engineering
mannesmann
Rexroth

High-Resolution
Main spindle position encoders

Project Planning Manual

DOK-ENCODR-MAIN*POSENC-PRJ1-EN-P

261910

Indramat

Titel High-resolution main spindle position encoders

Type of documentation: Project Planning Manual

Documenttype DOK-ENCODR-MAIN*POSENC-PRJ1-EN-E1,44

Internal file reference
- Mappe 7
- HSP_E-PJ.pdf
- 209-0042-4119-00

Reference This electronic document is based on the hardcopy document with document desig.: 209-0042-4119-00 EN/07.94

This documentation is used:
- It lists all the exact order numbers to make ordering easy.
- It assists in integrating the main spindle position encoder into the spindle structure.
- It lists guidelines on installing the high-resolution main spindle position encoder.
- It runs through the checklist of function tests to be run once the encoder is installed.
- It assists in identifying the individual components delivered.

Change procedures

Designation of documentation up to present edition	**Release-date**	**Coments**
209-0042-4119-00 EN/07.94	Jul./94	First Edition
DOK-ENCODR-MAIN*POSENC-PRJ1-EN-E1,44	Mar./97	First E-Dok

Publisher INDRAMAT GmbH • Bgm.-Dr.-Nebel-Straße 2 • D-97816 Lohr
Telefon 0 93 52 / 40-0 • Tx 689421 • Fax 0 93 52 / 40-48 85

Dept ENA (MR, FS)

Table of Contents

1. Applications and features

Main spindle position encoders are made up of a measuring wheel and a non-contact sensor. The measuring wheel is mounted directly onto the spindle, the sensor onto the spindle housing.

High resolution

INDRAMAT's AC main spindle controllers and digital AC servo drives evaluate the sensor signals and measure spindle position with a resolution of up to $^{1}/_{4\,000\,000}$ the of a revolution within the total speed range.

An economic solution

The determination of the spindle position needed for C-axis operations, thread-cutting or spindle positioning is advantageously handled with the use of only one encoder. The extremely high position resolution over the full speed range makes this possible. And, in comparison to other conventional encoders, costs and work are saved.

Installation requirements

The protection category of the high-resolution main spindle position encoder is IP00 due to its design. The ambient conditions needed for a faultless and reliable functioning of the encoder, therefore, depend entirely upon the spindle housing!

1.1. Applications

Spindle position determination

The main spindle drives KDA, TDA, RAC, and the digital drives DDS, DKS and DKR use the high-resolution main spindle position encoder to determine the position of the spindle.

The determined spindle position can be transmitted to the NC controller either by means of

- a SERCOS interface, or,
- the incremental encoder output of the drive controller.

Spindle position determination makes it possible for the main spindle drive to perform such tasks as spindle positioning, C-axis operation and thread cutting.

Drive with SERCOS interface

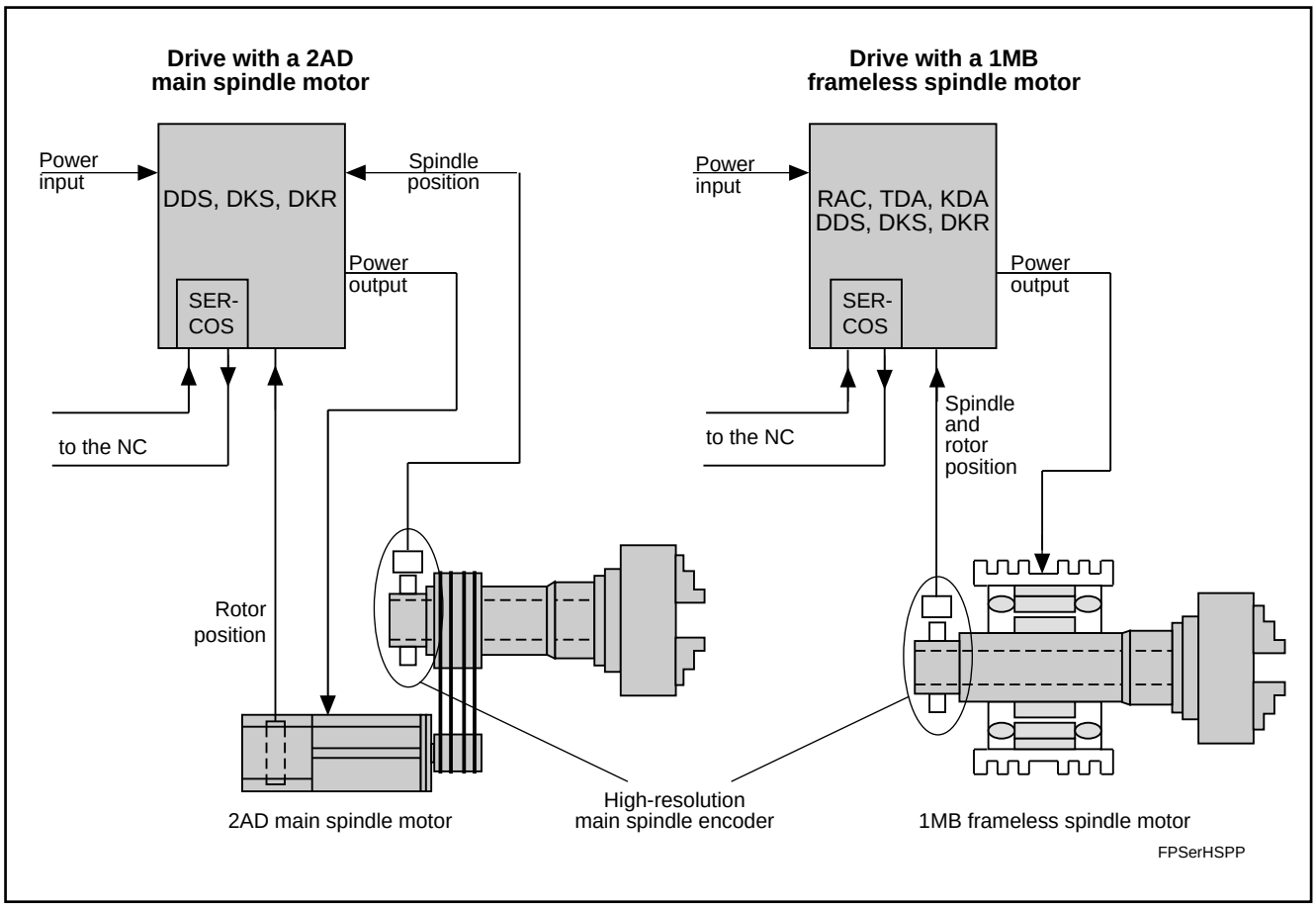


Figure 1.1: Basic prinicple of application of a high-resolution main spindle position encoder with SERCOS interface to the NC controller

The SERCOS interface transmits the actual position of the spindle to the controller with an accuracy of up to 0.0001 angular degrees. The NC controller can also read out the actual speed and torque values of the drive. The NC controller can control the drive by means of position, speed or torque command values.

