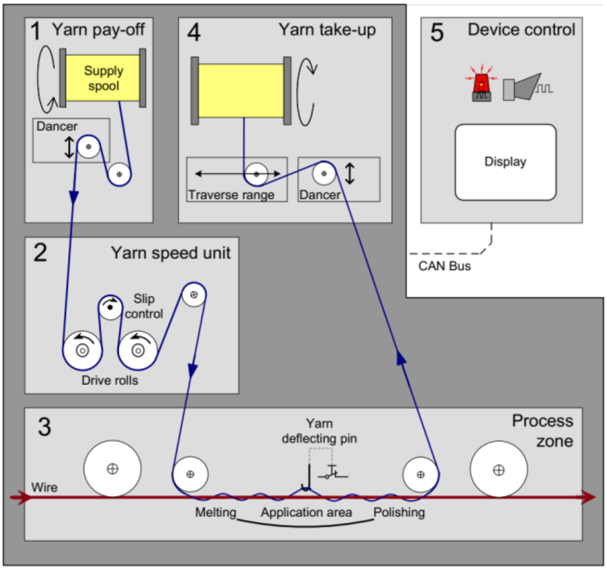


Fig. 4: Schematic of the HELILUB® process

The HELILUB® process is based on the application of lubricant to the surface of magnet wire by an impregnated cellulose yarn, wrapped around the wire several times and moved slowly in the same direction as the wire. The amount of lubricant applied is controlled by the calibration of the yarn and polished onto the wire surface by the yarn tension and speed difference between yarn and wire. The lubricant is extracted from the lubricating yarn using the wire temperature after the enameling oven. The lubricant quantity applied can be calculated from the difference in weights per meter of the lubricating yarn before and after the process.

HELILUB® offers the possibility to apply a large variety of lubricants, even high melting or insoluble ones, and to easily calculate and adjust the lubricant quantity.

It provides the following advantages:

- Exact lubricant dosage
- Easy calculation
- Easy to control
- Lowest coefficient of friction at high enameling speeds
- Constant supervision of lubrication
- Reliability in production on large delivery spools
- Lubrication interruption alarm

3 Calculation of Lubricant Metering and Yarn Consumption:

The applied quantity usually is around 20 mg/m², but can range from less than 6 to about 200 mg/m². The required process parameters are calculated as follows:

Symbol	Meaning	Data for example	Unit
M	Quantity of lubricant applied on the wire surface	18.5	mg/m²
G	Difference in weight of yarn per meter before and after application	60	mg/m
d	Diameter of the drive roll	17	mm
n	Rotation speed of the drive motor	1	min^{-1}
V	Wire speed	175	m/min
D	Wire diameter	0.375	Mm
F	Corrective factor for variable drive motor speed	1	

Table 4

Lubricant dosage: $M = \frac{G \times d \times n \times F}{V \times D}$

$$M = \frac{60 \ \times 17 \ \times 1 \ \times 1}{175 \ \times 0.315} \frac{mg}{m^2} = 18.5 \ \frac{mg}{m^2}$$

Yarn consumption: $q \approx \frac{V \times D \times M \times 3}{1000}$

$$q \approx \frac{55 \ \times 18.5 \ \times 3}{1000}$$

$$\approx 3 \ \frac{kg}{line \ \times year} \approx 12 \frac{Spools}{line \ \times year}$$

4 Industrial Applications of the HELILUB® Process

4.1 Standard application: Lubrication of Warm Wire

Figure 5a shows lubricators NB52G for standard applications. Models for wires with lower temperature (fig. 5b) and for fine wires (fig. 5c) are also available. The HELILUB® technology can be adapted to all magnet wire sizes and enameling machines, even with vertical wire run. It is also applicable for the special demands of the production of hermetic motors and sealed relays. All types of lubricators are easy to install.

