Spindle
Technology

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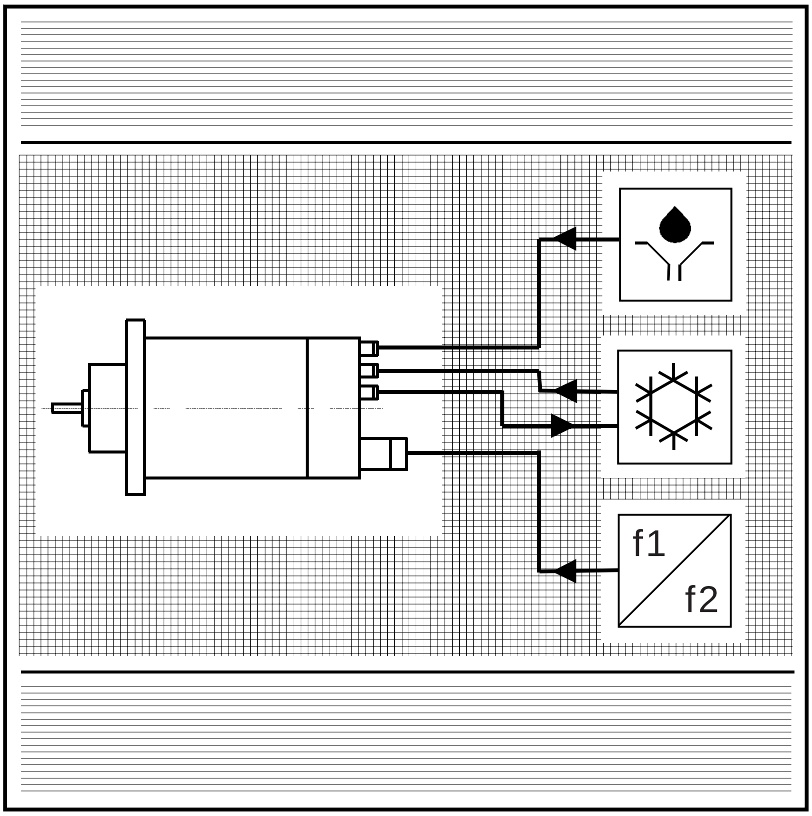
Operating Instructions

GMN High-frequency Spindles
HCS 230 - 30000 / 80
with Oil/Air Lubrication and
Automatic Tool Change



GMN Operating instructions 104 27 22

PREFACE

GMN high-frequency spindles are high-grade precision tools.

Their performance and service life are dependent on proper use and correct application.

It is therefore important that the operating instructions for the spindle be carefully studied, understood and observed by all personnel involved (operators and maintenance staff).

These operating instructions are valid for

GMN high-frequency spindles HCS 230 - 30000 / 80
GMN part no.: 104 60 46 R

with oil/air lubrication and automatic tool change (HSK 63)

Purchaser: ....

Order data:..

Order no.: ....

Spindle serial no.: ....

Contents

continue

1 Essential information

Intended use

GMN grinding, milling and drilling spindles are for installation and operation in machine tools in order to be able to carry out cutting work with suitable materials such as metal, wood and plastic. Use is only defined as being for the intended purpose if appropriate tools, which themselves must be used for the intended purpose, are used for the spindle.

Duties of the operator

The reliable operation and service life of the spindle are dependent on proper handling and use for the intended purpose. The operator assumes responsibility for the correct installation and operation of this spindle by qualified, trained personnel in accordance with the information in this operating manual.

For this reason, the operating manual for the spindle must be read, understood and followed by all persons involved (machine and maintenance personnel). Furthermore, the accident prevention regulations and safety guidelines applicable in the field of use of the spindle must be adhered too.

The operating manual must be kept in the immediate vicinity of the spindle.

Liability and warrenty

GMN can accept no liability for any personal injury or material damage, and no warrenty for warrented qualities of the spindle in case of use of the spindle for other than the intended purpose, non-compliance with the operating manual, accident prevention regulations and safety regulations, as well as modifications to the spindle not authorised by GMN.

Service and advice

We shall be pleased to help and advise you should you encounter any problems. If you have any questions, please contact the spindle service of the manufacturer or any of the GMN agencies with repair service (see Appendix).

Repairs

The installation and removal of the spindle require special tools and much experience. Repairs should only be carried out by qualified specialists using suitable tools.
Please remember that no guarantee claims can be accepted if the spindle is removed.

We recommend that you send the spindle to the GMN Spindle Service should repairs be necessary.

Manufacturer of the spindle

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Copyright

Date

This operating manual represents the state of the art at the time of delivery of the spindle. The date of issue appears on the top right of every page of this operating manual, with month and year.

2 Safety instructions

GMN spindles are equipment for use in industrial power installations. During operation, this equipment has dangerous, live, moving, rotating parts.It could thus cause very serious damage to personal health or to material through, for example, unauthorised removal or opening of covers, improper use, incorrect operation or inadequate maintenance.

The **accident prevention regulations, safety guidelines** and the **regulations of the local public utility** applicable in the appropriate field of application must be observed when operating the spindle.

The **intended use** of the spindle and of the machine tool must be observed.

The **installation site requirements** as well as the **useful limits** of the spindle must be taken into account.

The machine tool must be suitable for the installation of the spindle and fitted with **safety equipment** in such a way that personal injury through unavoidable dangers caused by the spindle (e.g. rotating parts) can be reliably prevented in accordance with the present state of the art.

Changes in comparison with normal operation (temperatures, vibrations, unusual noises, triggering of monitoring equipment etc.) indicate that the functioning of the spindle is impaired.
In case of doubt, switch off the system and contact the maintenance personnel!

The potential danger is even higher in **high-speed processing** due to the high peripheral speed and the resulting energy of the rotating parts (spindle shaft and tool) compared with the conventional processing. The protective equipment must be designed to cope with this increase in potential danger.

Tools running out of true and/or tools that have not been balanced can lead to unacceptably high oscillations and subsequently to tool breakage.
Please refer to the instructions in Chapters 6.1 and 6.2.

GMN spindles of HC... series with automatic tool changing system may only be operated with the permitted combination of tool and tool holding fixture and may only be started when the tool is clamped in position.

Please attend to the maintenance instructions in Chapter 8.

Warning and instruction symbols used in these operating instructions:

This symbol stands for imminent danger to life and limb.
Failure to observe these instructions may have serious conse quences for a person´s health, including fatal injures.

This symbol stands for important information about how to use the spindle correctly.
Failure to observe these instructions may result in damage to the machine or the surroundings.

This symbol draws attention to application-related tips and particularly useful information that will help you to put the spindle´s functions to optimum use.

3 Spindle describtion

3.1 Spindle equipment

- Drive: Direct drive by integrated asynchronous motor with a squirrel-cage rotor.

  Integrated speed sensor (encoder) to monitor the spindle speed.

- Cooling: Liquid cooling.

  Temperature monitoring of the motor windings by a temperature sensors of KTY type

- Lubrication of spindle bearings: Oil/air lubrication.

- Automatic tool changing system: HSK tool holding fixture.

  Clamping device locks the tool during spindle operation.

  Spring pack to produce the necessary drawing-in force.

  Hydraulic tool release unit.

  Tool changing process monitored by an analog sensor and a proximity switch.

- Air sealing: Prevents dirt particles or coolant from penetrating into the spindle.

- Taper cleaning: Equipment prevents dirt particles from penetrating to the locating surfaces during tool change.

- Cooling lubricant supply through spindle shaft: Device permits to eliminate the heat developed in the area of the lip of the tool during machining.

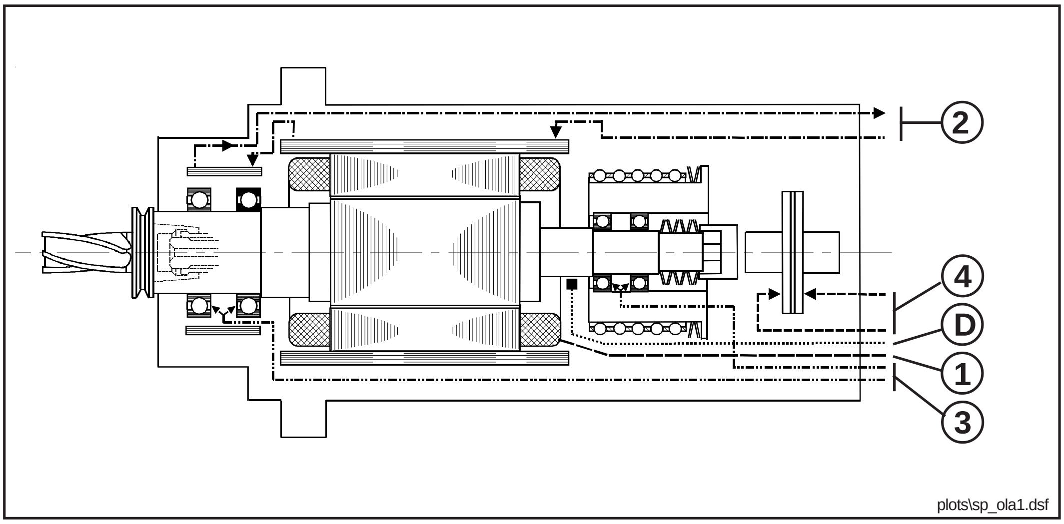
- Monitoring the bearing temperature: Integrated temperature sensors (Pt100) take the temperature of the front and rear bearing group.

- Monitoring the axial movement of spindle shaft: Integrated analog sensor Micro-Epsilon EDDY NCDT detects the axial displacement of spindle shaft during spindle operation.

3.2 Supply components for spindle operation

• Drive:	**Frequency converter(1)**
• Cooling:	**Cooling unit (2)** for cooling the spindle motor and the front bearing group
• Lubrication:	**Oil/air lubricating unit (3)**
• Tool change:	**Hydraulic supply (4)** **Speed monitoring (D)**
• Monitoring the tool change:	Evaluation unit(s) for analog sensor and proximity switch
• Air sealing:	Compressed air supply Compressed air monitoring
• Taper cleaning:	Compressed air supply Compressed air monitoring
• Cooling lubricant supply through spindle shaft:	Cooling lubricant supply Cooling lubricant monitoring
• Monitoring bearing temperature:	Evaluation unit(s) for temperature sensors (Pt100)
• Monitoring the axial movement of spindle shaft:	Evaluation unit for analog sensor EDDY NCDT

Fig. 3.2.1



Supply lines on spindle (Schematic diagram)

4.1 Type designations of spindle

Every GMN high-frequency spindle has a type designation and a type plate engraved on the spindle housing. This type plate indicates the electrical engineering data of the spindle (see Fig. 4.1.1).

All data of the type legend must agree with those of the test log issued with the spindle!

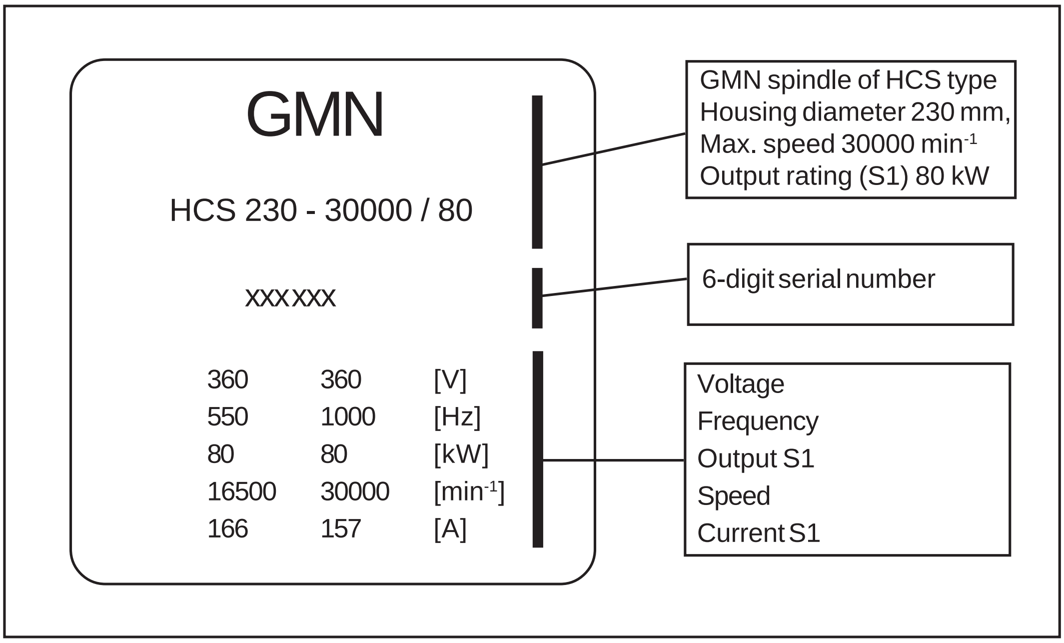


Fig. 4.1.1

Type designation, type plate

4.2 Storage and transport of spindle

- As far as possible, store the spindle in the transport packing.

- The storage place has to be dry, dust-free and clean. The temperature at storage place should be between 10 °C and 35 °C and should not vary too much.

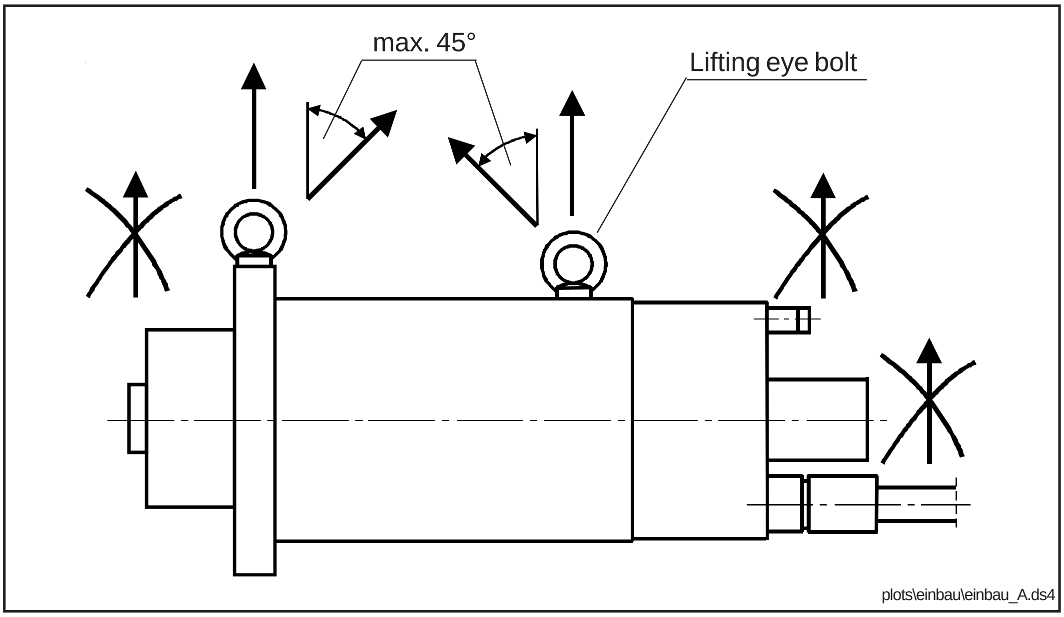
- As far as possible, lift up the spindle out of the transport packing not before installation at the locating place.
  Please note the weight lifting points in Fig. 4.2.1.

- At the periphery of the spindle housing there are two threads M10. Into these threads lifting eye bolts are srewed in respectively can be screwed in. Use these lifting eye bolts to lift up the spindle with suitable transport device (see Fig. 4.2.1).
  Prior to installation of spindle in the spindle head of the tool machine remove lifting eye bolts and transport logs.

- **Spindle weight:** **approx. 110 kg / 245 lbs**

Do not lift up the spindle at the spindle shaft and/or at the couplings, the connecting cables or the tool release unit!

Fig. 4.2.1



Transport of spindle

4.3 Clamping spindle

Protect spindle from impacts!

Spindle mounting bore:	Cylindrical mounting bore matching the clamping diameter of the spindle housing Ø 230_{h5} (see Fig. 4.3.1).
Locating length:	approx. 100 mm from spindle flange (see Fig. 4.3.1)
Mounting position:	horizontal, swivelling range +30°, -102° (see Fig. 4.3.1)

- Please attend to the tolerance of position shown in Fig. 4.3.1 between flange surface on the spindle head and the mounting bore.
- Avoid applying any blows to the live shaft nut, the spindle shaft and the spindle housing because this would be liable to damage the precision ball bearings.
- There must no screws or other clamping devices acting directly on the spindle housing in order to prevent deformation of the spindle bearing seats and bearing rings.
- The clamping diameters of the spindle housing should be oiled before installation to facilitate removal.
- Install the spindle in such a way that the connections T (vent/oil return) and L(D) (leakage rotary union) as well as one of the two leakage connections L(S) point down in case of horizontal spindle mounting position.
- Push the spindle into the spindle head.
- Bolt up the spindle flange to the spindle head.