Drive with incremental encoder output

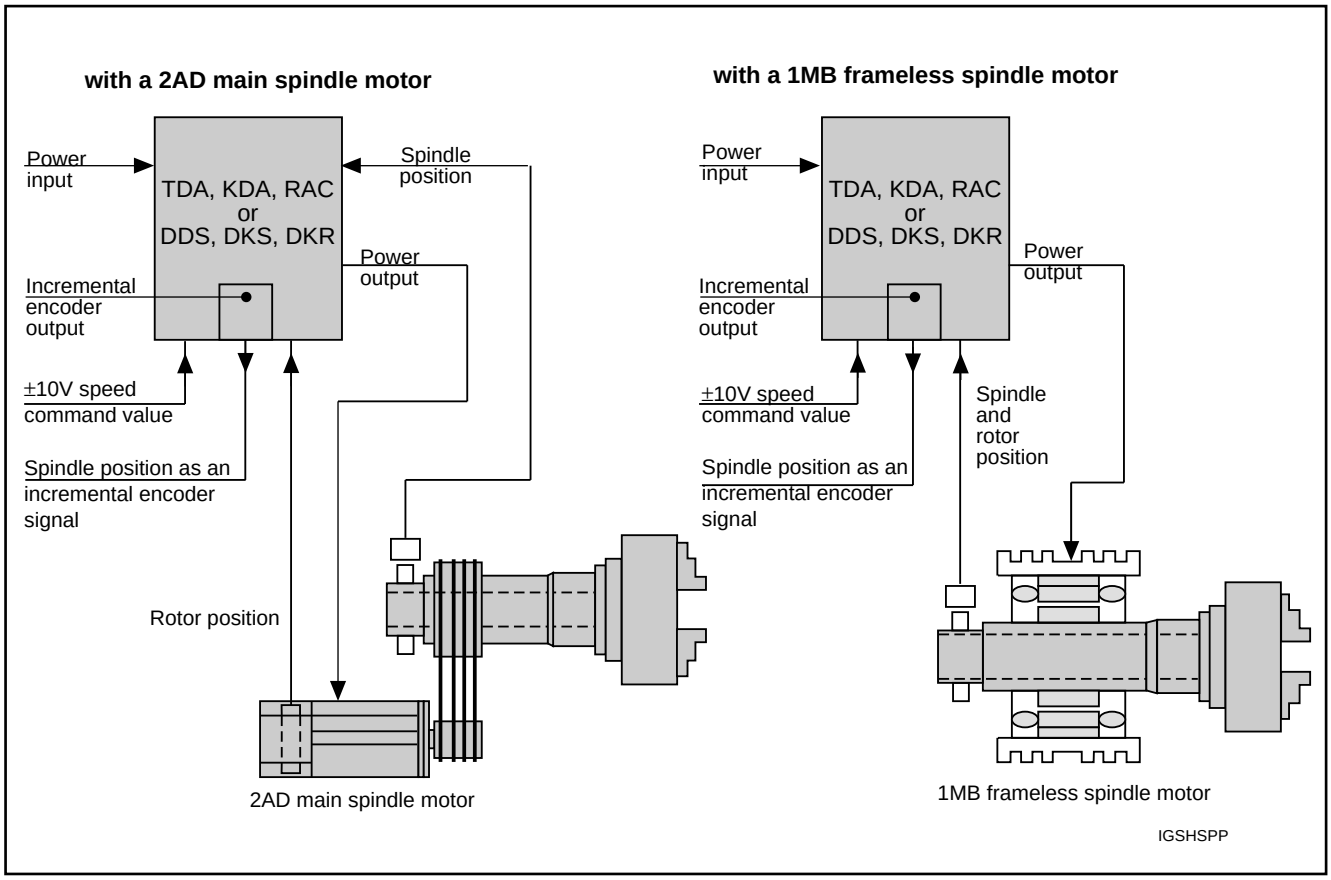


Figure 1.2: Basic principle of application of a high-resolution main spindle position encoder with an incremental encoder interface to the NC controller

The incremental encoder output transmits the actual spindle position to the NC controller with an accuracy of up to 0.001 angular degrees.

The incremental encoder output works in the same fashion as a conventional incremental encoder except that parameters can be used to set the encoder lines per revolution (1pr).

1.2. Components and installation variations

Position encoder with sensor mounting ring

A factory-set sensor with mounting ring is used in those applications where the installation position of the sensor is axially accessible. The mounting ring is fed over the end of the spindle. Once secured into place, the distance between the sensor and the measuring wheel is immediately correctly set.

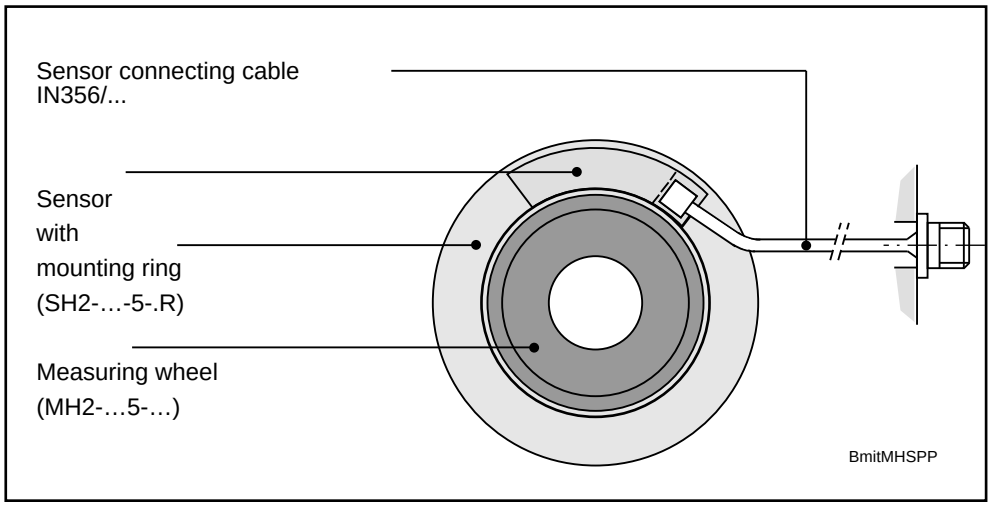


Figure 1.3: Parts of the high-resolution main spindle position encoder (with mounting ring)