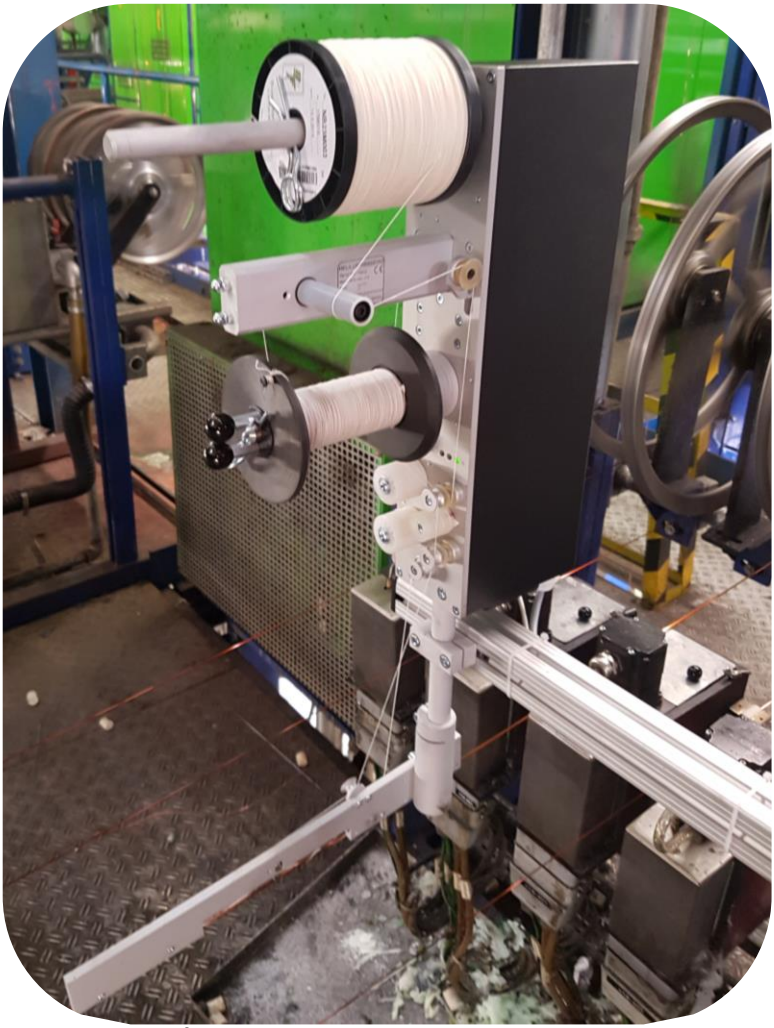


Fig. 5: a) HELILUB® model 2016 applicators NB52 for standard applications

Fig. 5 b.) NB53G6 for wires with lower temperature and

Fig. 5: c) NB53G0 for fine and ultra-fine wire.

4.2 Lubrication of Low Temperature Wire

Low wire temperature occurs mainly in vertical machines, and prevents proper lubricant transfer and dispersion.

Using felts this is a permanent problem, even when applying solutions of lubricants, because application felts get clogged and lubricant transfer is reduced or even interrupted.

Figure 6 shows the principle and figure 5b shows a photograph of a cold wire HELILUB® applicator which overcomes these problems. It uses heated rolls and increased friction between wire and yarn in order to melt and equalize

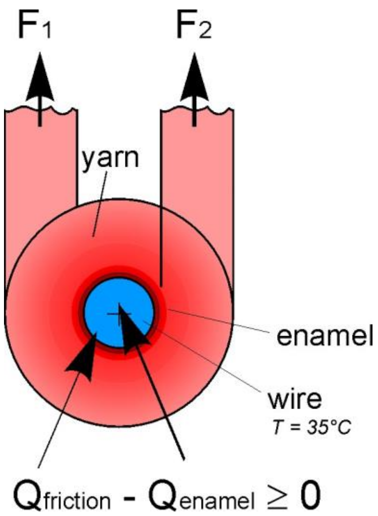


Fig. 6: Cold wire lubricant application

the lubricant on the complete surface nearly independently from ambient and wire temperature, provided that the latter is not lower than 10°C below the melting point of the wax.

Since cold wire lubricators can be mounted directly before the take-up spool, the variation of lubricant quantity due to losses caused by deposit of lubricant from the wire on wire guide pulleys can be reduced considerably.

4.3 Lubrication of Fine and Ultra Fine Wire

Lubrication of fine and ultra-fine enameled wire with diameters below 0.15 mm, compared to lubrication of medium-sized diameters (0.15 - 1mm), is particularly critical. Fine wire is almost always coated with solderable or even self-bonding enamels. These coatings are very sensitive towards any impact of solvents. Applying oil as a lubricant does not provide as good friction properties, especially at high wire or winding speed, as wax applied correctly from solutions or melt. On the other hand, a local over-concentration of wax is critical, as windings on the spool may adhere to each other and cause wire elongation or even breaks. Punctual accumulations of wax often appear in solvent-free lubrication by means of felts, when wax particles deposit on the felt at the wire outlet side or on pulleys, then are carried along by the wire. Besides that, the desired very even and thin coating of 4 to 10 mg/sqm is difficult to obtain due to the low heat capacity of fine wire, which does not provide sufficient time for consistent flow and wetting before solidification of the wax.

Figure 7 shows the principle of a HELILUB® fine wire application zone and figure 5c a photograph of a fine wire lubricator. In this case the lubricant-impregnated yarn is not wrapped around the wire, but the wire just touches the surface of the yarn which is wound around heated rolls (fig. 8 and 9).