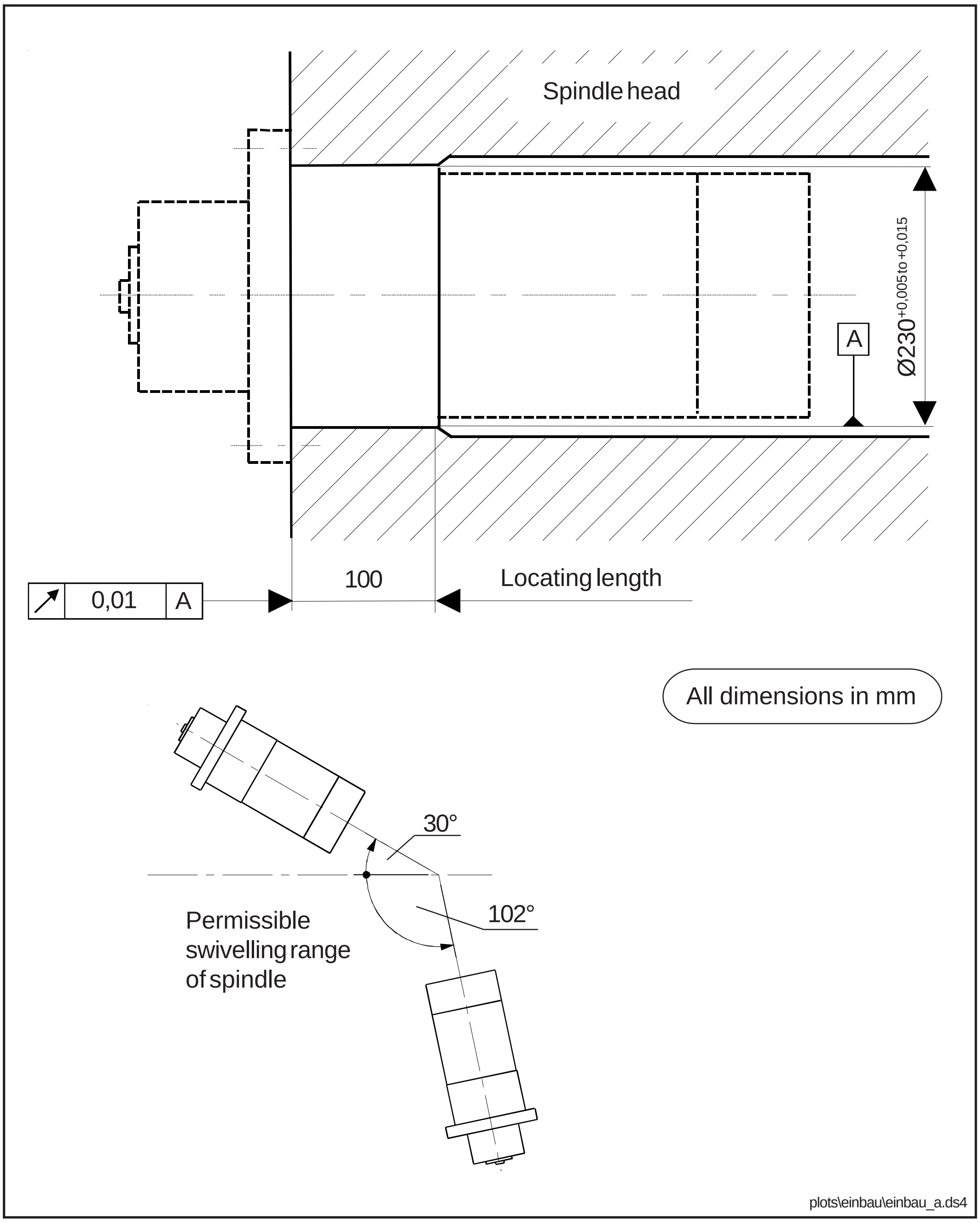
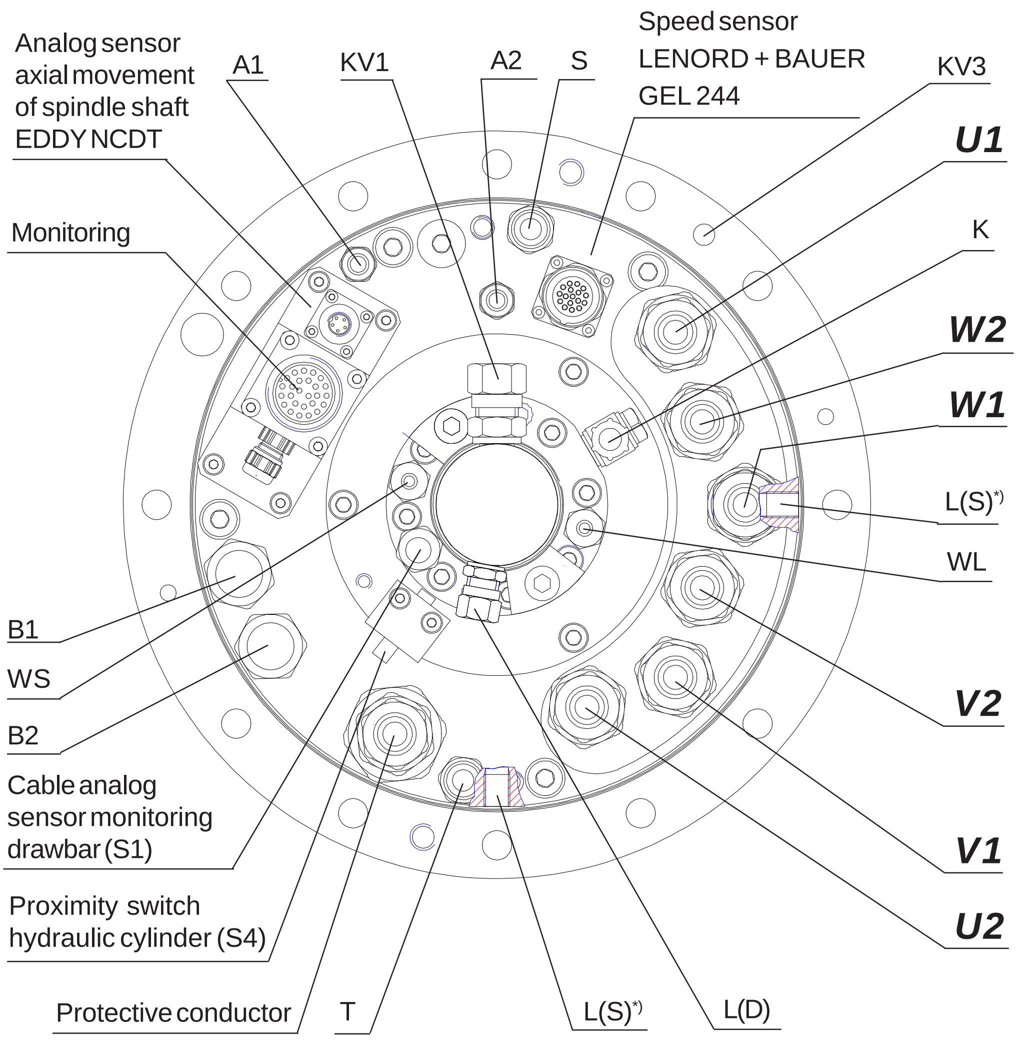


Fig. 4.3.1

Spindle mounting bore

4.4 Connecting spindle

- Remove protective hood(s).
- Remove stoppers and screw plugs on the connecting side of the spindle. They should be carefully stored.
- Connect all lines to the spindle.



Abbreviations see table of indication letters in this Chapter

Motor cables ***U1 ... W2***

*) Leakage bores L(S) (threads G1/8) closed with plugs.
Remove plugs prior to spindel operation.

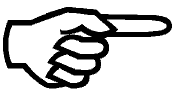
Fig. 4.4.1

Spindle connecting side / Position of supply connections

The indicating letters according to the following table are engraved on the spindle (spindle connecting side or spindle flange, see also Fig 4.4.1).

Table of indicating letters:
NW = Nominal width of the line
OD = Outer diameter of the line

- A1, A2	Oil/air lubrication	(4 mm NW, 6 mm OD)
- B1	Spindle cooling, run-on	(13 mm NW, 17 to 17.6 mm OD)
- B2	Spindle cooling, runback	(13 mm NW, 17 to 17.6 mm OD)
- K	Taper cleaning	(6 mm NW, 8 mm OD)
- KV1	Cooling lubricant supply through spindle shaft	(6 mm NW, 8 mm OD)
- KV3	Cooling lubricant external supply	Bore in spindle flange
- L(D)	Leakage cooling lubricant (rotary union)	(6 mm NW, 8 mm OD)
- L(S)	Leakage cooling lubricant (spindle)	Leakage bores G 1/8 (2x)
	In delivery status of spindle, the leakage bores are closed with plugs. Remove plugs prior to spindle operation. To drain off possibly leaking cooling lubricant suitable drain passages must be provided (bores in spindle head or hose lines).	
- S	Seal air	(6 mm NW, 8 mm OD)
- T	Vent / oil return	(8 mm NW, 10 mm OD)
	Line length 5 m maximum, **back pressure 0.1 bar maximum!**	
- WL (unclamp)	Tool release	(4 mm NW, 6 mm OD)
- WS (clamp)	Tool clamping	(4 mm NW, 6 mm OD)



Hose qualities:

The hose lines must be flexible and unloaded!

- Soft hose line: for FESTO screw fittings B1, B2, K

- Hose line in accordance with DIN 73 378or NFE 49100 (= hose lines with toleranced external diameters): for LEGRIS rapid couplers A1, A2, S, T

  We recommend to use transparent hose piping as lubricating lines (A1, A2). This allows the oil flow to be observed better.

- High pressure lines: for ERMETO fittings KV1, L(D)*), WL, WS

  *) There is no need of a high pressure line at connection L(D).

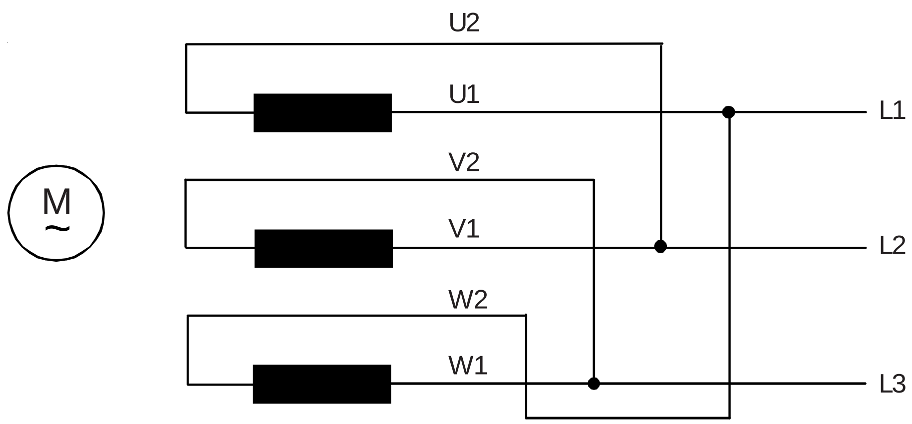
- Connect motor and monitoring cables.

- without plug-in connection:	- Motor cables
- with plug-in connection:	- Speed sensor (encoder) L + B GEL 244 - Analog sensor S1 (monitoring drawbar) - Proximity switch S4 (monitoring hydraulic cylinder) and bearing temperature sensors Pt100 - Analog sensor axial movement of spindle shaft EDDY NCDT

1) Motor

The ends of the motor cables U1, U2, V1, V2, W1, W2 and protective conductor PE are free.
The data of the voltage/frequency characteristic (see Chapter 5.4 "Drive") is valid in case of **delta connection** of the phase windings (see Fig. 4.2.2).

Fig. 4.4.2

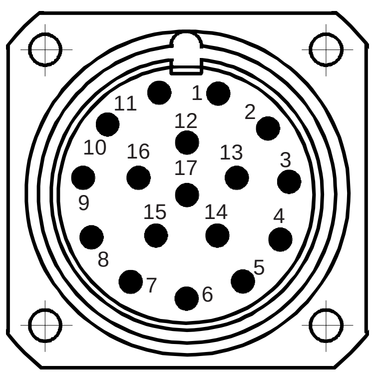


Δ-connection of phase windings

2) Speed sensor (encoder) LENORD + BAUER GEL 244

Suitable cable to connect the speed sdensor and the thermistor of KTY type to the frequency converter:
SIEMENS cable 6FX2002-2CA31-... or 6FX4002-2CA31-...

Fig. 4.4.3



1	A+	PK
2	A-	BK
11	B+	WH
12	B-	BN
3	R+	GY
13	R-	YE
10	+5 V	RD
7	0V	BU
16	Sens	GN
8	KTY+	BN
9	KTY-	WH

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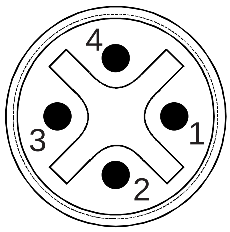
3) Analog sensor S1

Monitoring drawbar

Plug-in connector (output-side) on OTT sensor electronics



1	+15 to +30 V
2	Signal 4 to 20 mA or 2 to 10 V
3	Signal GND 0 V
4	GND 0 V
	Shield

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Fig. 4.4.4

4) Monitoring

- Proximity switch S4 (monitoring hydraulic cylinder)
- Temperature sensors Pt100 (2x)

Plug connection KEJA 26 C...

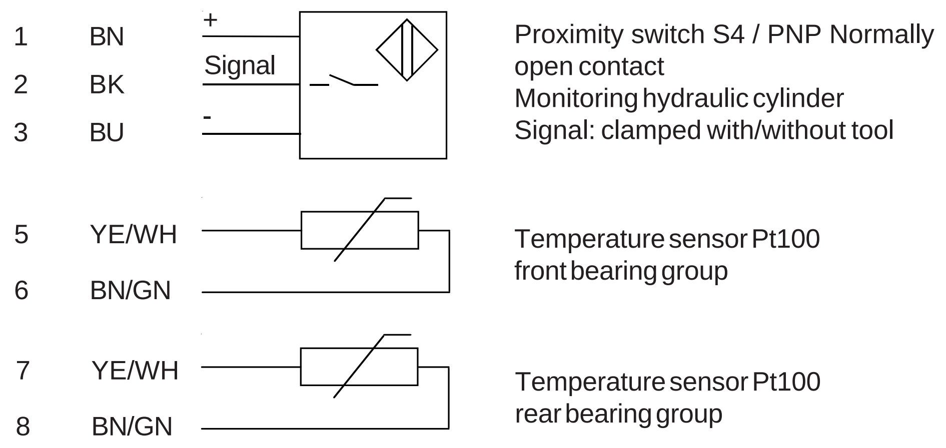
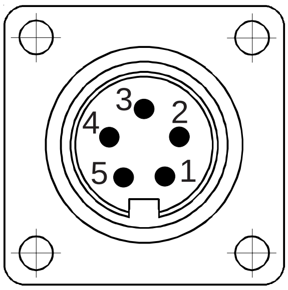


Fig. 4.4.5

5) Analog sensor axial movement of spindle shaft EDDY NCDT
Plug connection of type BINDER series 712



1	RD
2	YE
3	Outer shield
4	Shielding of contact
5	Contact

Fig. 4.4.6

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Without permission by GMN the connections and pipe couplings on the spindle must not be changed!

It is absolutely necessary to ensure that the spindle is galvanically isolated from the frequency converter as soon as the operator is able to touch the spindle shaft or the clamped tool!
Please take care that the direction of rotation of the spindle corresponds with the specified direction of rotation of the tool used.
Danger of accidents!

If the spindle rotates in the wrong direction, interchange two phase leads on the frequency converter.

4.5 Spindle connection of EMC design

In member countries of the European Community it is compulsory by law to observe EC Guideline 89/336/EEC concerning Electromagnetic Compatibility (EMC) when unsing electrical equipment.
The drive system "high-frequency spindle/frequency converter/connecting cable" lies within this field of application.

The spindle is to be connected in conformance with EMC requirements if the following connecting and fitting instructions are followed.
We are unable to provide any guarantee, however, since GMN has no influence on the quality of components used and on the execution of the installation work.

Connecting and fitting instructions (see also Figs. 4.5.1 and 4.5.2):

- Use only EMC-tested frequency converters.

- Make sure in particular that the frequency converter is installed in accordance with EMC regulations (see the operation and installation manual published by the manufacturer of the frequency converter).

- It is imperative to use shielded connecting cables for the spindle. Inside the connecting cable the power lines have to be shielded from the signal lines, i.e. the power lines and the signal lines must each be equipped with its own shield.
  Fig. 4.5.1 shows an example of the structure of a spindle connecting cable of EMC design.