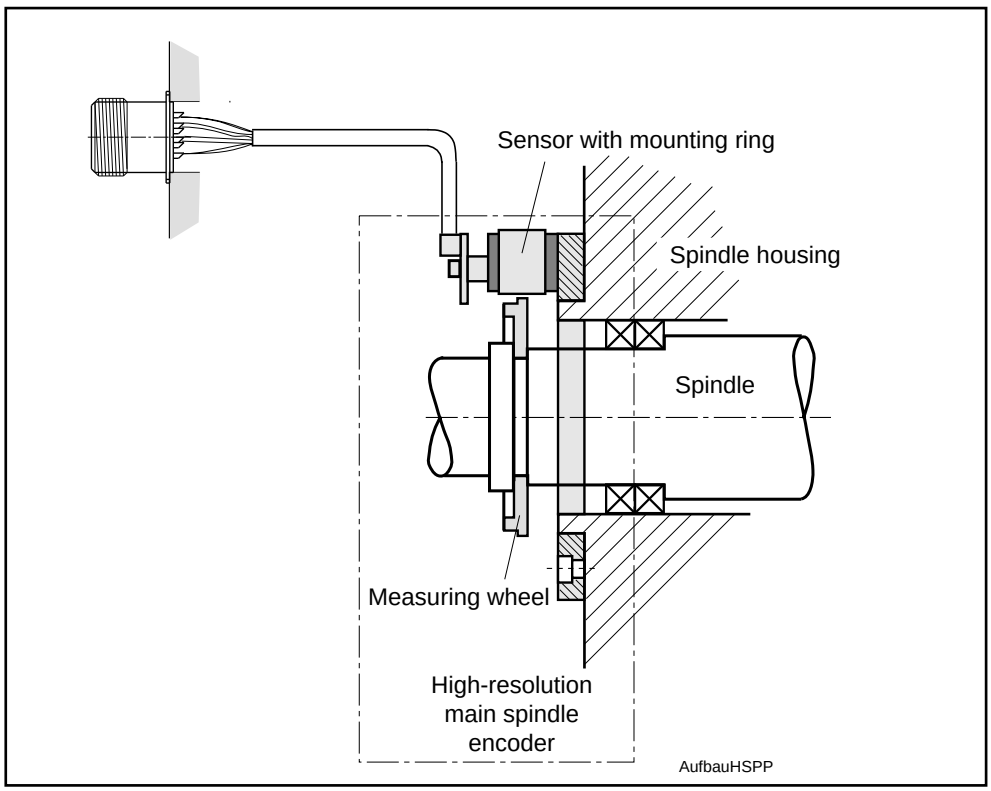


Figure 1.4: Installation variations of a high-resolution main spindle position encoder with sensor mounting ring

Position encoder without sensor mounting ring

A sensor without mounting ring must be used in all those applications where it is not possible to feed a mounting ring over the spindle. The correct distance between sensor and measuring wheel, in this case, must be set at the time of mounting on site.

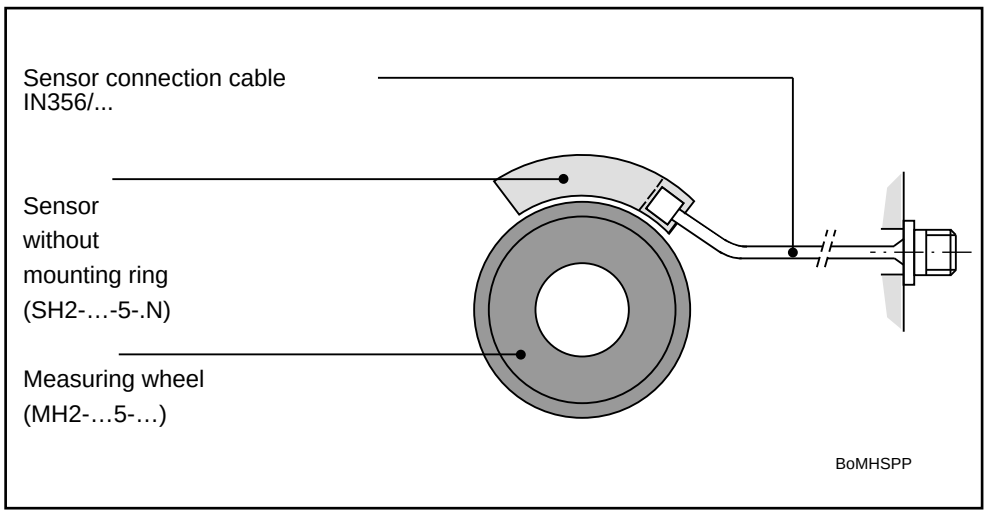


Fig.1.5: Components of a high-resolution main spindle position encoder (without mounting ring)

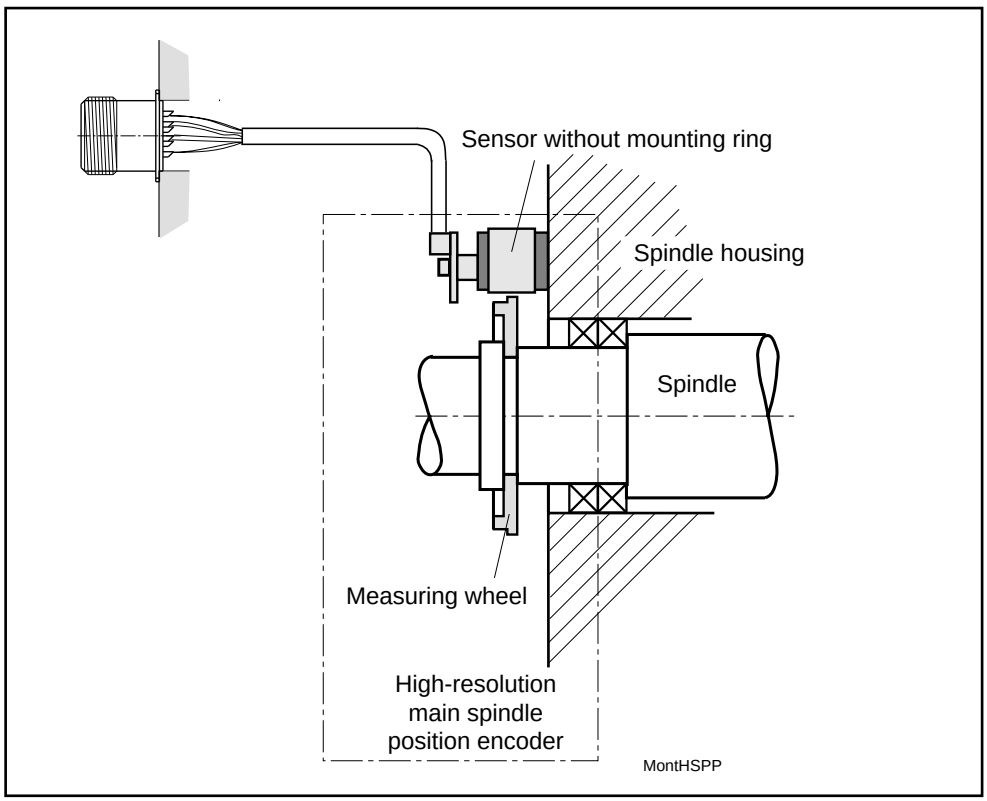


Figure 1.6: Installation variations of a high-resolution main spindle position encoder without sensor mounting ring