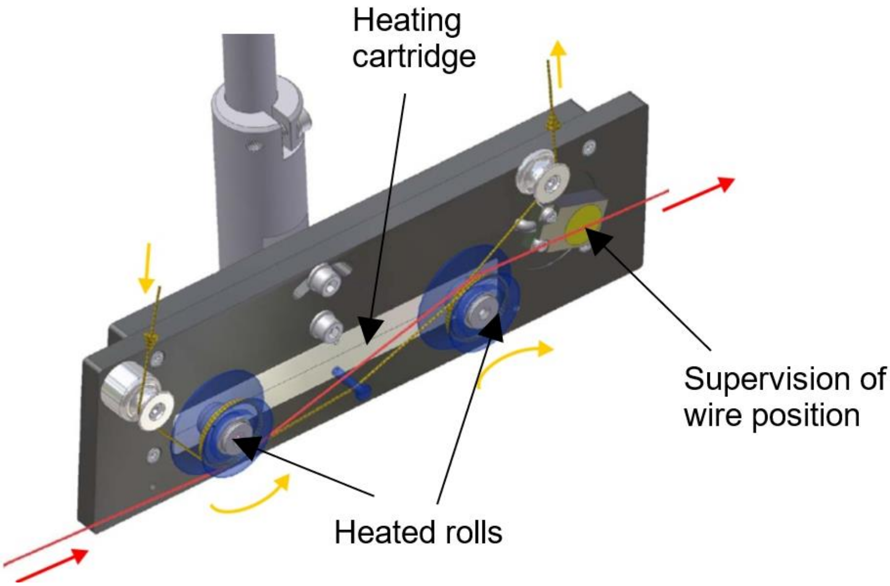


Fig. 7: Scheme of fine wire lubricant application zone

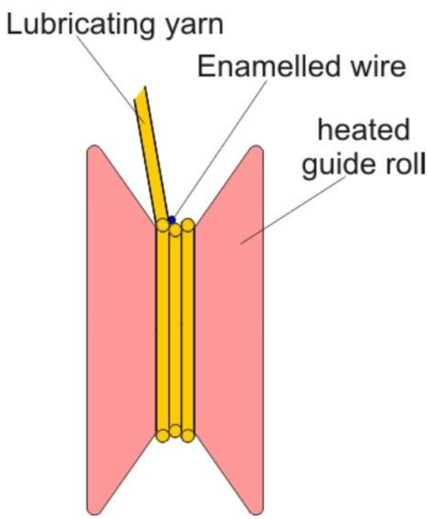


Fig. 8: Heated roll with HELILUB® application zone for fine wire lubrication

This HELILUB® setup for fine wire combined with appropriate yarn string-up (see pictures in fig. 9) provides good consistency, low coefficient of friction even with small lubricant quantities, no kinks, neither elongation nor wire breaks, no solvent attack to enamel and spools as well as precisely calculable lubrication due to elimination of drip losses.

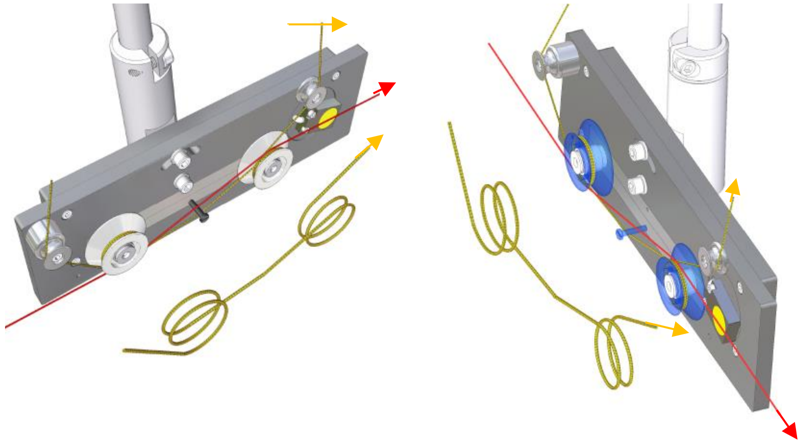


Fig. 9: How to correctly string-up the HELILUB® applicator for fine wire lubrication

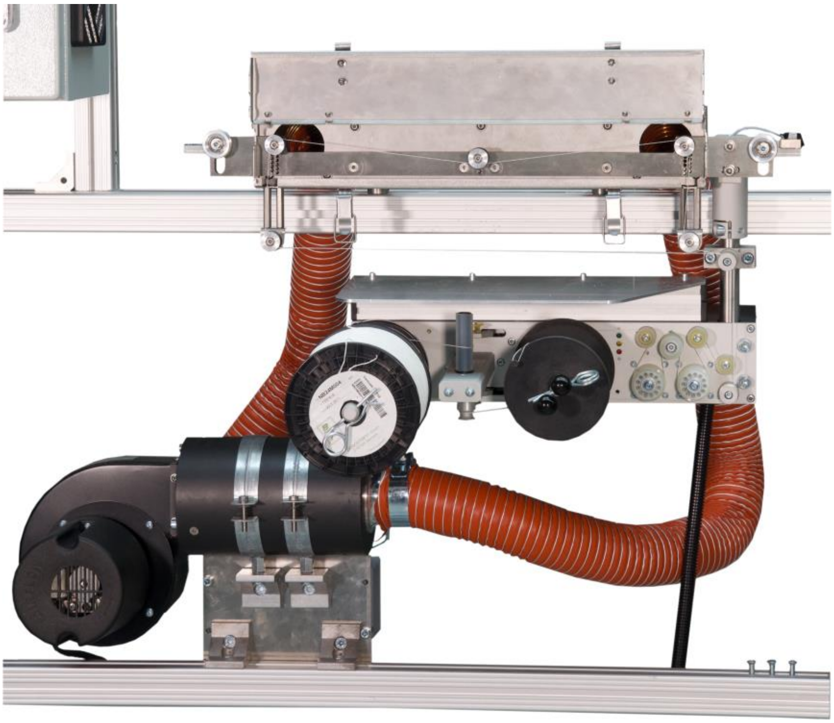
4.4 <u>Solvent-Free Lubrication of Large Diameter Magnet Wire</u>

Task

Large diameter magnet wires in some cases need to be lubricated, but leave the cooling zone of the enameling oven relatively cold (40 – 50°C). On the other hand, the heating power as well as the design of the process zone of the existing "cold wire" applicator NB53G6 are not suitable for this application.