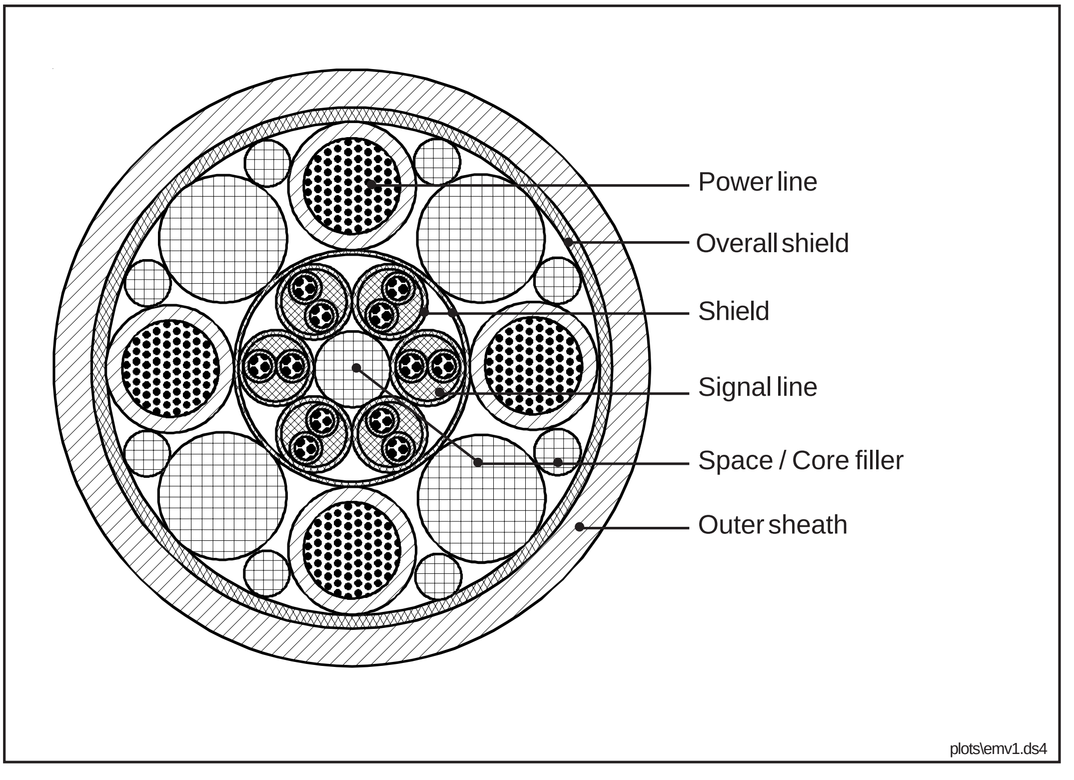
- Keep the length of the spindle connecting cable as short as possible (see Fig. 4.5.2).

- The plug housing with cable gland at the spindle end of the cable and the plug housing or the bulkhead gland at the control cabinet have to be electrically conductive (made of metal) and provide a large area for connecting the cable shields.

- Any coats of lacquer in the coupling area of the control cabinet housing either have to be removed or the cable coupling has to be designed to cut through the insulating lacquer layer when tightened (use couplings of EMC design).

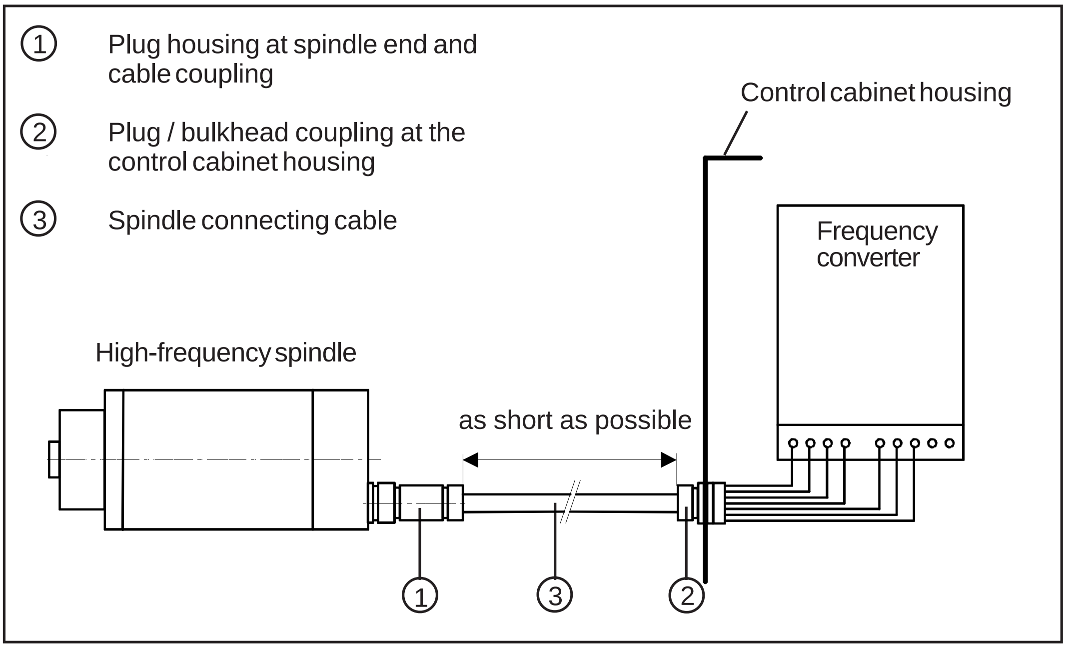
On request GMN can supply completely assembled connecting cables of EMC design as well as suitable frequency converters.

Fig. 4.5.1



Structure of a spindle connecting cable of EMC design (example)

Fig. 4.5.2



Schematic diagram of the spindle connection (electrical)

The operating data specified in the following should be set or established before putting the spindle into operation as described in Chapter 7.

Be sure to compare the data indicated here with those in the test log. All settings should be made in conformance with the data specified in the test log supplied with the spindle!

5.1 Compressed air supply

The compressed air requirements are dependent on the characteristics of the spindle to be supplied (oil/air lubrication, air sealing ...). Reference values for the air requirements are given in the appropriate chapters.

It is important that the air pressure to be set for the individual functions should be able to be reached under all operating conditions.

The compressed air supplied to the spindle must comply with the following values according to **ISO 8573**:

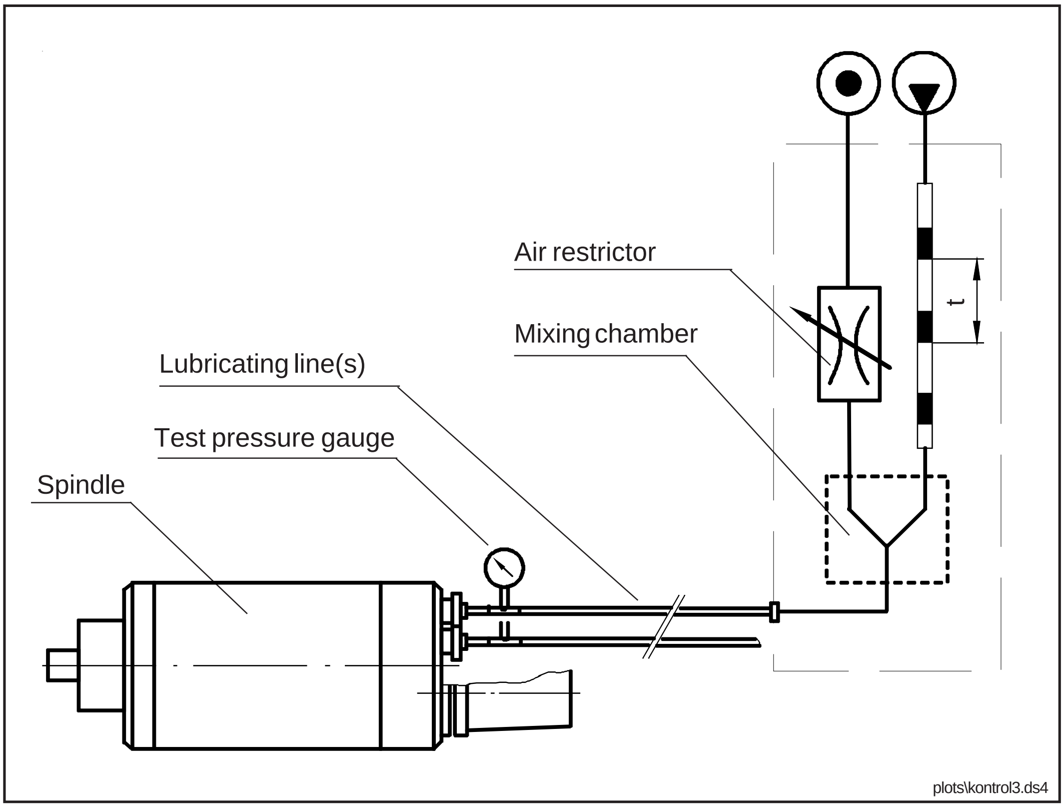
Table 5.1.1

Solids content:	Class 3,	max. particle size 5 µm
		max. particle content 5 mg/m^3
Pressure dewpoint:	Class 4,	max. pressure dewpoint +3 °C
Oil concentration:	Class 3,	max. concentration 1 mg/m^3

5.2 Oil/air lubrication

For the operation of the spindle an oil/air lubricating unit is necessary.

Fig. 5.2.1



Basic arrangement of oil/air lubricating unit

1) Function

The following description applies for one of the lubricating connections on the spindle.
In a mixing chamber, lubricating oil is added at timed intervals (cycle time t) to a continuously flowing air stream. The amount of oil per puls is determined by the displaced volume of a metering valve.
By varying the period between two lubricating pulses (interval), the amount of lubricating oil to be supplied can be changed. The air volume - and with that the lubricating pressure ahead of spindle - can be adjusted by means of an air flow restrictor.
The air flow distributes the lubricating oil along the wall of the pipe or tube, wets it with an oil film and conveyes the lubricating oil to the injection nozzle(s) ahead of the ball bearing.

2) Prelubricating time

Until a reliable supply of the spindle bearings with lubricating oil is established before starting the spindle, we recommend to program a waiting time in the machine control system - called prelubricating time or prelubrication in the following - during which the enable signal for starting the spindle is interrupted.

- Duration of prelubricating time during initial commissioning:
  see Chapter 7.1

- Duration of prelubricating time when restarting:
  At least as long as is required for oil to be observed flowing into the spindle respectively the spindle head at the connections of the lubricating lines.

3) Lubricating lines

Line sizes:	4 mm nominal width (NW) 6 mm outside diameter (OD)
Line length:	0.5 m minimum to 5 m maximum
Hose quality:	oil-resistant hose lines in accordance with DIN Standard 73 378 or NFE Standard 49.100 (= hose lines with toleranced external diameters) Transparent hose lines facilitate check of lubricating oil flow.

Avoid any sharp bends and abrupt changes in cross section in the lubricating oil lines.
The last hose coupling ahead of the spindle should be at least 0.5 m away from the spindle.
Lubricating lines and screwed connections must have no leaks! Even small leaks of oil can cause the spindle to break down.
Any deviations from the specified requirements in respect of the lubricating lines are subject to GMN´s approval!

4) Oil selection

The oils indicated in the following Tables 5.2.1 and 5.2.2 have to be used for oil-air lubrication of GMN spindles:

Oils of the viscosity class ISO VG 32

Table 5.2.1

Hydraulic oil	DIN 51524	-	HLP - D32
Hydraulic oil	DIN 51524	-	HLP - 32
Industrial oil	ISO 6743/4	-	HM32

or

Oils of the viscosity class ISO VG 46

Table 5.2.2

Hydraulic oil	DIN 51524	-	HLP - D 46
Hydraulic oil	DIN 51524	-	HLP - 46
Industrial oil	ISO 6743/4	-	HM 46
Lubricating oil	DIN 51517	-	CLP 46

If oils with other specifications than given in Tables 5.2.1 and 5.2.2 were used, the performance and the life of the spindle bearings would not be warrented!

In the Tables 5.2.3 and 5.2.4 some commercial oils are listed which meet the requirements mentioned above:

Selection table oils of the ISO VG 32 viscosity class

ARAL	VITAM DE 32 / VITAM GF 32
BP	Energol HLP D / DH / HM / S 32
FUCHS	Renolin B 10 / Renolin MR 10
GMN	Hydraulic Oil HM 32 S-82 according to works standard WN 3-51-05
MOBIL	DTE 24
SHELL	Tellus oil 32 / Tellus oil DO 32
TOTAL	Azolla AF 32 / Azolla DZF 32 / Azolla ZS 32

Table 5.2.3

Selection table oils of the ISO VG 46 viscosity class

ARAL	VITAM DE 46 / VITAM GF 46
BP	Energol HLP D / DH / HM / S 46
FUCHS	Renolin B 15 / Renolin MR 15
GMN	Machine oil according to works standard WN 3-51-02, No. 15
MOBIL	DTE 25
SHELL	Tellus oil 46 / Tellus oil DO 46
TOTAL	Azolla AF 46 / Azolla DZF 46 / Azolla ZS 46

Table 5.2.4

It is important to check the lubricating oil for compatibility with the coolant and the material of the workpiece.

Where hydraulic oil is used as lubricating oil, the national tax laws must be observed.

Filtration quality of lubricating oil for lubrication of spindle bearings:

Purity class 15/13/10 according to ISO 4406

This purity class can be guaranteed in the following manner:

- The filtration quality of the lubricating oil to be filled into the oil tank of the oil/air lubricating unit already meets the oil purity class required.
- The oil/air lubricating unit is equipped with an oil fine filter which guarantees the oil purity class required.

5) Setting values of the oil/air lubrication

The setting values should be compared with those in the test log. All settings should be made in conformance with the data specified in the test log!

While the setting procedure is already adjusted, lubricating pressure values and the initial pressure at the lubricating unit can change. Therefore it is recommended to check all pressures after finishing the setting procedure once more.

1) Metered volume per lubricating pulse and per lubricating connection A1, A2:

30 to 35 mm^3

2) Cycle time: **3 min**

In order to reduce oil consumption even further, the cycle time can, under certain conditions, be extended to **a maximum of 10 minutes**; please consult GMN.

3) Lubricating pressure ahead of spindle:

Spindle connection A1: **0.6 to 1 bar**

Spindle connection A2: **0.6 to 1 bar**

The setting of the lubricating pressure should be checked with a test pressure gauge (see Fig. 5.2.1).
Remove the test pressure gauge before starting the spindle!

Air consumption data for oil/air lubrication (reference value)**:**

8 to 12 m_n^3/h

5.3 Spindle cooling system

To dissipate heat losses from the spindle motor and the spindle bearings, the spindle must be cooled.

• Coolant run-on:	Spindle connection B1
• Coolant runback:	Spindle connection B2
• Coolant pressure ahead of spindle (B1):	max. 8 bar
• Differential pressure B1/B2:	2 to 4 bar depending on the required coolant flow rate
• Coolant flow rate (reference values):	Minimum flow rate 10 l/min Nominal flow rate 18 l/min
• Optimum coolant inflow temperature:	20 to 25 °C
• Maximum coolant inflow temperature:	35 °C
• Minimum coolant inflow temperature:	depending on ambient temperature (AT): AT ≥ 20 °C: t_{min} ≥ 20 °C AT < 20 °C: t_{min} ≥ AT, but 10 °C min.
• Required cooling capacity:	approx. 12% of the nominal spindle power in S6-60% mode approx. 15% of the nominal spindle power in S1 mode
• Filter fineness of the coolant:	< 300 µm

- Coolants: 1) Water with anticorrosive additives
  e.g.: Aral Sarol 350
  Henkel P3 - Prevox 6710
  Schilling Varidos Top

  Mixing rate: 1 to 3% in water

  or: 2) Water with anticorrosive and antifreeze additives on a glycol basis
  (e.g. commercially available anticorrosive and antifreeze agents for automobile cooling systems)
  Mixing rate: See manufacturer's specifications

  Adequate protection against corrosion is important; as a rule antifreeze properties are unimportant when used in machine tools.

Notes:

1) When calculating the flow rate of the coolant pump, try to attain the relevant value for the **nominal flow rate (approx. 18 l/min)**.
it is important not to go below the **minimum flow rate(10 l/min)** in order to ensure sufficient cooling for the spindle. For this reason, we recommend the installation of a flow monitor in the return flow line for the coolant.

2) An increase in the concentration of anticorrosive and antifreeze additives reduces the cooling effect of the coolant. Under unfavourable conditions it is therefore possible that the nominal power of the spindle might not be attained, even if the coolant temperature is ideal.

3) The pH-value of the coolant used should range between 8 and 9.
pH < 8: Rust formation (iron)
pH > 9: Aluminium corrosion

4) The specified nominal power of the spindle refers to a coolant temperature of 20 to 25 °C. At coolant temperatures above 25 °C, the nominal power of the spindle may not be attained.

5) Especially when using air-water coolers, please ensure that the maximum permissible incoming coolant temperature (35 °C) is not exceeded, even when ambient temperatures are high.

6) The losses in pressure in screwed connections and coolant lines must be taken into consideration when calculating the flow rate of the coolant pump. If anticorrosive and antifreeze additives on a glycol basis are used, please note that the viscosity of the coolant rises as its concentration in the water increases.
For this reason, a higher differential pressure between coolant inlet (B1) and coolant outlet (B2) on the spindle may be required (and with that a higher flow rate of coolant pump) in order to attain the value for the rated flow specified above.

5.4 Drive

The operating data of the frequency converter used must be set to match the drive motor installed in the spindle and the operating mode of the spindle.
For the operating data to be set during initial commissioning on the frequency converter used, please attend to the Tables 5.4.1 to 5.4.3.

Together with the integrated speed sensor (encoder) and the temperature sensor in the motor coil (KTY), the system consisting of frequency converter (with integrated automatic control device) and spindle motor forms a control circuit with the operating data as specified requirements (see schematic sketch in Fig. 5.4.1).