Mounting the measuring wheel

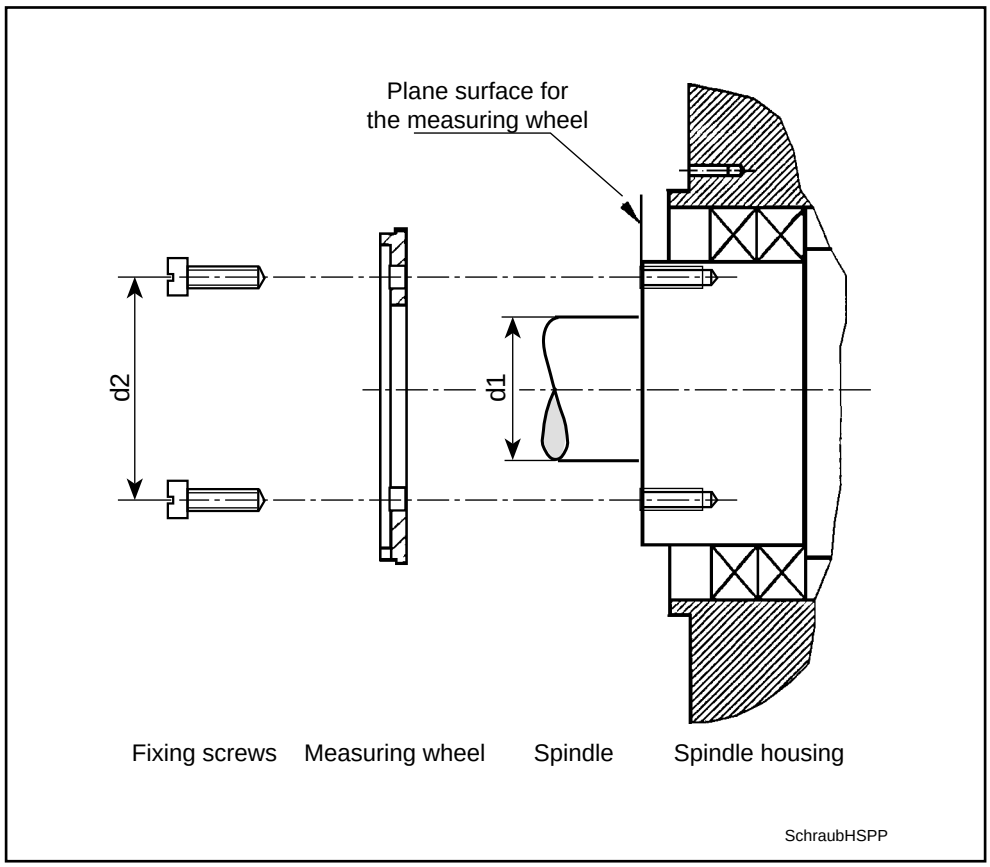


Figure 1.7: Affixing the screws

Because of the mechanical dimensions, it is not possible to affix measuring wheel MH2-128 with screws!

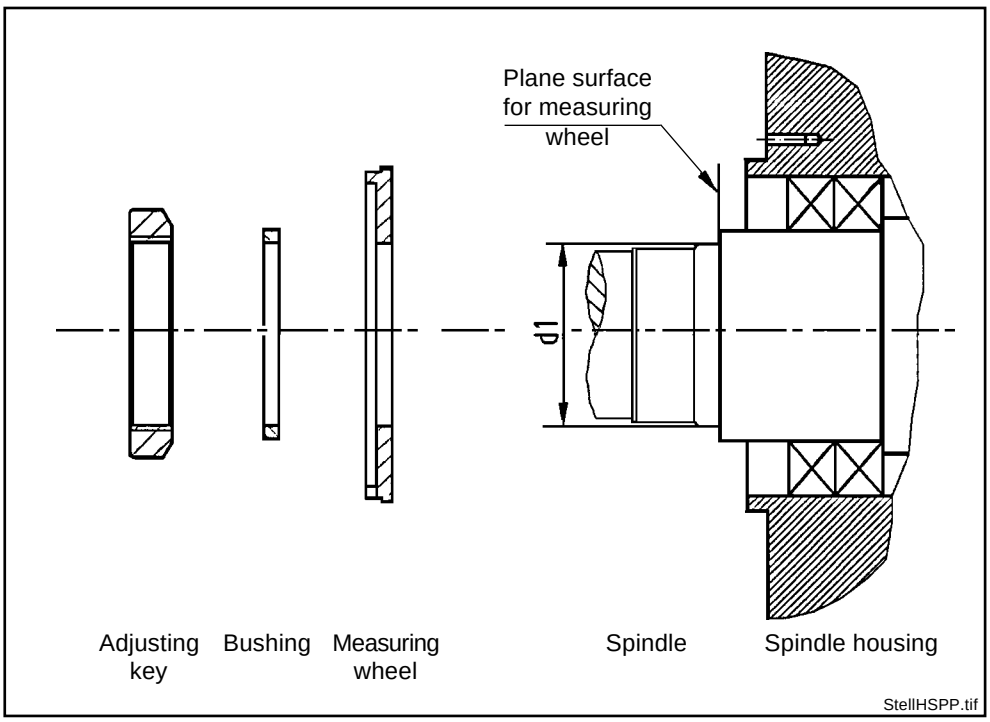


Figure 1.8: Mounting using adjusting key and thread

1.3. Designs

Measuring wheel sizes

The high-resolution main spindle position encoders are available in three sizes. The external diameters of the measuring wheels are coordinated with the sizes of the 1MB frameless spindle motors. The bore diameters are selected to correspond to the external diameter of the spindle.