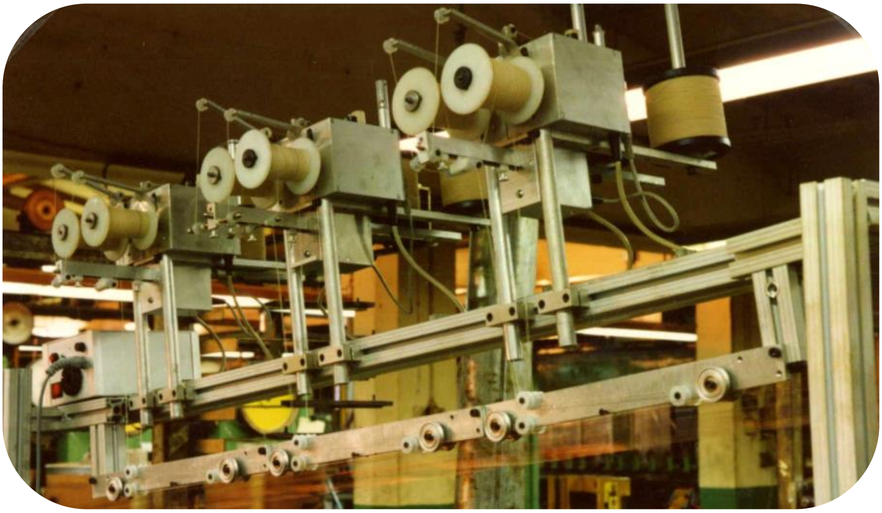
Solution

In order to meet the particular requirements of solvent-free large diameter wire lubrication, our standard HELILUB® device head was equipped with a newly designed process zone supported by a powerful circulating air heating, resulting in the new HELILUB® model NB53G7 (see pictures 18 to 21).

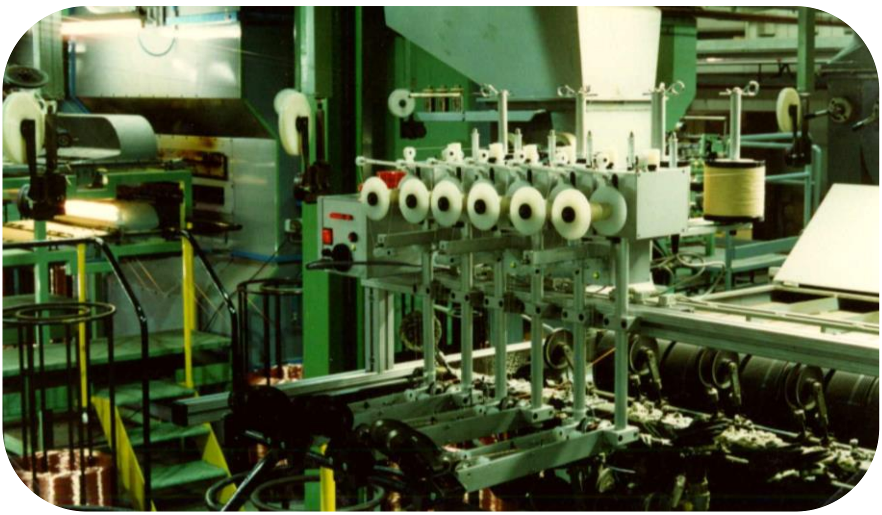


4.5 Examples for Industrial Installations

The process is well introduced in the industry, with several thousand lines running worldwide. The following fig. 10 to 13 show examples of industrial installation of four generations of applicators.



1992, ACEBSA; VD 10, 6 mm wire distance;



b 1995, SICME NEL; VD 30,

Fig. 10: Multi-line installations of the first generation of applicators NB50G with only one common motor for the fix yarn speed and the take-up by means of a friction clutch. The applicators were supplied and supervised by a multi-line control box with collective error alarm function.