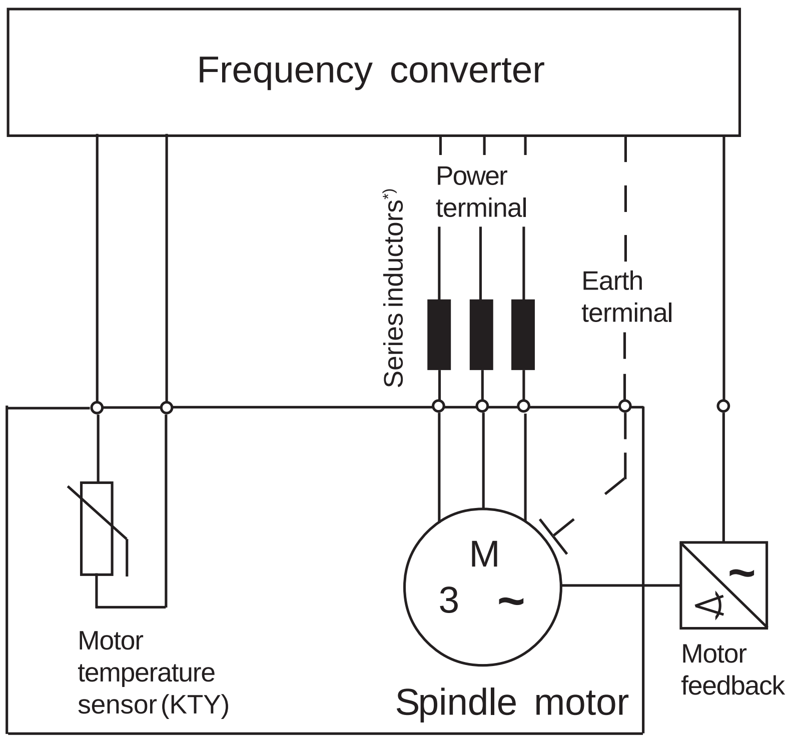


Fig. 5.4.1

*) If additional series inductors are necessary.

Perhaps additional series inductors installed between spindle and frequency converter are necessary when operating the spindle (compare with Table 5.4.3, parameter 1119).

For the following reasons the installation of additional series inductors between spindle and frequency converter could be necessary:

- To reduce the electrical losses in the spindle motor.

- For troublefree operation of frequency converters the leakage inductance should exceed a minimum value.

- Series inductors damp voltage peaks between frequency converter and spindle motor. This gives better insulation life of the motor windings.

Further information can be obtained from the operating manual of the frequency converter used.

1) Monitoring the motor temperature

A thermistor (KTY type) is incorporated in the stator coil of the drive motor to monitor the motor temperature.
Within its defined measuring range, the thermistor has a resistor which shows a linear increase as temperature rises. The current coil temprature can thus be determined with the help of a suitable evaluating unit.

Maximum permissible winding temperature: 145 °C
Feed drives and spindle must be stopped!

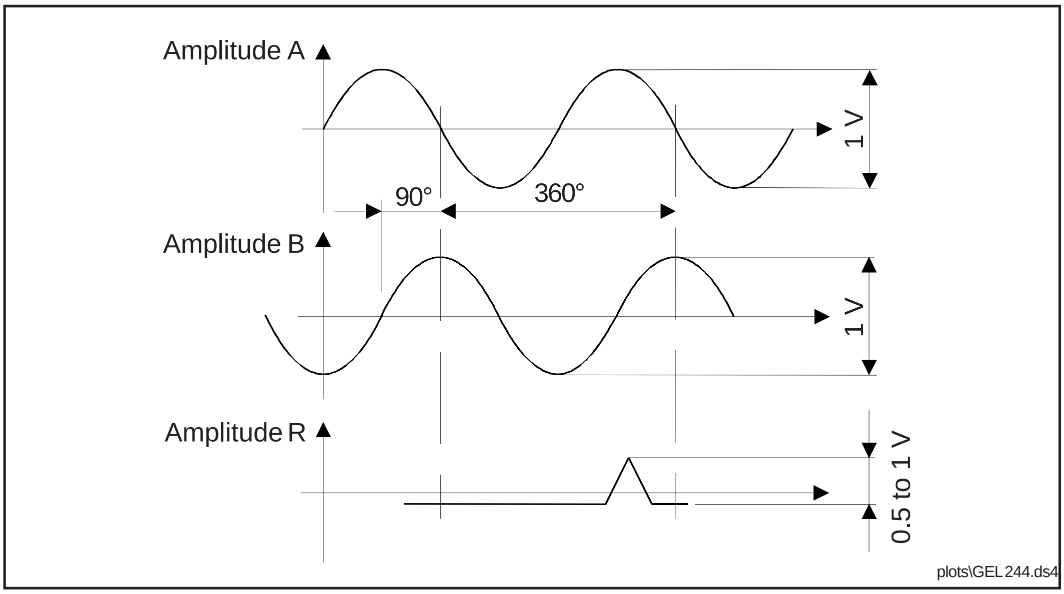
We recommend to evaluate thermistor of KTY type and to reduce the load of the spindle before the maximum permissible winding temperature (145 °C) to be reached.

LENORD + BAUER speed sensor (encoder) of type GEL 244

To record the spindle speed, a speed sensor (encoder) of type GEL 244 manufactured by LENORD + BAUER is installed inside the spindle.

The encoder consists of a measuring wheel mounted on the spindle shaft, a non-contact scanning head with an integrated electronic module for processing and amplifying the signals and a cable assembly.
The signal line of the motor temperatur sensor of KTY type is integrated in the cable assembly.
To detect the direction of rotation, the encoder provides 2 signals A and B, out of phase by 90°, as well as a reference signal R (see Fig. 5.4.2).

Fig. 5.4.2



Signal curve for clockwise rotation

The frequency converter used must be prepared for connecting the speed sensor.

For transmission of the speed sensor signals between spindle and frequency converter we recommend the following signal cable:

Signal cable: 6FX2 002 - 2CA31 - ... or 6FX4 002 - 2CA31 - ...
Supplier: SIEMENS AG

3) Motor data

Power and torque characteristics of integrated spindle motor see Appendix.

Voltage-frequency characteristic of spindle motor

Table 5.4.1

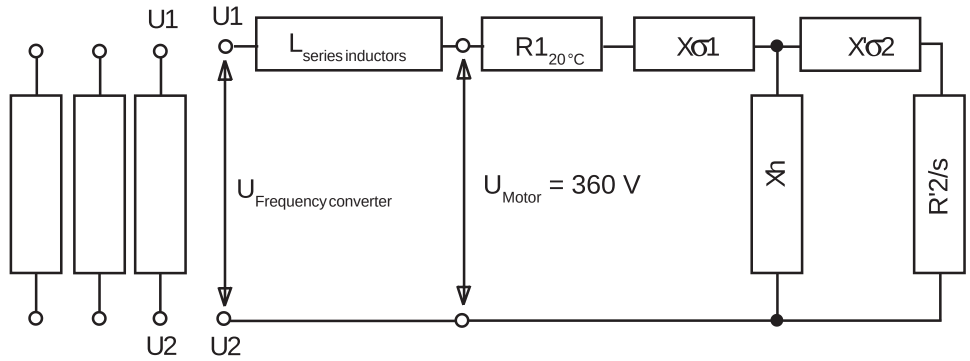
Voltage	[V]	360	360
Frequency	[Hz]	550	1000
Speed	[min^{-1}]	16500	30000
Output S1	[kW]	80	80
Current S1	[A]	166	157

Overload factors

Table 5.4.2

Voltage	Value	Unit
Overload factor*) torque	150	%
Overload factor*) current	150	%
Overload factor*) power	150	%
*) refered to rated values		

4) Equivalent wiring scheme of integrated motor



Connection: Δ

P = 80 kW

f = 550 Hz

I_μ = 46 A at no-load running

R1 = 0.030 Ω at 20 °C

R'2 = 0.030 Ω at 20 °C

Xσ1 = 0.290 Ω

X'σ2 = 0.200 Ω

Xh = 7.300 Ω

X2 = Xh + X'σ2

$$\tau_{Rotor} = \frac{X2}{2 \times \pi \times f \times R'2} = 0.070 \text{ s}$$

Fig. 5.4.3

5) Motor parameters for setting up the SIMODRIVE 611 module

Table 5.4.3

Parameter SIMODRIVE 611-D / 611-U			
Connection (Delta or Star)	Delta (Δ)		
Designation	*Parameter MD*	*Unit*	*Calc. value*
Encoder resolution	1005	---	256
Inverter switching frequency	1100	Hz	8000
Rated current	1103	A	166
Spindle moment of inertia	1117	kgm^2	0.031
Series inductor	1119	mH	0.050
Power factor cos(φ)	1129	---	0.81
Rated output	1130	kW	80
Rated voltage	1132	V	360
Rated frequency	1134	Hz	550
No-load voltage	1135	V	347
No-load current	1136	A	80
Stator resistance, cold	1137	Ω	0.010
Rotor resistance, cold	1138	Ω	0.010
Stator leakage reactance	1139	Ω	0.096
Rotor leakage reactance	1140	Ω	0.068
Main field reactance	1141	Ω	2.450
Start of field weakening	1142	min^{-1}	16300
Stall torque reduction	1145	%	100
Maximum speed	1146	min^{-1}	30000
Rated speed	1400	min^{-1}	16300
Winding temperature warning	1602	°C	125
Winding temperature limit	1607	°C	145

5.5 Automatic tool change

Warning

Tool change may only be carried out when the spindle is at a standstill!

For this reason it is essential that the integrated speed sensor should be connected to the frequency converter.
The system frequency converter / speed sensor positions the spindle shaft in the previously defined position to be required for automatic tool change.
A holding torque is produced at standstill to fix the spindle shaft in position, by means of the frequency converter and the spindle motor.

Clamping the tool

Prior to clamping of the tool, the tool clamping system must be switched in position "Tool released" (see section "Releasing the tool").

1)	Pressure at spindle connection WL: (WL = release tool)	0 bar
2)	Pressure at spindle connection WS: (WS = clamp tool)	5 to 140 bar pneumatic or hydraulic pressure

When clamping the tool, and when the spindle is rotating, there must be a pressure of 5 to 140 bar at the spindle connector marked WS in order to lift the release piston from the spindle shaft and to retain it in the rearmost position!

Releasing the tool

1) Pressure at spindle connection WS: 0 bar

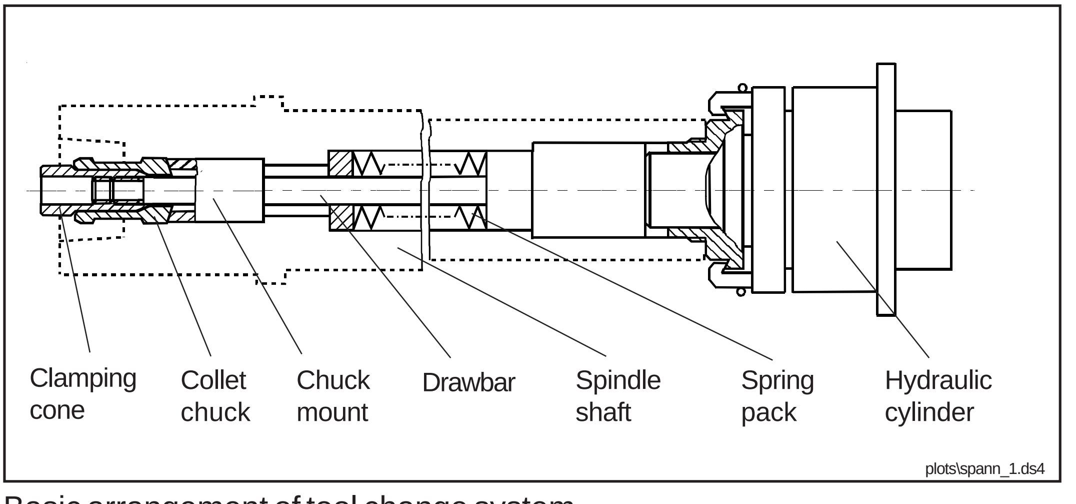
2) Pressure at spindle connection WL: min. 74 bar
max. 140 bar

The release piston is loaded with the tool releasing pressure; this compresses the disk springs and pushes the tool via the drawbar out of its seat (see Fig. 5.5.1).

Working volume of hydraulic piston for releasing and clamping the tool:

max. 45 cm^3 / 2.75 in^3

Fig. 5.5.1



Basic arrangement of tool change system

Regarding control of the tool release and tool clamping pressure see "action chart spindle operation" in the Appendix.

Safety instructions:

- **The spindle may only be started when the tool is clamped in position!**

- **After the first 100 clamping strokes with tool and use of the spindle in the machining process, the lock screw of the tool clamping system must be tightened through a clamped tool!**
  Tightening torque: 30 Nm

  After that the adjusting distance (10.5 ± 0.1 mm) must be checked in *release position*. (see Fig. 5.5.2)
  If any correction is necessary, the operation must be repeated (approx. 100 clamping strokes, tighten)!

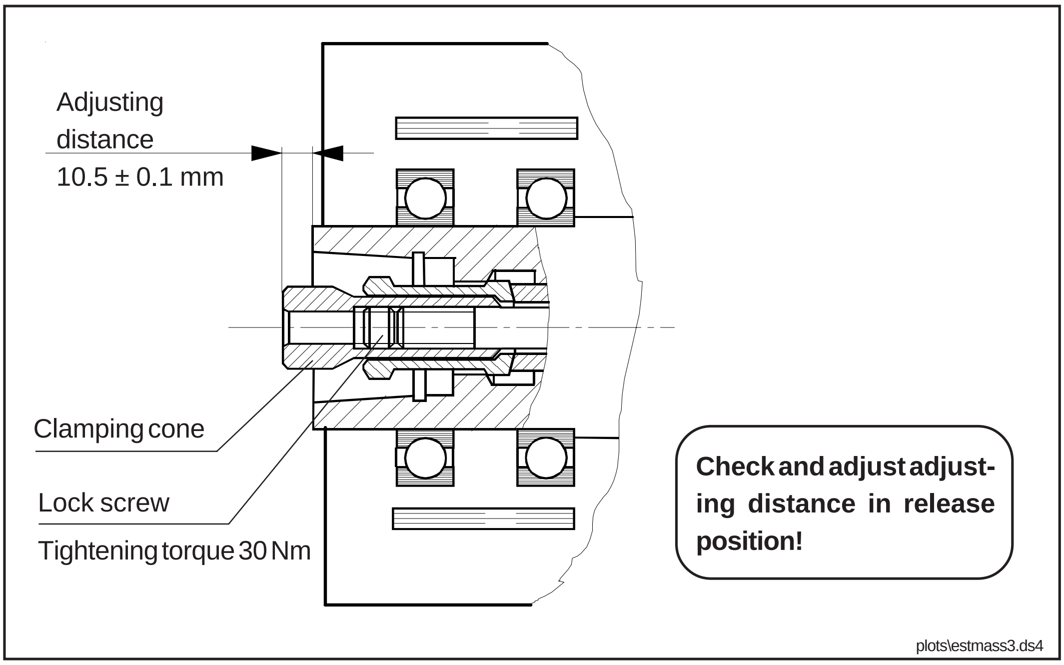
- **Check functioning of clamping system regularly!**
  See Chapter 8.2.

- **When positioning the tool in front of the spindle shaft for clamping process - especially when using automatic tool grippers - the gap between clamping cone and tool must not exceed 0.1 mm (see Fig 5.5.3)!**
  Only this ensures, that the tool is drawn in properly and that the tensile rod reaches the position "Tool clamped" during clamping process.

Correcting of adjusting distance:

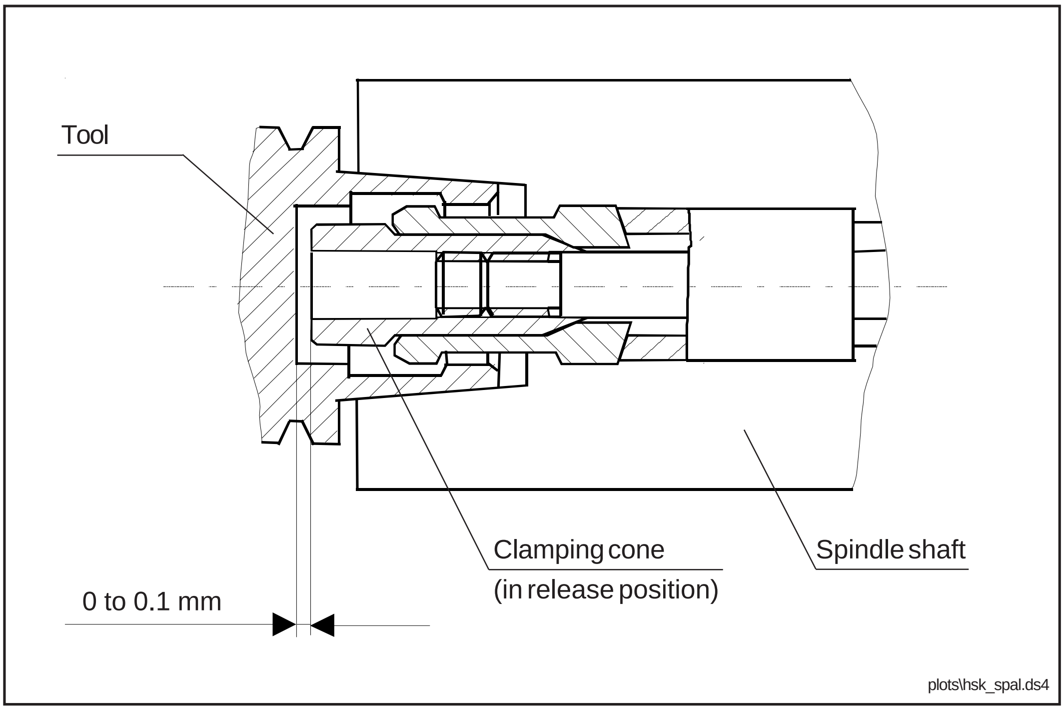
- Loosen lock screw. While doing this retain at the spanner face of the clamping cone with a fork wrench.
- Set adjusting distance by turning the clamping cone.
- Tighten the lock screw (tightening torque 30 Nm).