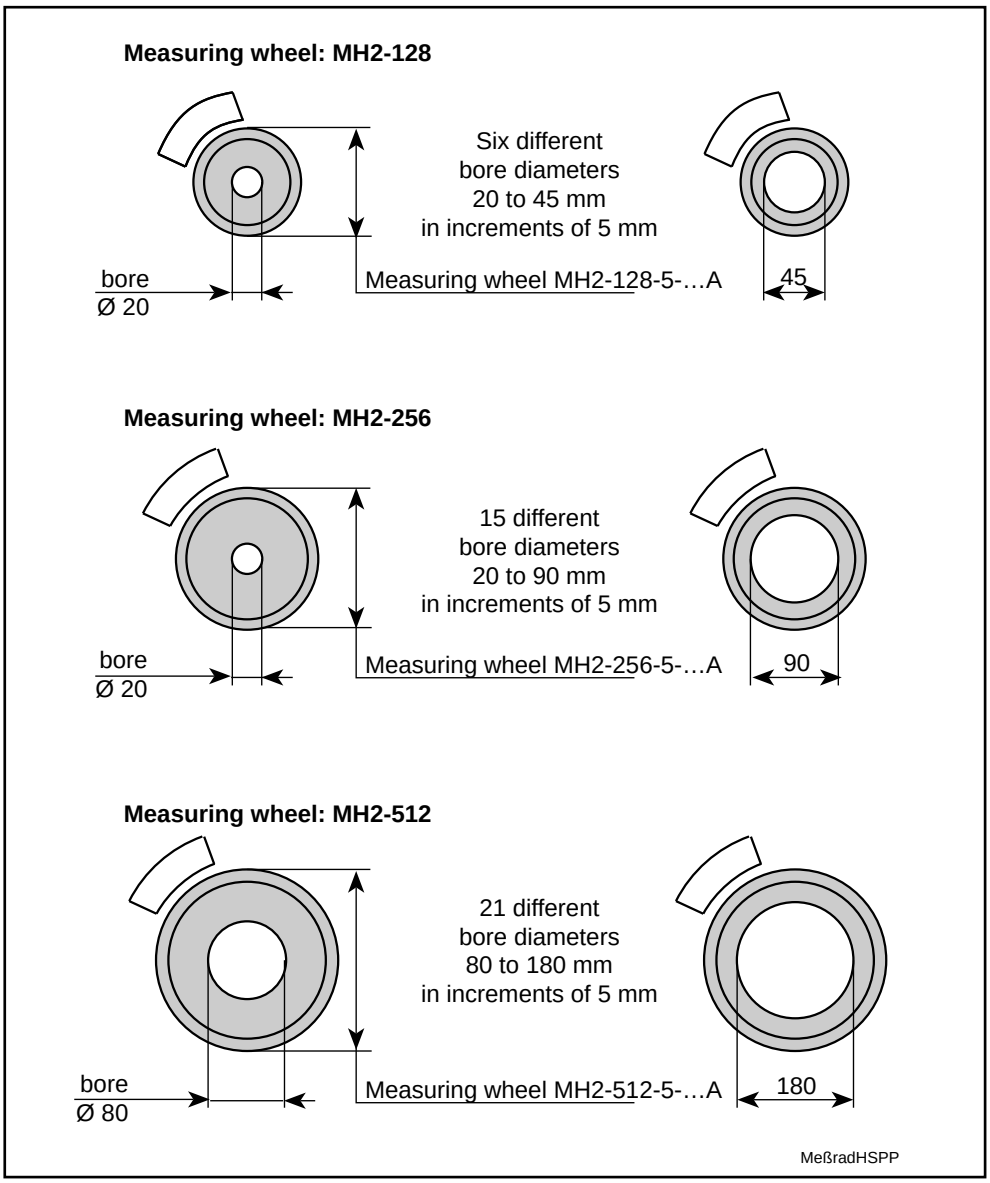


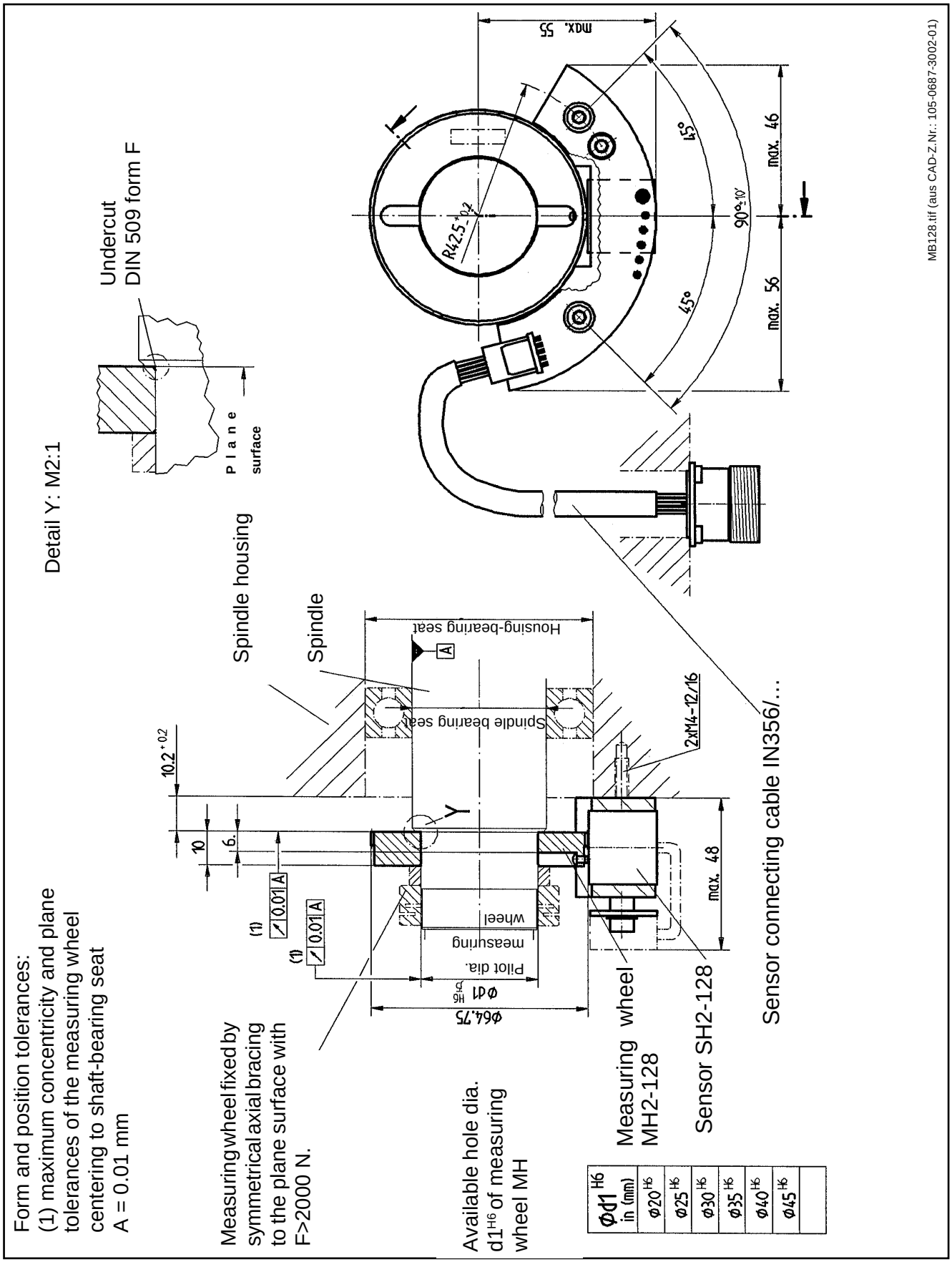
Figure 1.9: Measuring wheel sizes and bore diameters