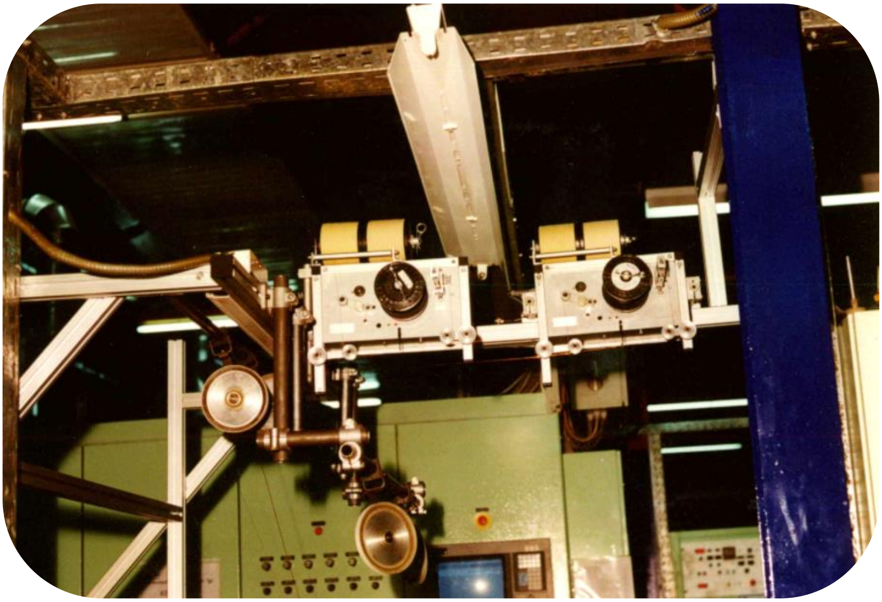
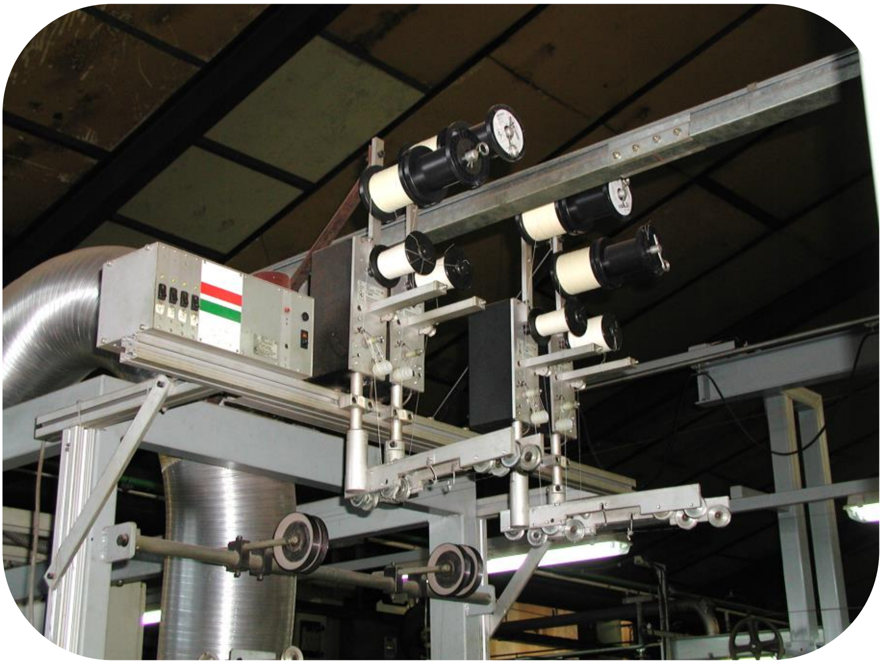


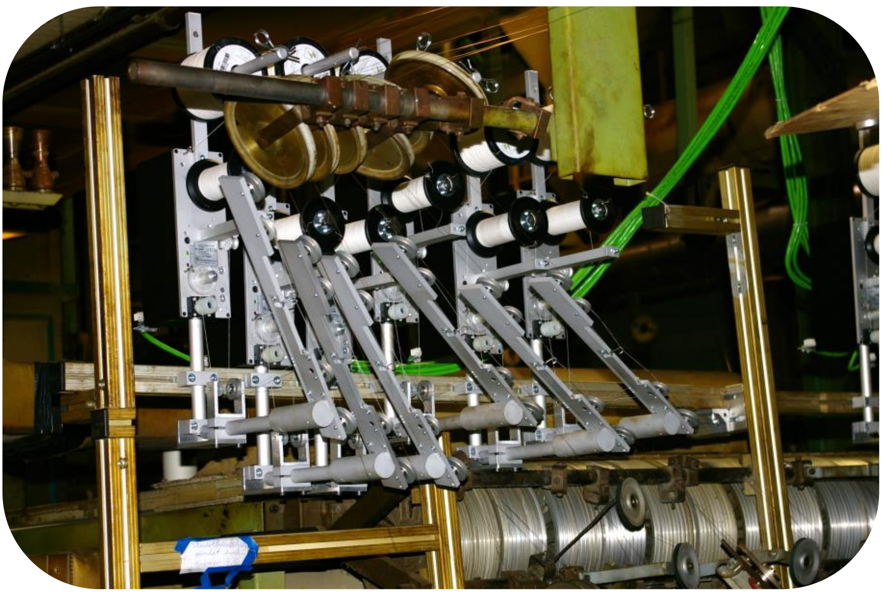
Fig. 11: 1995, SICME; VD 30, 6 mm; second generation single line applicator NB51 with integrated power supply, traverse range and error alarm

Fig. 12: Installations of third generation applicators, here NB52 for warm wire. These applicators had individual synchronous motors for yarn speed, take-up and traverse range.

a 1996: vertical oven; VD 30



b 2005: Italia Impianti; VD 100, narrow wire spacing; installation with a 4-line control box with integrated collective error alarm function



c 2009: SICME NEM; VD 60; these lubricators were supplied and supervised by a PLC-based control box NB50E606 with two-line text display, yarn slip supervision and detailed error alarm function