Fig. 5.5.2



Check and adjust adjusting distance

Fig 5.5.3

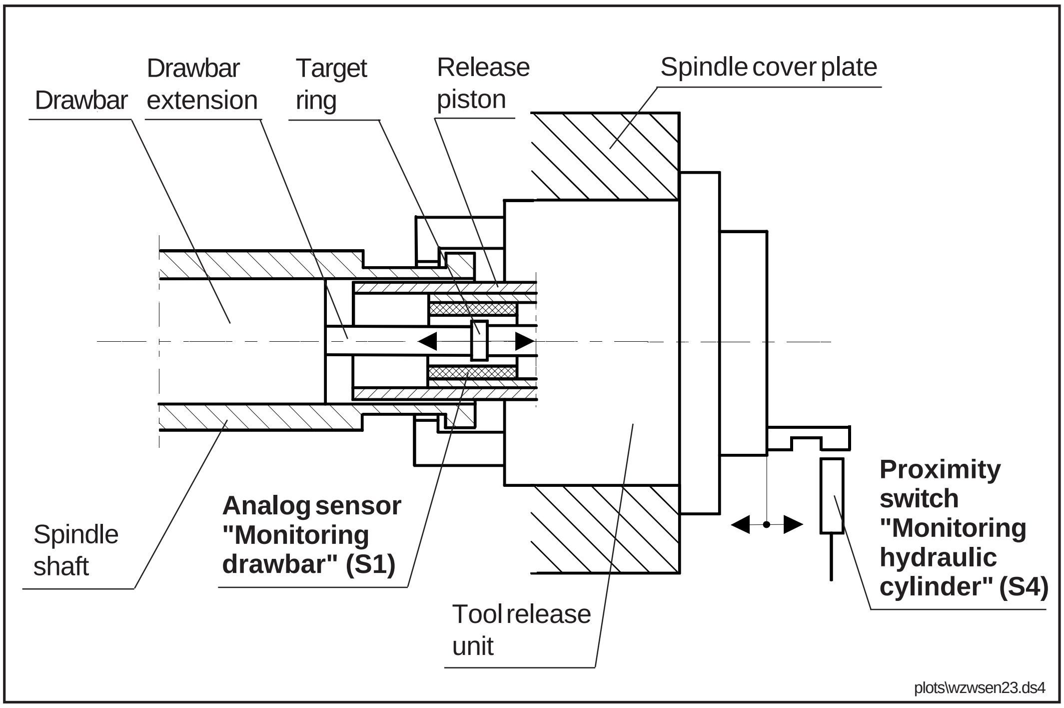


Positioning of tool for clamping operation

5.6 Monitoring tool change

To monitor the tool changing process, the spindle is equipped with 2 monitoring sensors (see schematic diagram in Fig. 5.6.1).
An **analog sensor (S1)** with analog output signal monitors the position of the drawbar, a **proximity switch (S4)** with digital output signal checks the position of the hydraulic cylinder of the tool release unit.

Fig 5.6.1



Schematic diagram "Monitoring tool change"
(diagramed position "tool clamped")

Warning

The signals of sensors S1 and S4 must be processed in the machine controller to control the tool changer and as an enable condition of the spindle after completion of tool change!

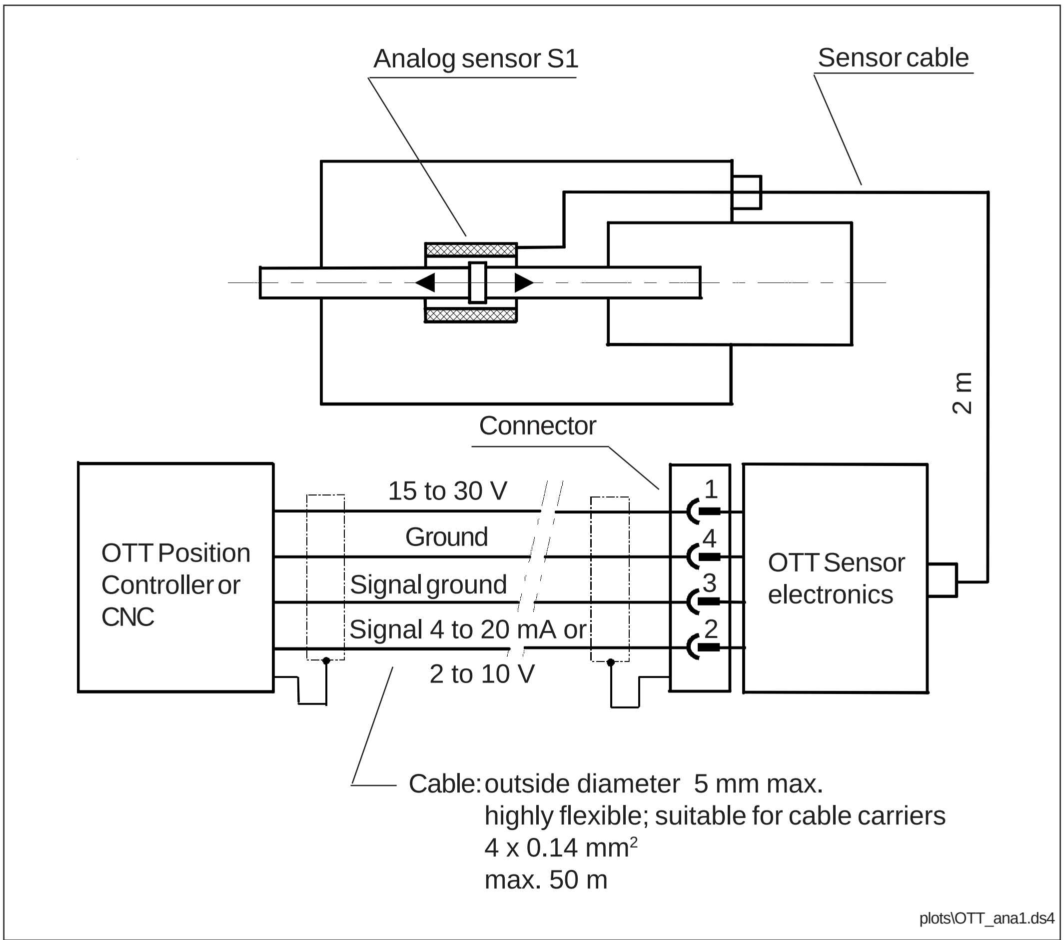
1) Analog sensor S1

The OTT position monitoring system consists of an analog sensor S1, a sensor cable and a sensor electronics (see Fig 5.6.2). The sensor electronics works up the sensor signal to an analog output signal (4 to 20 mA or 2 to 10 V).
Inside the sensor electronics box there is a switch to choose the requested type of output signal. The type adjusted is marked on the box:

"JA" = current output signal (mA)
"UA" = voltage output signal (V)

The *current output signal* can be evaluated with the OTT Position Controller or with the control system (CNC) of the machine tool, the *voltage output signal* can only be processed with the CNC.

Fig. 5.6.2



Connecting scheme of analog sensor S1

Analog sensor S1, sensor cable and the OTT sensor electronics are adjusted on each other. Therefore the length of the sensor cable (2 m) must not be varied.
In case of repair, analog sensor S1, sensor cable and the OTT sensor electronics must be replaced together!

When installing the OTT sensor electronics please note:
The sensor cable between analog sensor S1 and the OTT sensor electronics is not highly flexible, i.e. it is not suitable for constant movements!

The analog output signal of the analog sensor S1 is dependent on the depth of immersion of the target ring in the analog sensor (see Fig. 5.6.1).

The depth of immersion varies through axial movement of the drawbar.
A certain value can thus be assigned to each drawbar position - tool released, tool clamped, clamped without tool.

Fig. 5.6.3 shows the output signal of the inductive analog sensor S1 as a function of the drawbar stroke.
In consideration of temperature effects as well as componant and tool tolerances, current or voltage values can be specified for the various drawbar positions. These values are determined during the test run of the spindle before delivery and can be found in the **spindle test log**.

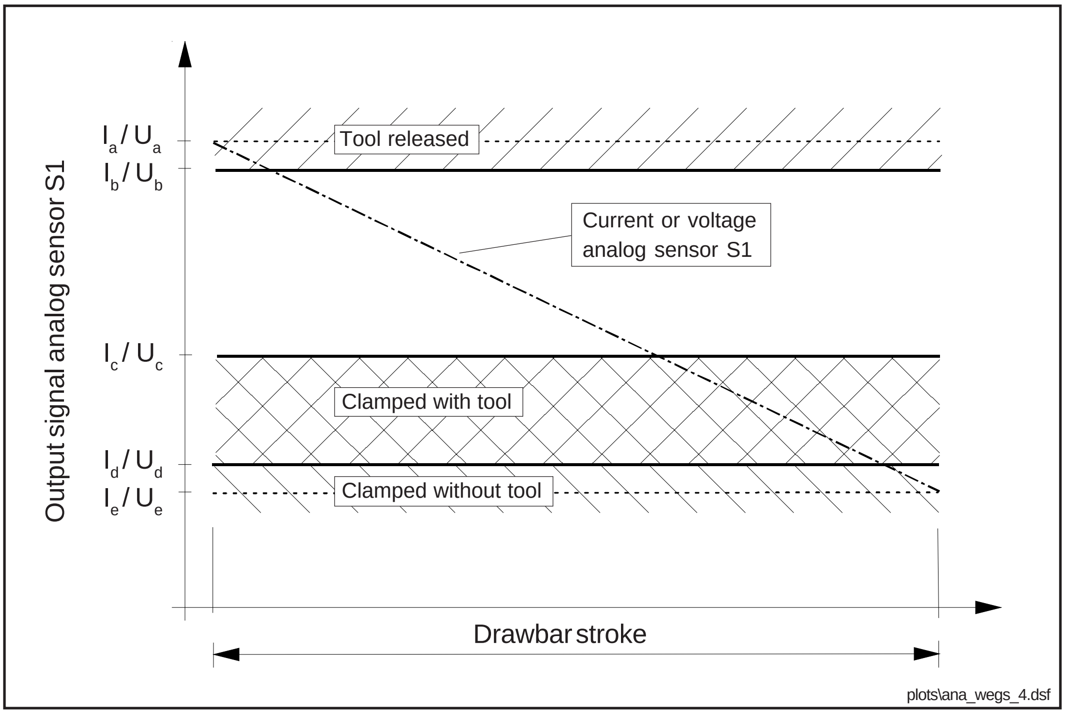


Fig. 5.6.3

Warning

In case of accurate functioning of the clamping system the current or voltage signals in the various drawbar positions must be within the relevant ranges indicated in Fig 5.6.3:

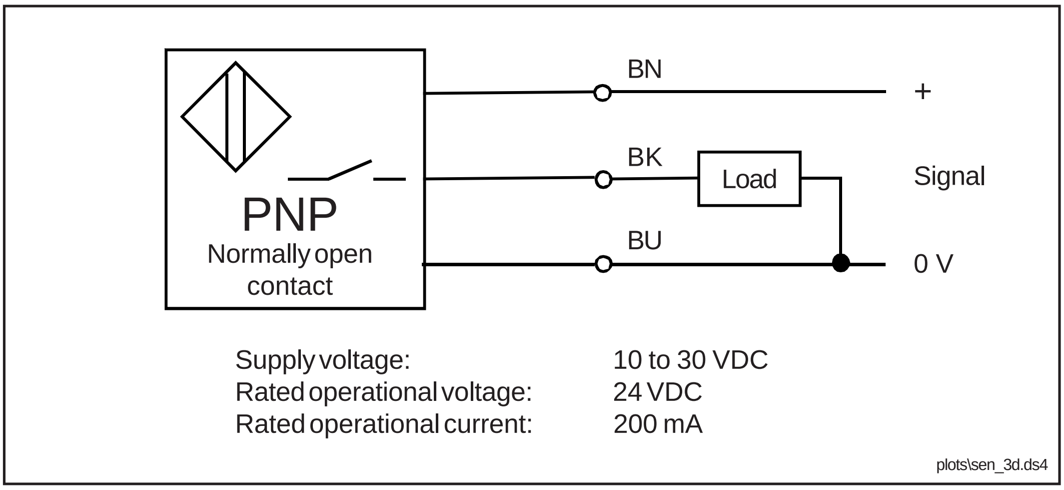
> I_b or	**U_b**	**Tool released**
I_c / I_d or	**U_C / U_d**	**Clamped with tool**
< I_d or	**U_d**	**Clamped without tool**

Please note that the current or voltage values apply only for the spindle in question and cannot be transferred to other spindles of the same type.
In case of a spindle change it may therefore be necessary to adjust the OTT Position Controller respectively the machine controller to other current or voltage values for the various drawbar positions.

2) Proximity switch S4 with digital output signal

The proximity switch S4 - a PNP three-wire sensor with normally open contact - for monitoring the hydraulic cylinder of the tool release unit provides a digital output signal (ON/OFF).

Fig 5.6.4



Circuit diagram proximity switch S4

The target logic status of the proximity switch in the different positions of the drawbar please take from the following table:

Table 5.6.1

0 = OFF 1 = ON (activ)	Tool released	Tool clamped **Make condition Spindle START**	clamped without tool
Proximity switch S4, (PNP normally open contact)	0	1	1

5.7 Air sealing

The seal air flow is fed into the spindle via the spindle connection S on the spindle connection side.
Air sealing is designed to prevent leakage of lubricant during operation of the spindle and the ingress of contaminants from the outside. This is achieved by establishing a continuous air stream between the stationary and rotating spindle parts at the working end. In addition, surplus lubricant is removed from the spindle by means of the seal air through the connection T under controlled conditions (see basic arrangement in Fig. 5.7.1).

Air pressure setting:

0.9 to 1.1 bar ahead of spindle

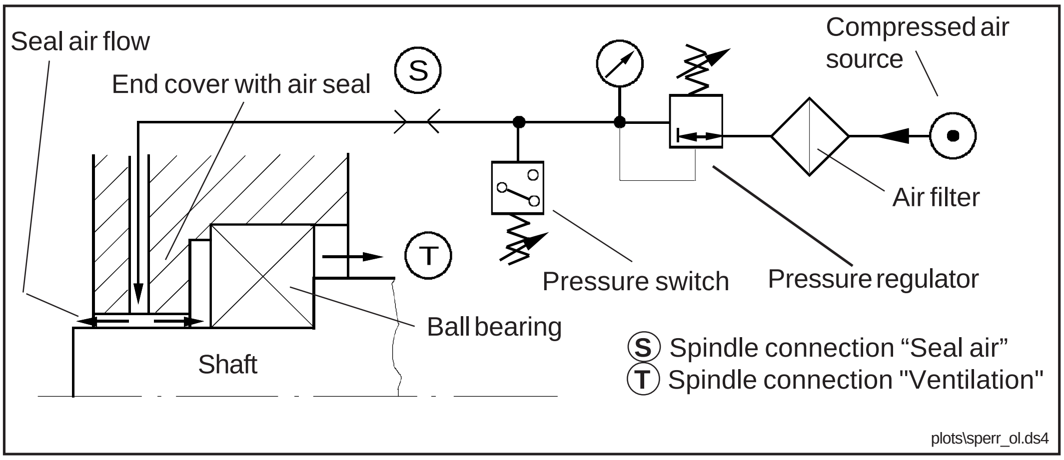


Fig. 5.7.1

The lubrication settings (see Chapter 5.2) have to be checked again and adjusted if necessary after the air sealing is setted.

The compressed air supplied must comply with the requirements according to Chapter 5.1 "Compressed air supply"!

Air consumption for air seal supply of the spindle: 6 to 10 m_n^3/h

5.8 Taper cleaning

The cleaning air flow is fed into the spindle shaft via the spindle connection marked K on the rear side of the spindle and the tool release unit, and emerges again via the tool holding fixture.
On the one hand, the flow of air cleans the tool holding fixture of loose dirt, and, on the other hand, it prevents dirt particles from entering and being deposited on the tool seating during tool change.
When cleaning the taper, ensure that the system pressure does not fall below a minimum value, at which other spindle components are switched off due to lack of air.

The taper cleaning air flow must only be available as long as the piston of the tool release unit is in contact with the stationary spindle shaft while the tool is being changed!
There must be NO taper cleaning pressure during spindle operation!
As soon as the signals "Tool released" of the monitoring sensors S1 and S4 are cancelled, the taper cleaning air flow must be switched off!

Conditions for taper cleaning:

- **Spindle must be at a standstill! (n = 0)**
- **Sensor signals "Tool released" enabled!**
  Piston of the tool release unit must be in contact with the spindle shaft!

Pressure of cleaning air (ahead of spindle):

Minimum pressure:	**1 bar**
Maximum pressure:	**5 bar**

Regarding control of cleaning air see "Action chart spindle operation" in the Appendix.