Sensor

The sensor without mounting ring is available for all three measuring wheel sizes. The sensor with mounting ring is only available for measuring wheel sizes MH2-256-… and MH2-512-… !

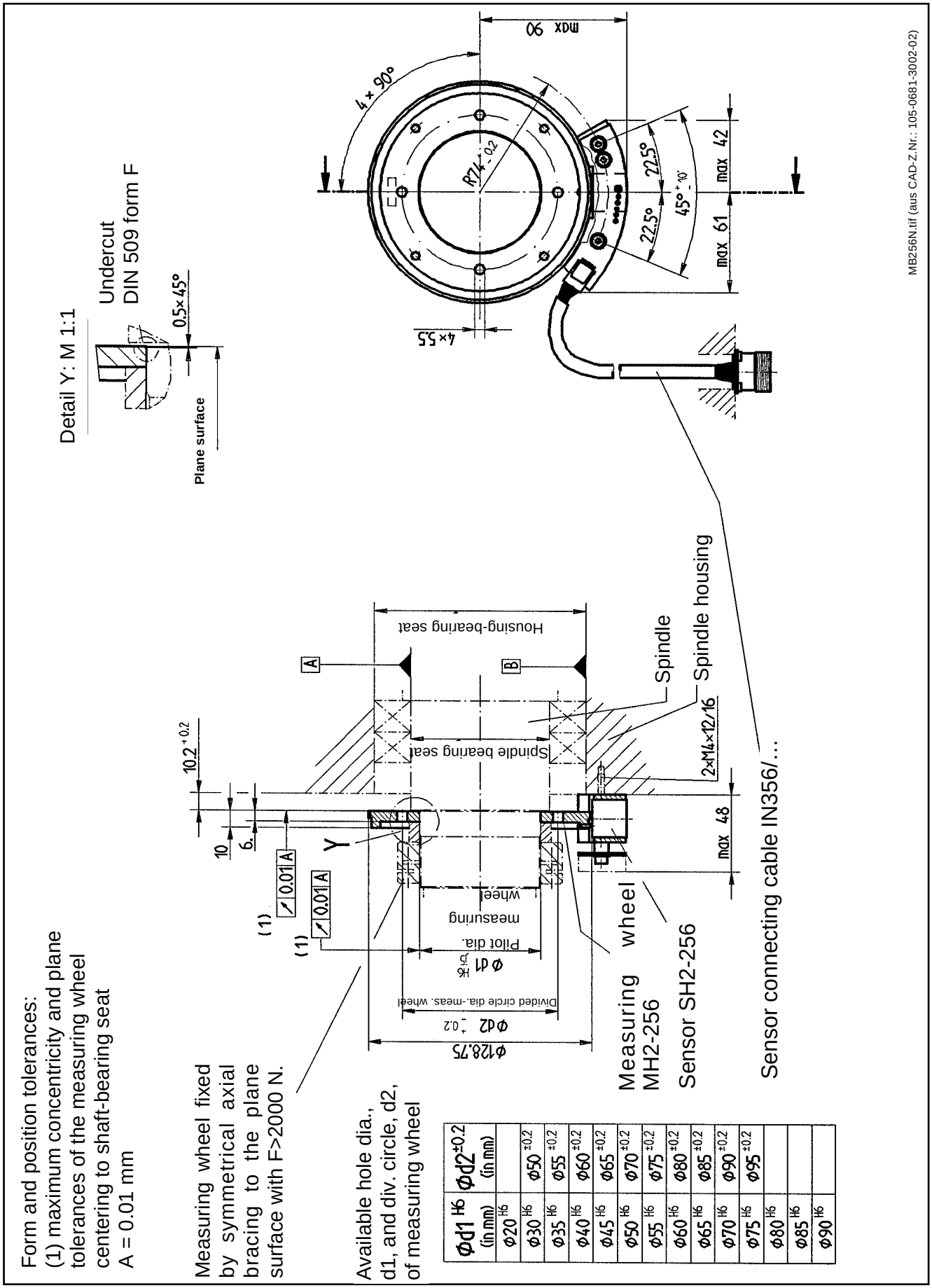
2. Mechanical data

2.1. Dimensional data



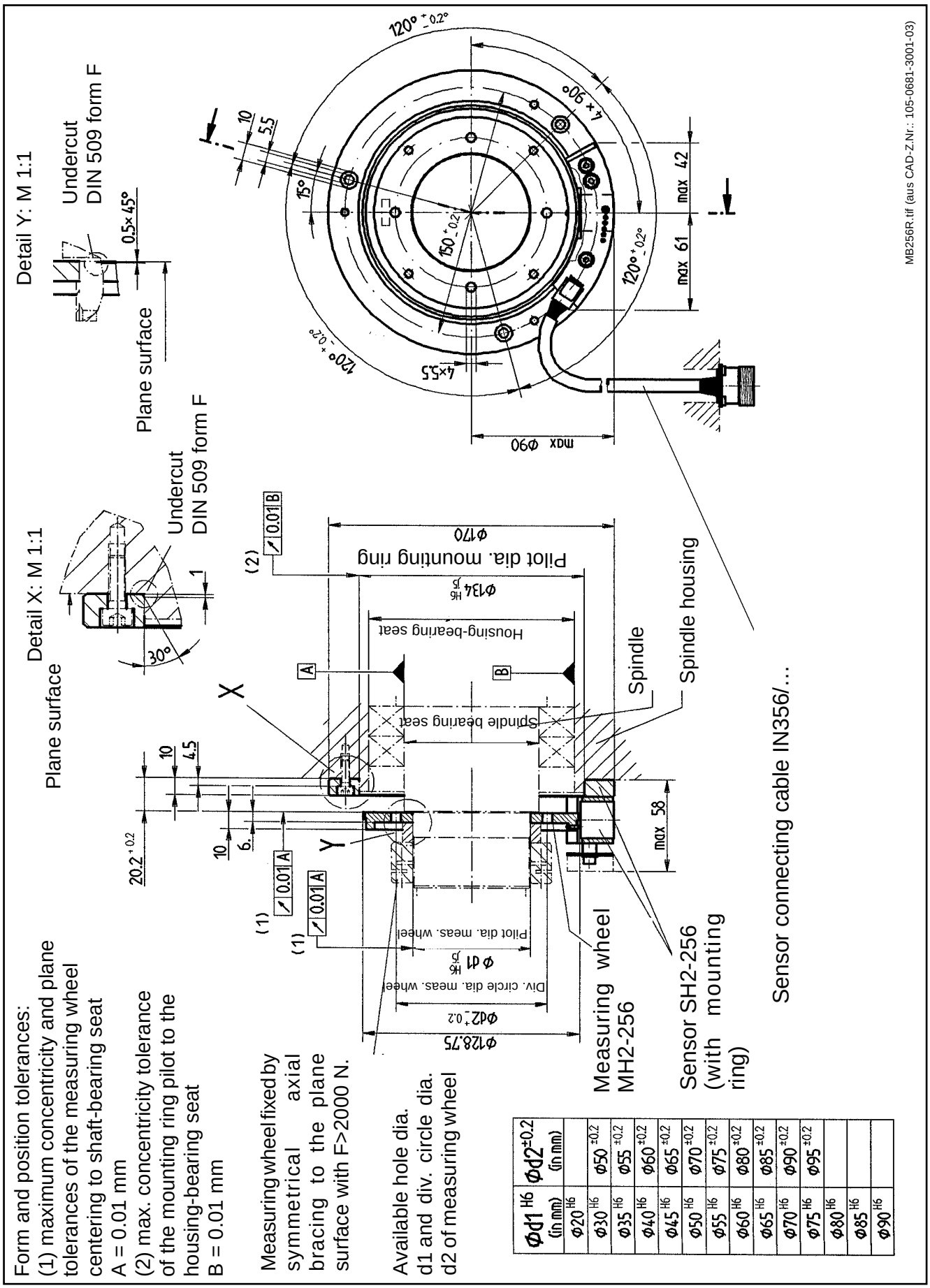
Φd1 H6 in (mm)
Φ20 H6
Φ25 H6
Φ30 H6
Φ35 H6
Φ40 H6
Φ45 H6

Figure 2.1: Dimensions and connecting dimensions of the position encoder with measuring wheel MH2-128 and sensor SH2-128 without mounting ring



Φd1 H6 (in mm)	Φd2±0.2 (in mm)
Φ20 H6	
Φ30 H6	Φ50 ±0.2
Φ35 H6	Φ55 ±0.2
Φ40 H6	Φ60 ±0.2
Φ45 H6	Φ65 ±0.2
Φ50 H6	Φ70 ±0.2
Φ55 H6	Φ75 ±0.2
Φ60 H6	Φ80 ±0.2
Φ65 H6	Φ85 ±0.2
Φ70 H6	Φ90 ±0.2
Φ75 H6	Φ95 ±0.2