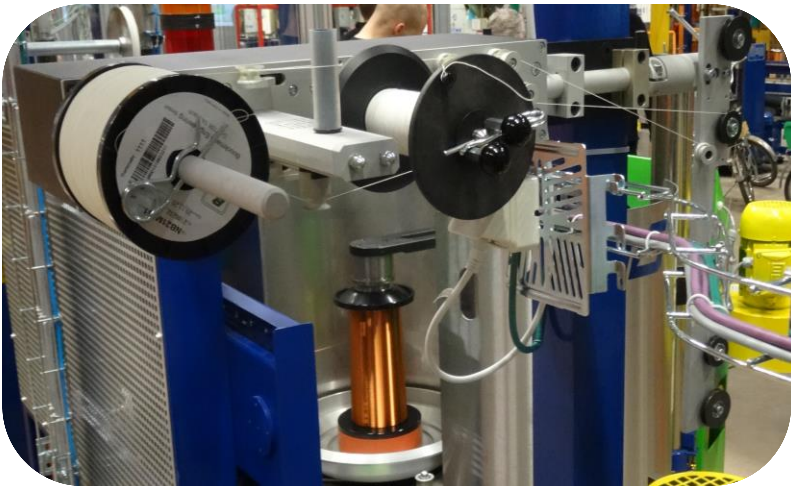


Fig. 13: NB52 (model 2016) for warm wire lubrication

5 µ-Processor Control and Process Data Documentation of the HELILUB® Process

Current HELILUB® applicators can be operated by means of a control box type NB50E70x (model 2016), equipped with µ-processor main board and an operator panel. This allows the operator to set individual parameters for each lubricator and even to store parameter sets as recipes. The control calculates, regulates and supervises the individually required yarn speed according to equation 1. Thus, not only the correct wire position and movement of the yarn is supervised, but also yarn slippage, and the temperature of an optionally installed process zone with heated yarn guide pulleys.

Furthermore, data from the control unit can be provided to a superordinate control which collects and evaluates errors and process data in order to allow comprehensive and traceable process data documentation (figure 19).

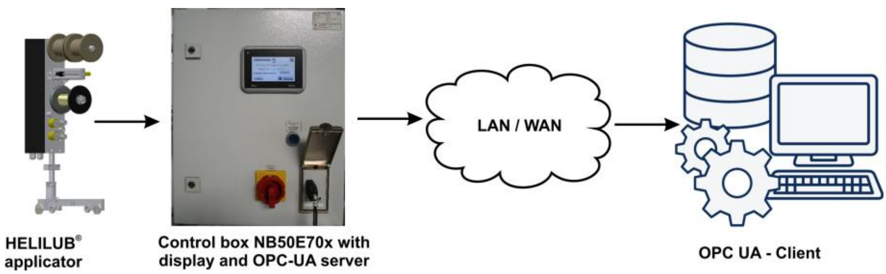


Fig. 19: Scheme of µ-processor control and process data documentation for the lubricant yarn process

6 HELILUB® Machines

6.1 Control Units for HELILUB® Applicators Model 2016

			
1	Device model numbers	NB50E701	NB50E704
2	Range of application	Control of HELILUB® applicators (model 2016) NB52… and NB53…	
3	Max. number of HELILUB® applicators	1	4
4	Mounting instructions	Wall installation by means of 4 screws, opening angle of the door. 120°, opening radius: 400 mm	
5	Operator's interface/HMI	Touchscreen 4,3“; 800x480 Pixel	
6	Authorization, security	Electronic access keys with different levels	
7	Acoustic alarm	92 dB at 1 m distance; alternating sound; interruptible	
8	Optical alarm	Red blinking light; non-interruptible; can be quit only by eliminating the error	
9	Input power supply	100 - 240 VAC / 50/60 Hz; 6 A pre-fuse	
10	Input power consumption (W)	~500	
11	Output power supply for HELILUB® applicators	24 V DC, 4 A per HELILUB® applicator	
12	Connection to the HELILUB® applicators	Power supply: 3 conductor cable and 3-pin connector CAN-Bus network: shielded 2 conductor cable with sub-D 9-pin CAN-Bus connector)	
13	Max. length of cables for power supply and CAN-Bus (m)	Power supply: 50 (cross section 1,5 mm²) CAN-Bus: 300 (cross section 0,35 mm²)for max. ten connected applicators	
14	Optional interfaces	Ethernet (VNC), MODBUS RTU (with superordinate control)	
15	Special features	Monitoring of yarn slippage	
16	Operating temperature (°C)	+ 10 - + 45	
17	Storage/transport temperature (°C)	- 20 - + 60	
18	Relative air humidity (%)	5 to 70 (at 25°C, not condensing)	
19	Air pressure (hPa)	860 – 1080	
20	Ca. dimensions H × W × D (mm)	400 x 200 x 200	590 x 500 x 210
21	Weight (kg)	2.8	~ 20

Table 6

			
1	NB50E706	NB50E708	NB50E710
2	Control of HELILUB® applicators (model 2016) NB52… and NB53…		
3	6	8	10
4	Wall installation by means of 4 screws, opening angle of the door. 120°, opening radius: 400 mm		
5	Touchscreen 4,3“; 800x480 Pixel		
6	Electronic access keys with different levels		
7	92 dB at 1 m distance; alternating sound; interruptible		
8	Red blinking light; non-interruptible; can be quit only by eliminating the error		
9	100 - 240 VAC / 50/60 Hz; 6 A pre-fuse		
10	~500	~1000	
11	24 V DC, 4 A per HELILUB® applicator		
12	Power supply: 3 conductor cable and 3-pin connector CAN-Bus network: shielded 2 conductor cable with sub-D 9-pin CAN-Bus connector)		
13	Power supply: 50 (cross section 1,5 mm²) CAN-Bus: 300 (cross section 0,35 mm²)for max. ten connected applicators		
14	Ethernet (VNC), MODBUS RTU (with superordinate control)		
15	Monitoring of yarn slippage		
16	+ 10 - + 45		
17	- 20 - + 60		
18	5 to 70 (at 25°C, not condensing)		
19	860 – 1080		
20	590 x 500 x 210	590 x 600 x 210	
21	~ 20	~ 25	