5.9 Cooling lubricant supply through spindle shaft

To cool the tool and workpiece, the spindle is fitted with a rotary union to feed cooling lubricant (liquid or cooling lubricant/air mixture) or compressed air through the spindle shaft to a drilled tool.
Please take note of the **maintenance instructions** in Chapter 8.

The cooling lubricant respectively the compressed air is fed into the spindle via the bolted connection KV1 on the rotary union (see Fig. 5.9.1).

As shown in Fig. 5.9.1, we recommend to install a vent valve into the pressure line leading to the rotary union in order to reduce completely the pressure in the line in case of dry machining operation.

The "Action chart spindle operation" in the Appendix includes a suggestion for controlling the cooling lubricant pressure.

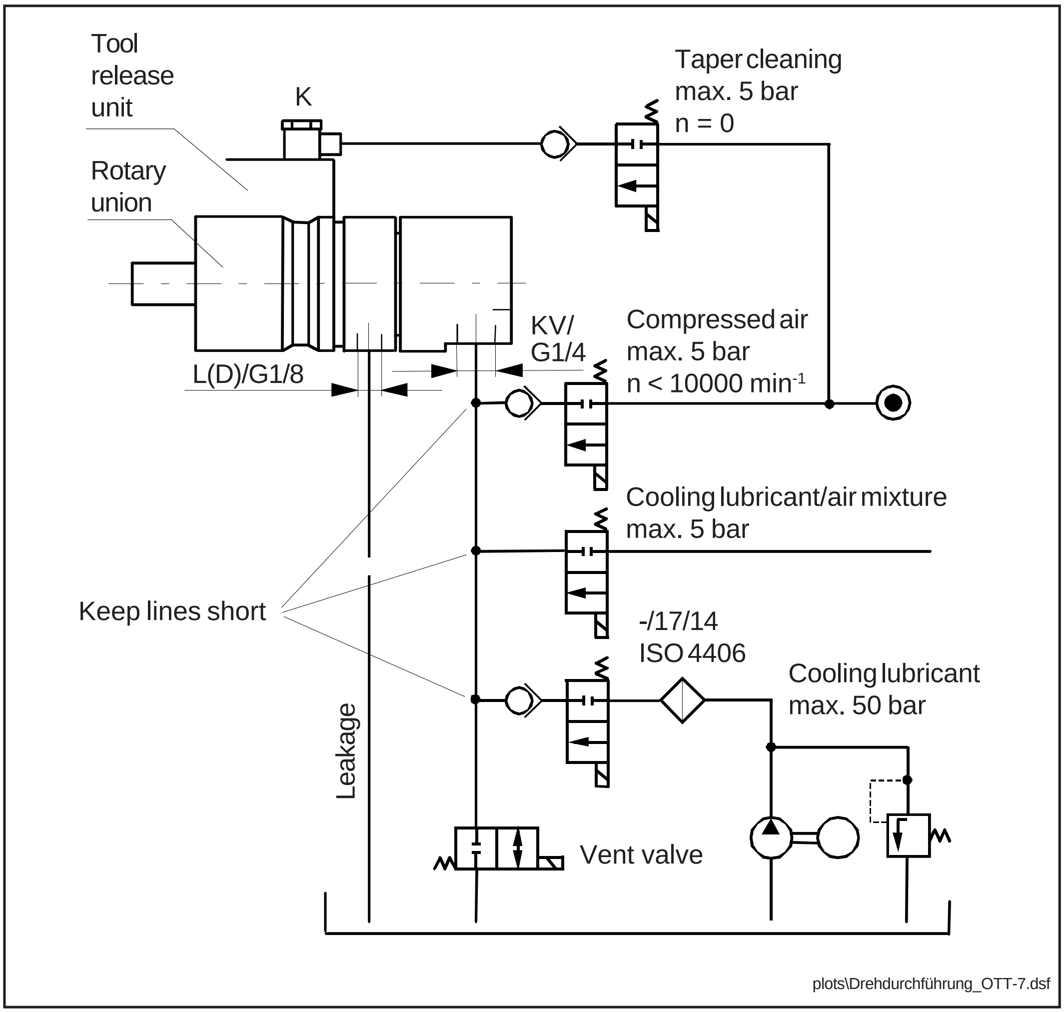


Fig. 5.9.1

1) Spindle operation with liquid cooling lubricant

Maximum cooling lubricant pressure:	≤ 50 bar
Filter fineness of cooling lubricant:	-/17/14 (ISO 4406)
Permissible cooling lubricant temperature:	+15 to +40 °C

Cooling lubricant flow must be guaranteed!
When operating the rotary union, ensure that pressure peaks in the supply line system - especially when switching on or off cooling lubricant supply - do not exceed the maxmimum permissible cooling lubricant pressure!

Tool: with coolant pipe
with coolant bore

2) Spindle operation with cooling lubricant/air mixture

Generation of mixture:	outside the spindle
Maximum mixture pressure:	≤ 5 bar
Portion of lubricant in the mixture:	≥ 10 ml/h
Filter fineness of mixture:	-/17/14 (ISO 4406)
Permissible mixture temperature:	+15 to +40 °C

Lubrication of the gaskets and washers inside the rotary union must be guaranteed.

Tool: with coolant pipe
with coolant bore

The spindle is delivered to be operated with liquid cooling lubricant or compressed air. For this the lock screw of the tool clamping system is fitted with a valve.

If the spindle should be operated with cooling lubricant/air mixture, a lock screw without valve must be mounted inside the tool clamping system!

This ensures, that the cooling lubricant/air mixture does not segregate when flowing through the lock screw.

Lock screw without valve / OTT order no.: 95.101.372.5.1
Position of the lock screw see Fig. 5.9.2.

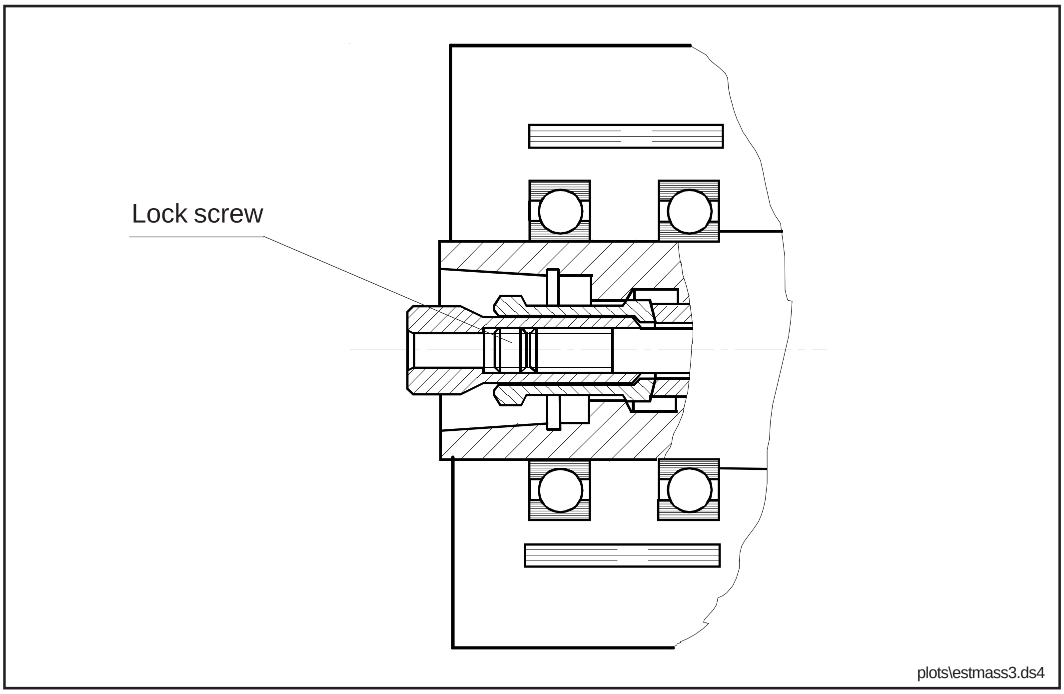


Fig. 5.9.2

The valve mounted in the supply line for cooling lubricant / air mixture shown in Fig. 5.9.1 must ensure unhindered flow through in order to avoid segregation of the mixture.

3) Spindle operation with compressed air

Dry machining operation with air cooling of the tool.

Admissible only in rotation with wet/dry operations!

Air pressure:	1 to 5 bar
Spindle speed:	≤ 10000 min^{-1}
Compressed air temperature:	+15 to +40 °C

Tool: with coolant pipe
with coolant bore

4) Spindle operation without cooling lubricant or compressed air

Dry machining operation

There must be NO cooling lubricant or air pressure on the rotary union! The cooling lubricant line to spindle connection KV1 must be depressurized (vent valve open, see Fig 5.9.1).

Tool: with or without coolant pipe
with or without coolant bore

Leakage connections L(D) and L(S)

- **Leakage connection L(D)** (Drehdurchführung):
  Connect hose line (approx. 1 m line length) in order to prevent dirt particles from penetrating into the spindle. The hose lines should be laid such as penetrating cooling lubricant indeed could drain off.

- **Leakage connections L(S)** (Spindle):
  In delivery status of spindle, the leakage bores L(S) (2x G 1/8, compare with Chapter 4.4, Fig. 4.4.1) are closed with plugs.
  Remove plugs prior to spindle operation. To drain off possibly leaking cooling lubricant suitable drain passages must be provided (bores in spindle head or hose lines).

Leakage at spindle connection L(D):
Continuous **leakage of cooling lubricant indicates a defective seal inside the rotary union.**
Cooling lubricant supply and spindle must be switched off!
The rotary union needs to be replaced.

Leakage at spindle connections L(S):
If there is any leakage of cooling lubricant at connections L(S), the rotary union is defective. Cooling lubricant is penetrating into the spindle.
In order to prevent failure of the spindle bearings, cooling lubricant supply and spindle must be switched off immediately!
The rotary union needs to be replaced.

5.10 Monitoring the bearing temperature

To monitor the temperature of the front and rear bearing group two temperature sensors (precision resistor Pt100 in accordance with DIN EN 60751) are installed in the vicinity of the outer bearing ring of the 1st and 3rd bearing (seen from the spindle working side).
The signals of the temperature sensors can be used to assess the operating status of the front and rear bearing group during spindle operation.

The bearing temperature is dependent not only on the type of lubrication but also on the speed and load of the spindle, the preloading of the bearings, the coolant temperature in case of spindles with cooling jacket and the clamping conditions.

If the operating data is adjusted correctly and under normal operation conditions, the rise in temperature should correspond to the curve in the following diagram after the spindle is switched on:

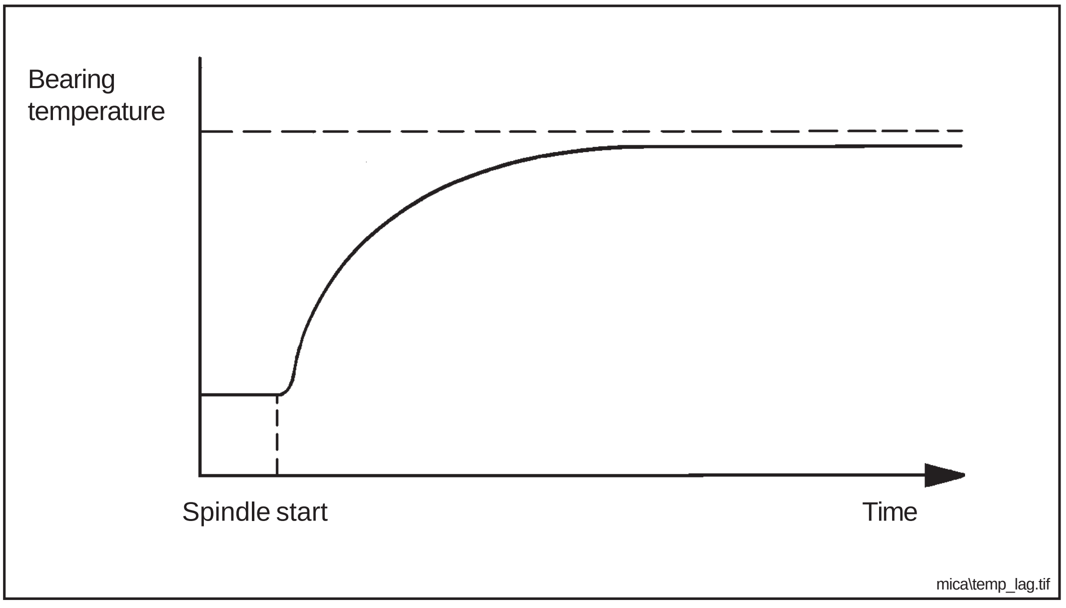


Fig. 5.10.1

Because of the plurality of influencing variables, a **limit value** for the permissible bearing temperature cannot be determined till real operating conditions.

Circuit diagram and pin assignment of bearing temperature sensors see Chapter 4.4, Fig. 4.4.5.

5.11 Monitoring axial movement of spindle shaft

The axial position of the spindle shaft and with that the position of a clamped tool varies when operating the spindle.

Axial movement during spindle operation is caused by:

- Thermal effects due to spindle heating.
- Speed effects due to centrifugal forces to the balls of the spindle bearings.

To record the displacement of the spindle shaft an analog sensor EDDY NCDT manufactured by MICRO-EPSILON MESSTECHNIK is installed in the front cover plate of the spindle.
The signal of the analog sensor is fed via a connecting cable to an evaluation electronics (Controller), processed to an output signal and then led to the control system (CNC) of the machine tool. By means of the control system (CNC) a compensation of shaft displacement can now be carried out.
Please note the connection diagram of the analog sensor EDDY NCDT in the Appendix.

The signal cables of the analog sensor EDDY NCDT are connected to a socket at the spindle connecting side. Pin assignment see Chapter 4.4, Fig. 4.4.6.

The connecting cable between spindle and evaluation unit is adjusted to the evaluation electronics and must not be modified or replaced with another cable. In case of repair, both components, connecting cable and evaluation unit, must be replaced together!

Compensation of shaft displacement with MICRO-EPSILON sensor EDDY NCDT:

Before delivery of the spindle, the analog sensor EDDY NCDT is calibrated in a test cycle by means of a « dummy » tool and a high resolution capacitive displacement sensor as reference. Purpose of the test cycle is the determination of the sensor specific compensation factor « K_z ». Please note, that the compensation factor « K_z » only is valid for the spindle in question.

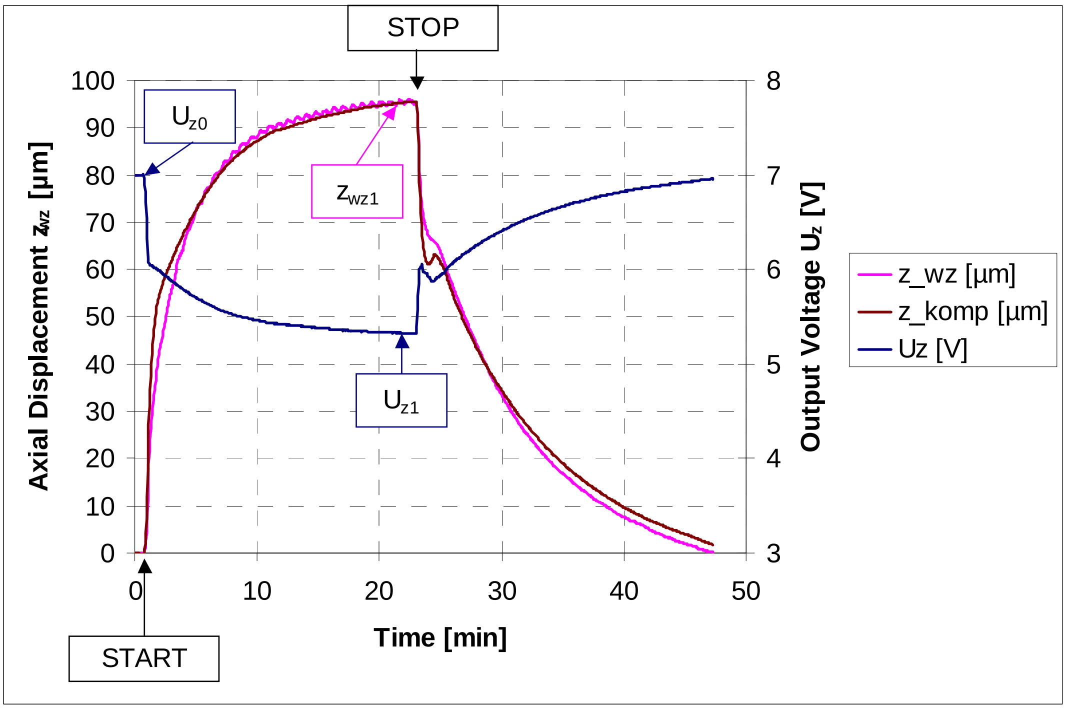
$$K_z := \frac{z_{wz1}}{U_{z1} - U_{z0}}$$

z_{wz}: Axial displacement at « dummy » tool measured with high resolution capacitive displacement sensor as reference

U_{z0}: Output signal of analog sensor EDDY NCDT before starting the test cycle (Spindle cold)

Supposition: before start of test cycle (Spindle cold) axial displacement $z_{wz0} = 0$

Fig. 5.11.1



Output voltage U_z and axial displacement z_{wz} in a test cycle - example data only

The compensation value « z_{komp} » for compensation of shaft displacement in the control system (CNC) of the machine tool is calculated as follows:

$$z_{komp} := K_z \times (U_z - U_{z0})$$

Compensation factor « K_z » and voltage value « U_{z0} » please find in the **test log** of the spindle.