Φ80 H6	
Φ85 H6	
Φ90 H6	

Figure 2.2: Dimensions and connecting dimensions of the position encoder with measuring wheel MH2-256 and sensor SH2-256 without mounting ring



Ød1 H6 (in mm)	Ød2±0.2 (in mm)
Ø20 H6	Ø50 ±0.2
Ø30 H6	Ø55 ±0.2
Ø35 H6	Ø60 ±0.2
Ø40 H6	Ø65 ±0.2
Ø45 H6	Ø70 ±0.2
Ø50 H6	Ø75 ±0.2
Ø55 H6	Ø80 ±0.2
Ø60 H6	Ø85 ±0.2
Ø65 H6	Ø90 ±0.2
Ø70 H6	Ø95 ±0.2
Ø75 H6	
Ø80 H6	
Ø85 H6	
Ø90 H6	

Figure 2.3: Dimensions and connecting dimensions of the position encoder with measuring wheel MH2-256 and sensor SH2-256 with mounting ring

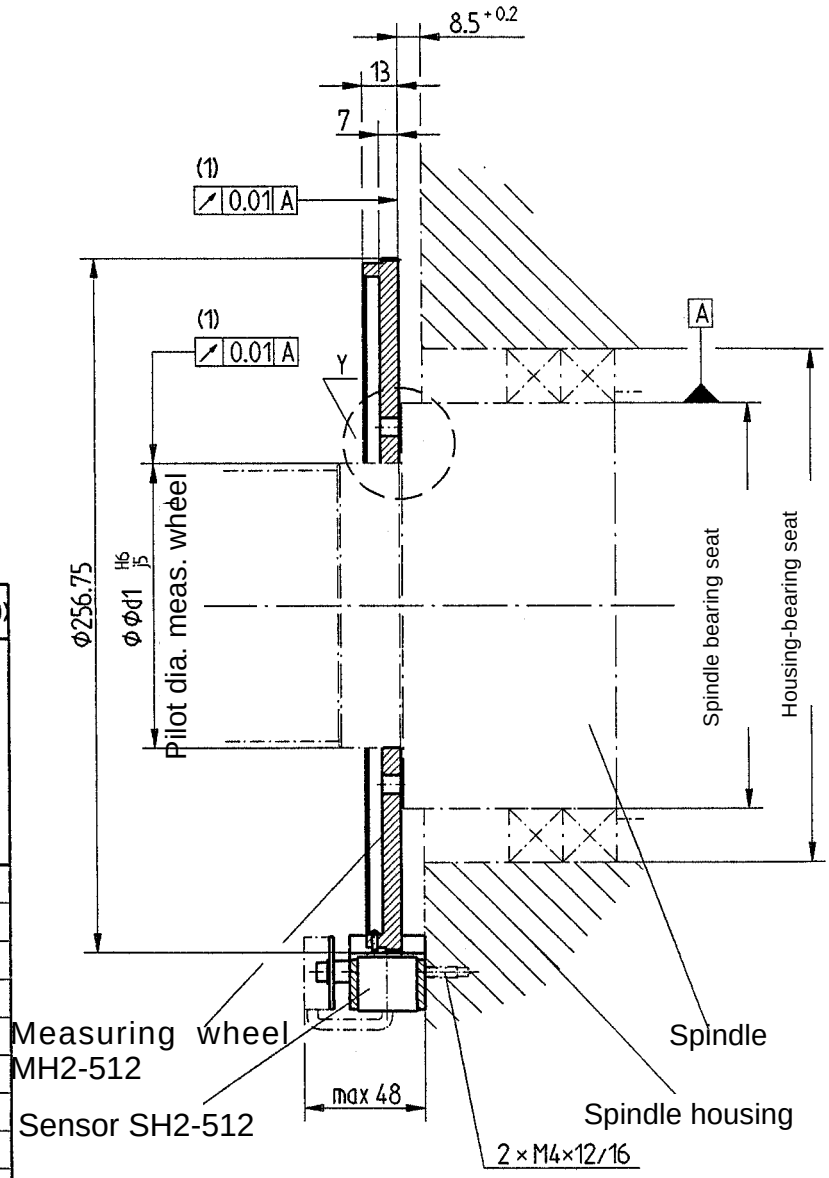
Form and position tolerances:
(1) maximum concentricity and plane tolerances of the measuring wheel centering to shaft-bearing seat
A = 0.01 mm