Table 6 (continued)

6.2 Microprocessor-controlled HELILUB® Applicators

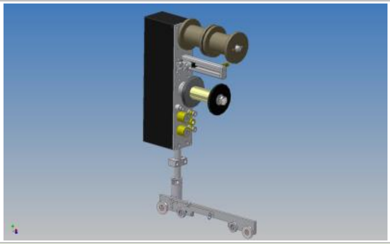
		
1	Model number	NB52G1…
2	VxD range	5 to about 200 (for lubricant application from 5 to 150 mg / m²)
3	Recommended application	for hot wires (refer to 7.), for multi-line enameling machines
4	Mounting instructions	Close to oven exit (refer to 7)
5	Wire spacing of the enameling machine	Minimum 50 mm, respectively above 12 mm and 140 mm alternating
6	Range of wire diameter (mm)	0.15(*) to 2 (12 AWG to 35 AWG(*))
7	Required wire temperature	Higher than 10°C above the melting point of the lubricant, but lower than 120°C (wax evaporation)
8	Process monitoring	Device connection (power supply/CAN-Bus) Wire breakage by inductive-sensor-supervised yarn guide hook (range of sensitivity 2 – 15 cN) Yarn tension before and after lubricant application (yarn breakage) Yarn slippage by rotation speed of the guide roll
9	Release tension (N)	0.5 – 6
10	Take-up tension (N)	2 – 6
11	Dimensions (mm)	Height: about 570 (min.) – 770 (max.), dependent on the length of the supporting tube Width: about 80 Depth: about 450
12	Weight (kg)	6
13	Connections	Power supply: 3-core cable with 3-pin plug CAN-Bus: 2-core cable with CAN-Bus plug Optional wire speed signal: pulses + 24 VDC (max. 4 kHz)
14	Input power supply (V DC)	24 (min. 22 to max. 30) **Attention! Out of this range, the correct operation of the device is not guaranteed.**
15	Max. power consumption	60 W
16	Suitable control devices	NB50E7xy (model 2016)
17	Maximum length of power supply and CAN-Bus cable (m)	Power supply: 50 (cross section 1,5 mm²) CAN-Bus: 300 (cross section 0,35 mm²) for max. ten connected applicators
18	Special applications	-
19	Operating temperature (°C)	+ 10 to + 45
20	Storage and transport temperature (°C)	-20 to +60
21	Relative air humidity (%)	5 to 70 (at 25°C, not condensing; indoor use only)
22	Environmental air pressure (hPa)	860 - 1080

Table 5

(*) for thin wires with PUR enamels the type of lubricator has to be decided after preliminary tests

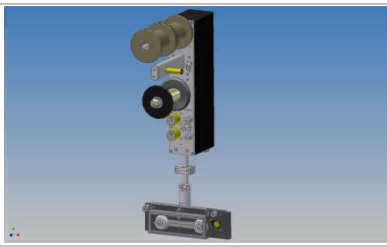
		
1	NB53G0…	NB53G5/G6…
2	5 to about 200 (for lubricant application from 5 to 150 mg / m²)	
3	Yarn lubricant applicator for low temperature ultra-fine wire for multi-line enameling machines	Yarn lubricant applicator for low temperature medium diameter wire for multi-line enamelling machines
4	At the oven exit or also directly at the winder (refer to 7)	
5	Minimum 61 mm	
6	Ultrafine up to about 0.3 mm(*) (above 28 AWG(*))	about 0.18 to 2 mm (33 AWG to 12 AWG)
7	20°C below the melting point of the lubricant or warmer	
8	Device connection (power supply/CAN-Bus) Wire position: capacitive sensor (wire breakage) Yarn tension before and after lubricant application (yarn breakage) Yarn slippage by the speed of the yarn guide roll Temperature	Device connection (power supply/CAN-Bus) Friction by yarn tension (range of sensitivity 200 – 1000 cN) Contact between wire and yarn (wire breakage) Yarn tension before and after lubricant application (yarn breakage) Yarn slippage by rotation speed of the guide roll Temperature
9	0.5 – 6	
10	2 – 6	
11	Height: 620 (min.) – 670 (max.) dependent on the length of the supporting tube Width: about 136 Depth: about 270	
12	6	
13	Power supply: 3-core cable with 3-pin plug CAN-Bus: 2-core cable with CAN-Bus plug Optional wire speed signal: pulses + 24 VDC (max. 4 kHz)	
14	24 (min. 22 to max. 30) **Attention! Out of this range, the correct operation of the device is not guaranteed.**	
15	100 W	
16	NB50E7xy (model 2016)	
17	Power supply: 50 (cross section 1,5 mm²) CAN-Bus: 300 (cross section 0,35 mm²) for max. ten connected applicators	
18	Post-process re-lubrication of sub-standard wire Pre-treatment of wire before coil winding machines	
19	+ 10 to + 45	
20	-20 to +60	
21	5 to 70 (at 25°C, not condensing; indoor use only)	
22	860 - 1080	