5.12 Control

Control and monitoring of starting and stopping cycles of the spindle and its supply units has to be provided via a sequence control system.
The starting and operating permissives for safe spindle operation are listed in the following. When all permissives are satisfied, the spindle will be ready for operation.
The enable signal will be issued subject to the correct functioning of the supply circuits to permit starting the spindle (see Chapter 5.13).

Permissives:

- Lubrication in operation.
- Spindle cooling in operation.
- Prelubrication completed (prelubricating time see Chapter 5.2).
- Spindle stand still.
- Temperature of the motor windings (KTY monitoring) below switching-off level.
- Tool clamped.
- Pressure at spindle connection WS.
- Monitoring tool change: correct signals of monitoring sensors S1 and S4, see Chapter 5.6
- Air sealing operative.
- Compressed air for taper cleaning depressurized.
- Bearing temperature below permissible level.
- Pressure line leading to the rotary union depressurized (vent valve open, see also Chapter 5.9).

Spindle operation enabled

In case of wet machining with cooling lubricant supply through spindle shaft:

- Vent valve in pressure line leading to the rotary union closed.
- Cooling lubricant supply operative.

5.13 Monitoring

With a view to ensuring trouble-free operation of the spindle, it is necessary to monitor the following parameters and functions by a machine control system:

Drive:	• Motor temperature (KTY) • Maximum spindle speed • Maximum permissible current
Cooling:	• Coolant temperature • Flow in coolant return circuit (B2)
Lubrication:	• Compressed air supply to lubricating unit • Lubricant level in lubricating unit • Lubricant delivery (e.g. oil pressure built-up and drop) • Timer function, if provided, and control system of lubricating unit
Control:	• Permissives for spindle operation (permissives see Chapter 5.12)
Tool change:	• Spindle standstill • Tool release pressure • Tool clamping pressure
Monitoring tool change:	• Evaluation of the integrated monitoring sensors S1 and S4
Air sealing:	• Pressure for seal air
Taper cleaning:	• Pressure for cleaning air
Cooling lubricant supply through spindle shaft:	• Permissible cooling lubricant pressure • Cooling lubricant flow

Bearing temperatures :
- Evaluation of the integrated temperature sensors (Pt100)

In the event of any abnormal conditions, feed drives must be stopped before spindle to be stopped! (see Chapter 7.4)

6 Tools

Tools to be used:

Spindle of type:	**HCS 230 - 30000 / 80**
GMN part no.:	**104 60 46 R**
Tool:	**DIN 69893 - HSK - A63**
	or
	DIN 69893 - HSK - C63

If the tool/tool holding fixture combination is not permissible, the tool cannot be drawn in properly!
If the spindle is still started, considerable risk to the operating personnel must be expected!

6.1 General

The tools must run absolutely true. Oscillations by tools running out of true can lead to tool breakage, thus representing a hazard for operating personnel!

Before installing the tool, make sure that the locating surfaces at the interfaces are free from dirt.
Even very fine foreign matter trapped between the locating surfaces are liable to cause deviation errors.

Check tool holding fixture taper for radial deviation with a test arbor on installation. (see Fig. 6.2.1)

In case of dry machining operation using tools without coolant pipe and without coolant bore there must be NO cooling lubricant or air pressure on spindle connection KV1! The cooling lubricant line to spindle connection KV1 must be depressurized (no residual pressure)!
(Please compare with Chapter 5.9)

Balancing grade of tools

For *safetey reasons* the balancing grade of the tool to be used must not be worse than G40 according to E DIN EN ISO 15641!

Dependig on the demands to the machining resault a significant better balancing grade of the tool may be necessary.
When defining the balancing grade we recommend to consider the following VDMA guide line:

"Auswuchtanforderungen schnelldrehende Werkzeugsysteme"
(Balancing requirements fast rotating tool systems)
ISBN 3-8163-0393-5
published by VDMA Verlag GmbH

Permissible vibrations

Permissible vibrations (effective) of spindle with tool at no load:

1.8 mm/s

Calculation of permissible speed

GMN milling and drilling spindles are designed so that with the usual clamps and the appropriate cylindrical tools, whose length/diameter ratio does not exceed 4:1, the critical speeds of the spindles are above the nominal speed.

Warning

If tools are to be used with dimensions varying significantly from these specifications, the permissible speed must be calculated!

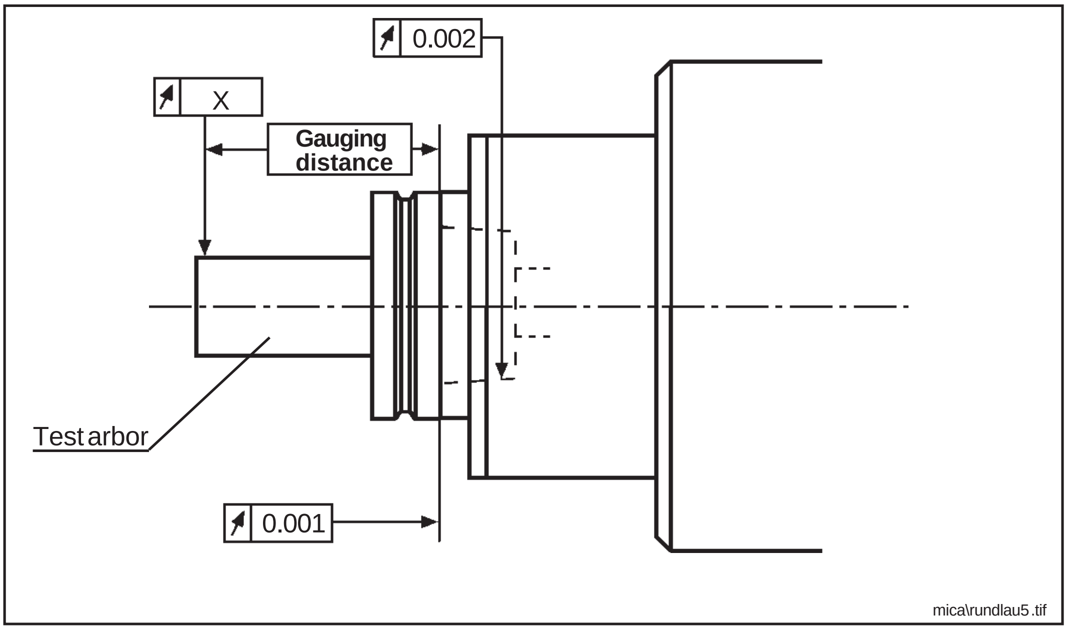
If the tool dimensions and material(s) are given, GMN can determine the permissible speed with the help of calculation programs.

Consideration must be given not only to the speed limits imposed by critical speeds of the spindle/tool system but also to speed limits resulting from the technology data of the machining process, e.g. permissible cutting speed!

6.2 HSK tool holding fixture

Permissible radial and axial deviation:

Bild 6.2.1



Radial deviation tool holding fixture taper: ≤ 0.002 mm

Radial deviation "X" of test arbor in gauging distance 50 mm: ≤ 0.005 mm

Radial deviation "X" of test arbor in gauging distance 250 mm: ≤ 0.010 mm

Axial deviation: ≤ 0.001 mm

The spindle may only be started when the tool is clamped in position! The tool clamping element is not tightly fixed in the spindle shaft until the tool is clamped in position!

7 Spindle operation

7.1 Initial commissioning

Prior to initial commissioning of the spindle, it is necessary to have all lines connected according to Chapters 4.4 and 4.5 and the operating data set according to Chapter 5. It is recommended that these connections be checked again prior to the first start of the spindle.

Oil/air lubrication:

- Establish air pressure to lubricating unit or oil/air mixing distributor.
- Start lubricating unit.
- Seal air should be cut off.
- Set lubricating pressure at each lubricating point directly ahead of the spindle (see Chapter 5.2).
- Start prelubrication of the spindle until a constant oil flow reaches the spindle.
  After that wait another **15 minutes** to allow the lubricating oil ducts in the spindle to fill with oil. If transparent hose lines are provided, the flow of oil can be observed and checked by watching the moving oil film.
  Lubricant delivery takes place at a rate of about 20 cm (≅ 8 inch) line length per minute.
- Check and, if necessary, adjust cycle time on lubricating unit timer (see Chapter 5.2).

Seal air:

- Start seal air supply and adjust seal air pressure.
  After that check and adjust, if necessary, the lubricating pressure settings of the oil/air lubrication once more.

Cooling system:

- Start spindle cooling circuit.
- Check direction of rotation of coolant pump.

Tool / tool clamping system:

- Tool clamped.
- Pressure at spindle connection WS.

Cooling lubricant supply through spindle shaft:

- Cooling lubricant supply switched off.
- **If the cooling lubricant supply is switched off, the pressure line to the rotary union must be depressurized for operating the spindle (vent valve open, see also Chapter 5.9).**
  No residual pressure!

Taper cleaning:

- Compressed air depressurized.

Drive:

Warning

The spindle may only be started when the tool is clamped in position!

- Start spindle motor upon enable signal (permissives see Chapter 5.12).
- Operate spindle at half rated speed for 5 minutes without load for warming up before machining the workpiece.

Cooling lubricant supply through spindle shaft:

In case of wet machining with cooling lubricant supply through spindle shaft:

- Close vent valve in the pressure line to the rotary union (see also Chapter 5.9).
- Start cooling lubricant supply.

Now the spindle is ready for machining operations.

7.2 Restarting after shut-downs

During short machining interruptions - e.g. spindle stop during a tool change cycle - oil/air lubrication, spindle cooling and seal air supply should remain switched on.

- Start lubricating unit and operate prelubrication cycle.
  (Prelubricating time see Chapter 5.2)

- Establish seal air supply.

- Start spindle cooling circuit.

Warning

- Tool clamped.
  The spindle may only be started when the tool is clamped in position!

- Start spindle motor upon enable signal (permissives in Chapter 5.12).

In case of wet machining with cooling lubricant supply through spindle shaft:

- Close vent valve in the pressure line to the rotary union
  (see also Chapter 5.9).

- Start cooling lubricant supply.

If any modifications have been made to the lubricating system, putting into operation should be carried out according to Chapter 7.1!

7.3 Shut-down sequence

If the machine tool should be shut off for an extented processing break (machine stop), please act on the following shut-down sequence:

- Stop machine feed and cooling lubricant supply if necessary.

- Stop spindle via frequency converter.
  The spindle should be started and stopped in a special "parking position" in order to prevent cooling lubricant from dropping onto the spindle.

- Shut off seal air supply.
  Please note that lubricating oil can drop from the seal gap at the working end of the spindle when the seal air supply is switched off.

- Shut off oil/air lubricating unit.
  It is necessary to shut off the compressed air in the lubricating lines at the same time as the lubricating oil supply in order to prevent the lines and ball bearings being blown dry.

- Shut off spindle cooling system.
  Do not shut off spindle cooling system until about 5 minutes after stopping the spindle in order to permit the temperature in the spindle motor to stabilize.

During cleaning of the machine tool, oil/air lubrication and air sealing should remain switched on!

7.4 Action on failures

If any of the individual circuits should fail during operation of the spindle, it is necessary to shut down feed drives and spindle:

Table 7.4.1

Fault	Action
Exceeding of permissible motor temperature (KTY monitoring)	Spindle to be stopped immediately
Compressed air failure or drop oil/air lubrication Compressed air drop air sealing Pressure drop tool clamping pressure Pressure drop cooling lubricant supply through spindle shaft	Spindle to be stopped within 4 seconds
Fault feed of lubricating oil	Spindle to be stopped within a period corresponding to the cycle time of the oil/air lubrication
Fault spindle cooling and general trouble	Spindle to be stopped within 60 seconds

...OLA4x2_e2.tbl

In the event of any abnormal conditions, feed drives must be stopped *before* spindle to be stopped!

8.1 General information

Manufacturer of the spindle:	Paul Müller Industrie GmbH & Co. KG Äußere Bayreuther Straße 230 D - 90411 Nuremberg Telephone: 0911 / 5691 - 600 Telefax: 0911 / 5691 - 699 E-mail: vertrieb.spi@gmn.de Internet: http://www.gmn.de
Spindle designation:	High-frequency spindle
Spindle type:	HCS 230 - 30000 / 80
Spindle serial no.:	see page 2 or engraved data on the spindle
Part no. spindle:	104 60 46 R
Issue of operating instructions:	September 2005 (09 05)
Part no. operating instructions:	104 27 22
Service addresses:	see GMN homepage: http://www.gmn.de ⇨*Spindles* ⇨*Contact* ⇨*Representative World Wide*

8.2 Service and maintenance instructions

1) Tool clamping system

After the first 100 clamping strokes with tool and use of the spindle in the machining process:

1) Check lock screw of tool clamping set for tightness through a clamped tool.
   Tightening torque: 30 Nm
   Regarding the position of the lock screw see Fig. 8.2.1.

2) Check the adjusting distance of 10.5 ± 0.1 mm and adjust if required.

Correcting of adjusting distance:

- Loosen lock screw. While doing this retain at the spanner face of the clamping cone with an open jaw wrench.
- Set adjusting distance by turning the clamping cone.
- Tighten the lock screw (tightening torque 30 Nm).

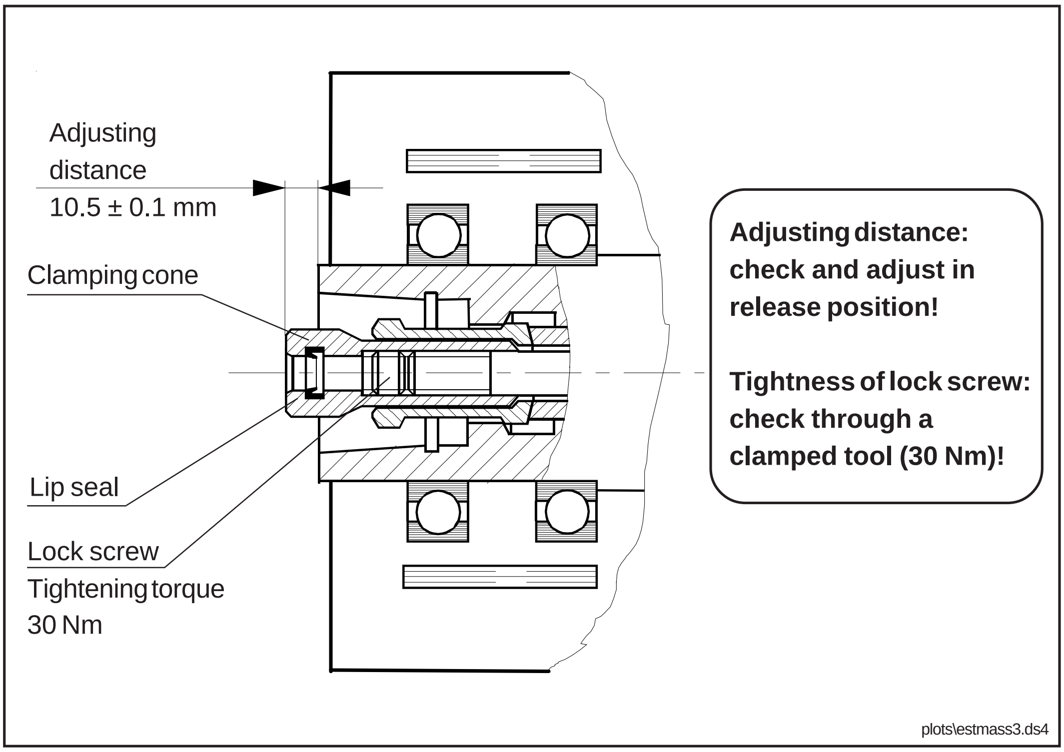


Fig. 8.2.1

- **every 80 spindle operating hours:**

1) Check tool holding fixture taper and HSK clamping kit for dirt and clean in case of strong soiling (e.g. deposits of graphit dust).

2) Spray the clamping system in the tool holding taper of the spindle shaft with METAFLUX Moly Spray No. 70-82 lubricant.

3) Check the sequence of movements by means of a clamping and a releasing operation. The tool must be ejected correctly, and during clamping the tool must be drawn against the end face of the spindle shaft.

4) Check the lip seal inside the clamping cone for wear or damage (visual check).
If the lip seal is worn-out or damaged, replace the lip seal.
Regarding the position the lip seal see Fig. 8.2.2

Lip seal:	Dimensions:	12 x 18.5 x 4.5 mm
	Supplier:	OTT-JAKOB, 87663 Lengenwang, Germany
	Order no.:	0.926.030.103

The thread of the ring (see Fig. 8.2.2) is guarded with adhesive. To loose the adhesive joint requires considerable heating (case of repair).