Table 5 (continued)

(*) for thin wires with PUR enamels the type of lubricator has to be decided after preliminary tests

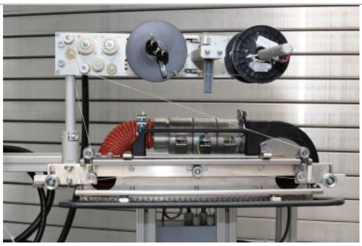
		
1	Model number	NB53G7…
2	VxD range	5 to about 100 (for lubricant application from 5 to 100 mg/m²)
3	Recommended application	For “cold” wires (refer to 7.), For single- or multi line enameling machines with sufficient wire distance (refer to 5)
4	Mounting instructions	As close as possible to oven exit or before the winder (refer to 7)
5	Wire spacing of the enameling machine	Minimum 500 mm,
6	Range of wire diameter (mm)	2.0 to 5 (12 AWG to 4 AWG)
7	Required wire temperature	Higher than 20°C below the melting point of the lubricant, but lower than 120°C (wax evaporation)
8	Process monitoring	Device connection (power supply/CAN-Bus) Wire breakage by capacitive-sensor-supervised Yarn tension before and after lubricant application (yarn breakage); Yarn slippage by rotation speed of the guide roll
9	Release tension (N)	0.5 – 6
10	Take-up tension (N)	2 – 6
11	Dimensions (mm)	Height: about 500, width: about 590, depth: about 550
12	Weight (kg)	15
13	Connections	Power supply: 3-core cable with 3-pin plug CAN-Bus: 2-core cable with CAN-Bus plug Optional wire speed signal: pulses + 24 VDC (max. 4 kHz)
14	Input power supply (V DC)	220 - 240 (P + N + PE) **Attention! Out of this range, the correct operation of the device is not guaranteed.**
15	Max. power consumption	2,000 W
16	Suitable control devices	NB50E901
17	Maximum length of power supply and CAN-Bus cable (m)	Power supply: 50 (cross section 1,5 mm²) CAN-Bus: 300 (cross section 0,35 mm²) for max. ten connected applicators
18	Special applications	Solvent-free lubrication of large diameter magnet wire
19	Operating temperature (°C)	+ 10 to + 45
20	Storage and transport temperature (°C)	-20 to +60
21	Relative air humidity (%)	5 to 70 (at 25°C, not condensing; indoor use only)
22	Environmental air pressure (hPa)	860 - 1080

Table 5

(*) for thin wires with PUR enamels the type of lubricator has to be decided after preliminary tests

7 HELILUB® Consumables

Product number	Basis	Melting range (°C)	Tensile strength (cN)	Weight of lubricant (mg/m)	Weight of lubricating Yarn (mg/m)	Range of application
NB21M001	Blend of paraffin with ester wax	53 - 58	~1000	~ 70	~ 140	Standard with applicator NB52G1… and for fine wires with applicator NB53G0…
NB23M003	Blend of paraffin with ester wax	53 - 58	~ 3000	~ 160	~ 300	Standard for higher VD or for larger quantity of lubricant
NB23K203	Hydroxyester wax	49 - 51	~ 3000	~ 160	~ 300	For all hermetic motors, also for HFC (134 a)

Table 7

Upon request the following lubricant bases are also available:

Beeswax: lowest coefficient of friction at low application quantities, also suitable for food industry (depending on national laws)

Paraffin: preferred for self-bonding wires, also suitable for food industry (depending on national laws)

References

1. Boockmann, G. and R. Fichtner. “Nonpolluting Solid Lubrication of Enamelled Wires”. Proceedings of Electrical Electronics Insulation Conference and Electrical Manufacturing & Coil Winding Conference, Chicago 1993. IEEE Publication 93CH3219-3, pp. 165-171

2. Boockmann, G., K. Boockmann, R. Fichtner: “Innovation for Magnet Wire Lubrication”. Proceedings of Electrical Insulation Conference and Electrical Manufacturing & Coil Winding Conference, Chicago 1997. IEEE Publication 97CH36075, pp. 195-201

3. Boockmann, G., K. Boockmann, R. Fichtner: “Magnet Wire Lubrication Technology”; Proceedings of Electrical Manufacturing & Coil Winding Conference ‘98, Cincinnati 1998

4. W. Parussel “Defining the Surface Smoothness of Varnished Wires” Electrotechnical Periodical, pp 692 695, December 1961

5. European Community: “COUNCIL DIRECTIVE 1999/13/EC of March 11 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations”, Official Journal of the European Communities, Brussels, 29.03.1999, pp. L85/1 – L85/22

6. MAG: Company brochure “Vapolub” MAG - Maschinen und Apparatebau Aktiengesellschaft, Puntigamerstraße 127, A-8055 Graz, Austria and Ferjancsik, Zsombor. “Vermeidung von Lösemittelemissionen bei der Gleitmittelbeschichtung von Elektrodrähten bei der Firma Eldra”. Thesis at the Technische Universität Graz, 1996

Boockmann Engineering GmbH

Eckartspfad 6
97708 Bad Bocklet / OT Steinach
Germany

info@helicord.de