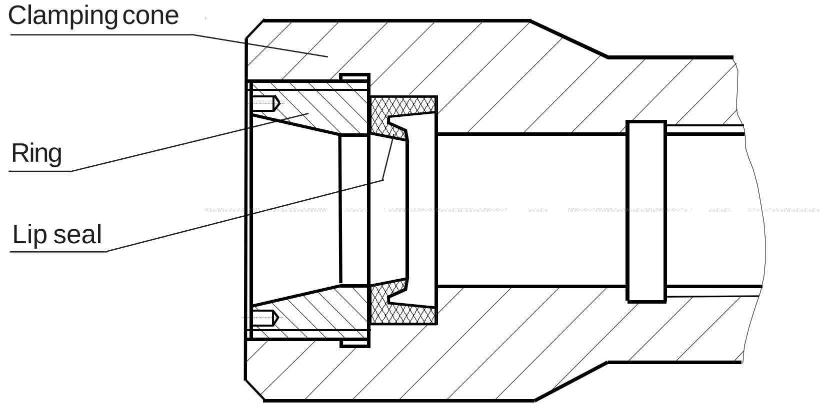


Bild 8.2.2

Replacing the lip seal (see Fig. 8.2.3):

1) Pull the defective lip seal out of its seat by using a hook or pliers.

2) Press the new lip seal together and built in.
Please note the correct fitting position.

3) Press the lip seal with a blunt tool into the groove.

4) Take a suitable mandrel to bring the lip seal into the final position.

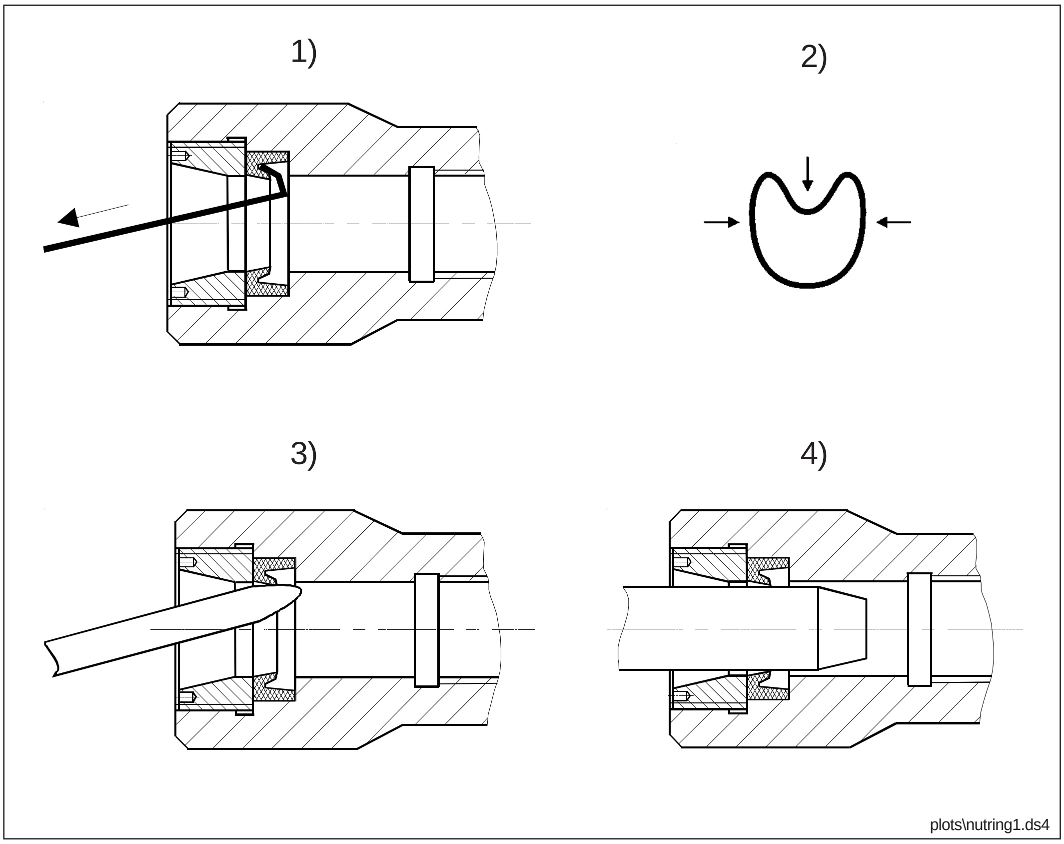


Fig. 8.2.3

- **additionally every 320 spindle operating hours:**

  1) Check the adjusting distance and reset if necessary (see above).

  2) Check the drawing-in force using a drawing-in force gauge.

  Minimum drawing-in force (static): **14 kN**

  If the drawing-in force falls below this minimum, spray the HSK clamping system with METAFLUX Moly Spray No. 70-82 lubricant and carry out several clamping and releasing operations. If the drawing-in force is still too low after this, the complete clamping system must be repaired or replaced.

If the drawing-in force is lower than the value given above, the spindle must not be put into operation! Risk of accident!

Should poor machining results give rise to the suspicion that the rigidity of the tool interface is reduced as a result of an insufficient drawing-in force, the correct functioning of the clamping system must be checked with the help of the maintenance work described in section "every 80 spindle operating hours" points 1 to 3, even outside normal maintenance intervals.

- **additionally every 640 spindle operating hours:**

  Replace lip seal inside the clamping cone.
  Regarding the position of the lip seal see Fig. 8.2.2.
  Mounting instructions see section "every 80 spindle operating hours", in this chapter.

Lip seal:	Dimensions:	12 x 18.5 x 4.5 mm
	Supplier:	OTT-JAKOB, 87663 Lengenwang, Germany
	Order number:	0.926.030.103

2) Rotary union

The rotary union is maintenance-free within a service interval of 4000 operating hours.

If liquids with hard and fine-grained contamination (e.g. silicon) are used, increased wastage of the seals must be taken into account.
Indication for worn seals is (increased) leakage of liquid at the leakage connections of the spindle (compare with Chapter 5.9). If this case occurs, the complete rotary union must be replaced even outside the service interval of 4000 operating hours.

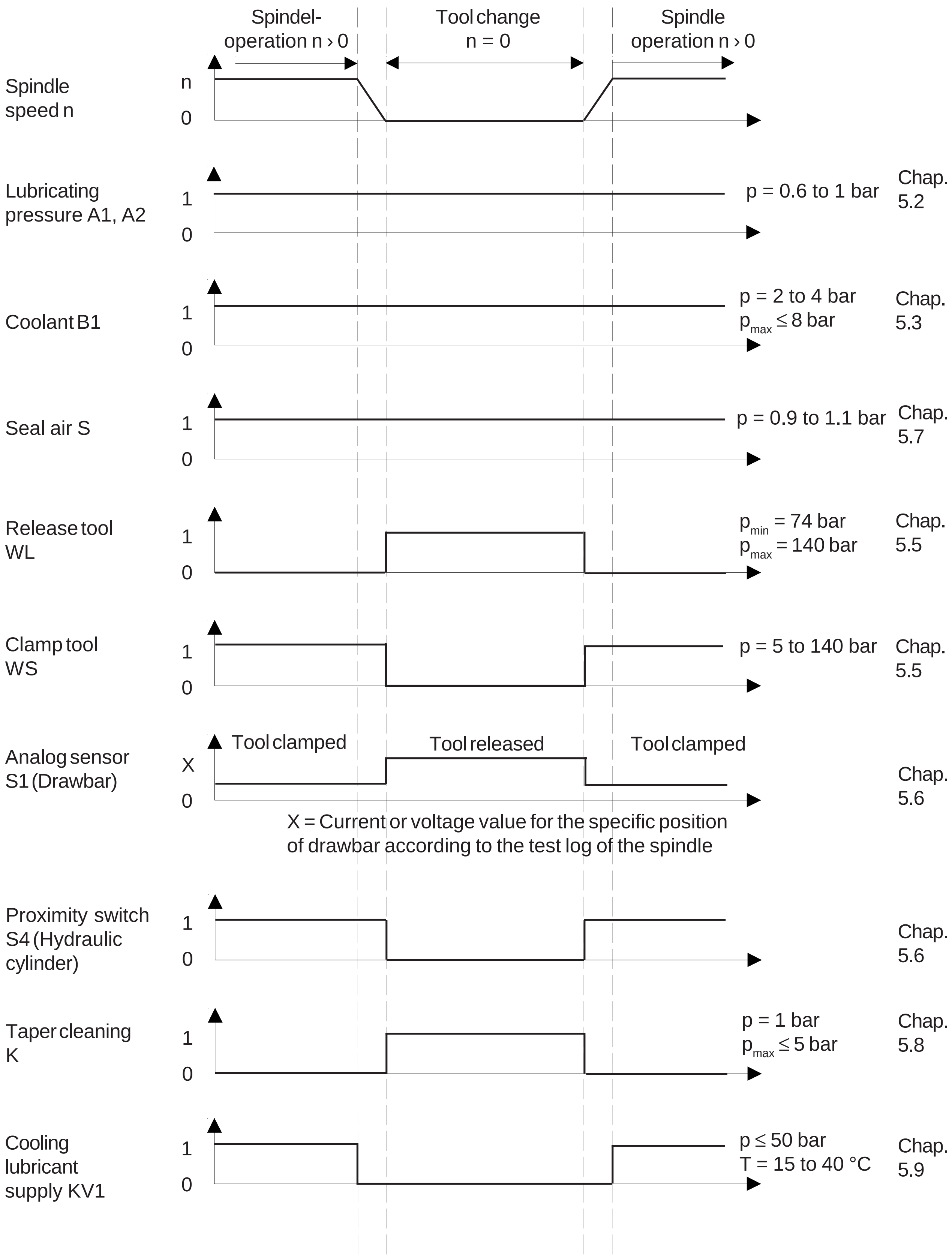
The bearings of the rotary union are grease-packed.
For high performance usage we recommend to renew the grease after 4000 operating hours. Alternatively replace the complete rotary union.
The bearings of the rotary union must be replaced after 3 years at the latest.
We recommend to replace the complete rotary union.

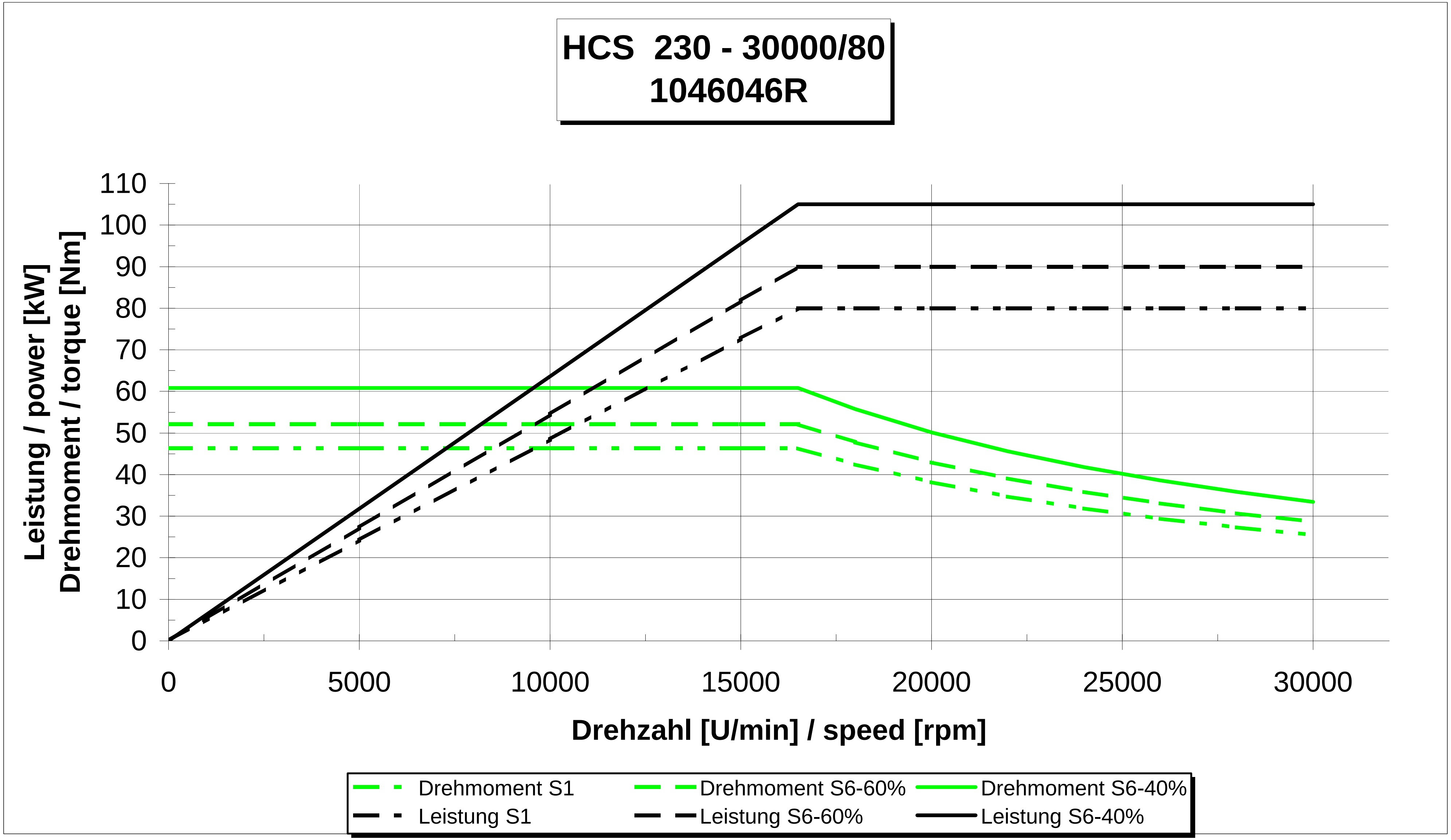
When replacing the rotary union, please follow the installation instructions of the manufacturer.

9 Appendix

- Action chart spindle operation
- Power and torque characteristics of spindle motor
- Connection diagram MICRO-EPSILON analog sensor EDDY NCDT
- GMN agencies with repair service see GMN homepage:
  http://www.gmn.de
  ⇨ *Spindles* ⇨ *Contact* ⇨*Representative World Wide*

09 05	Action chart spindle operation HCS 230 - 30000 / 80 // 104 60 46 R	GMN



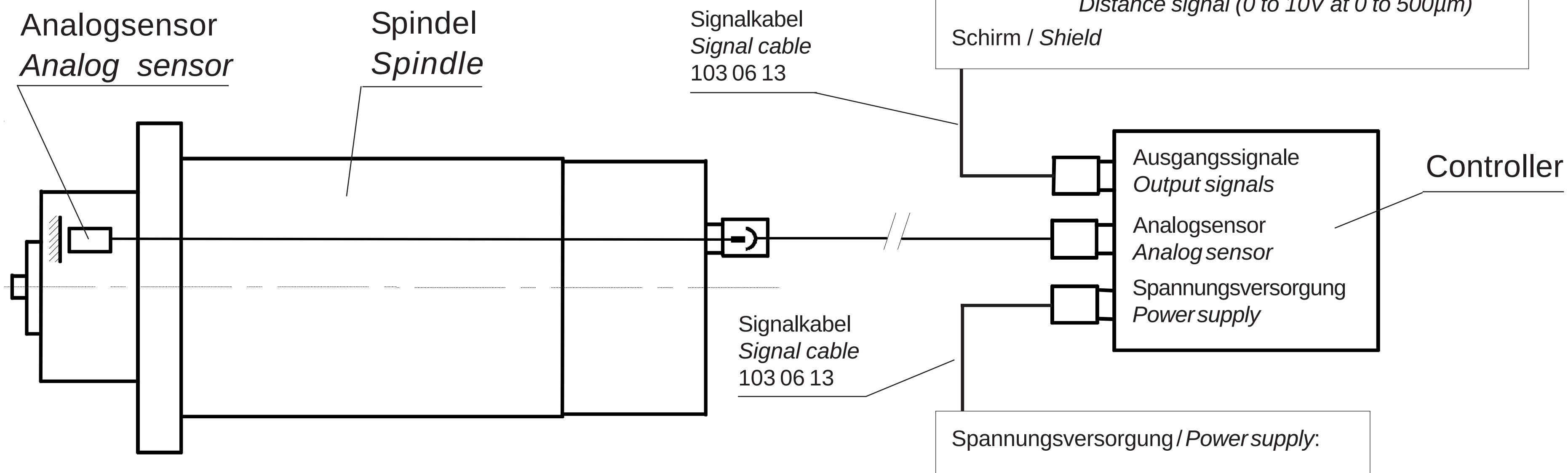

HCS 230 - 30000/80
1046046R
Leistung / power [kW]
Drehmoment / torque [Nm]
110
100
90
80
70
60
50
40
30
20
10
0
0
5000
10000
15000
20000
25000
30000
Drehzahl [U/min] / speed [rpm]
Drehmoment S1
Drehmoment S6-60%
Drehmoment S6-40%
Leistung S1
Leistung S6-60%
Leistung S6-40%

11 02	**Anschlußschema / *Connection diagram*** **MICRO-EPSILON Analogsensor EDDY NCDT (axiale Wellenverlagerung)** ***MICRO-EPSILON analog sensor EDDY NCDT (axial displacement of shaft)***	GMN

Ausgangssignale / *Output signals*:

BK	1	Masse (Abstand) / *Ground (Distance)*
OR	2	Temperatursignal (0 bis 10V bei 0 bis100°C) *Temperature signal (0 to 10V at 0 to 100°C)*
BN	4	Masse (Temperatur) / *Ground (Temperature)*
RD	5	Abstandssignal (0 bis 10V bei 0 bis 500µm) *Distance signal (0 to 10V at 0 to 500µm)*

Schirm / *Shield*



Spannungsversorgung / *Power supply*:

RD	4	+ 24VDC
BK	5	Masse / *Ground*

Schirm / *Shield*