Φd1 – Available drill hole dia. of measuring wheel MH

Φd2^{H6} – Available hole circle dia. for fixing holes

Wheel 1H2-512-5-XXX Y

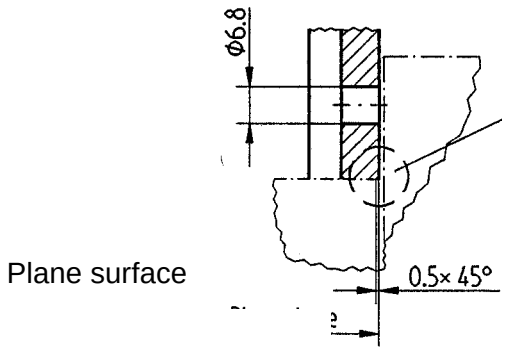
Φd1 H6 [mm]	E (Φd2=112)	D (Φd2=132)	C (Φd2=200)
Φ80 H6	x	x	
Φ85 H6	x	x	
Φ90 H6	x	x	
Φ95 H6	x	x	
Φ100 H6	x	x	
Φ105 H6		x	
Φ110 H6		x	x
Φ115 H6		x	x
Φ120 H6		x	x
Φ125 H6			x
Φ130 H6			x
Φ135 H6			x
Φ140 H6			x
Φ145 H6			x
Φ150 H6			x
Φ155 H6			x
Φ160 H6			x
Φ165 H6			x
Φ170 H6			x
Φ175 H6			x
Φ180 H6			x

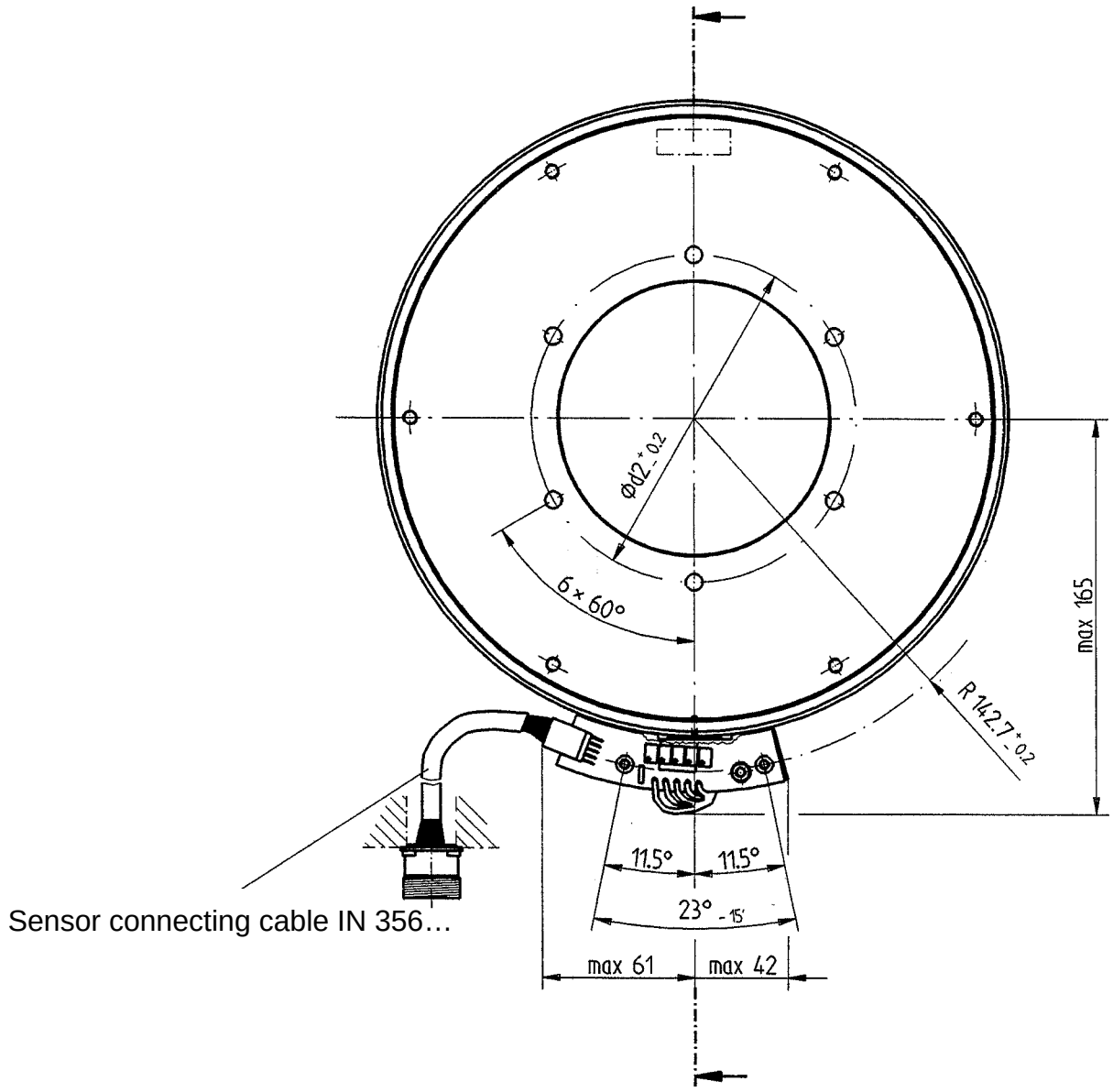


MBa512oM.tif (aus CAD-Z.: 105-0682-2004-01/C,D,E)

Figure 2.4: Dimensions and connection dimensions of the position encoder with measuring wheel MH2-512 and sensor SH2-512 without mounting ring

Detail Y: M 1:1





MBb512oM.tif (aus CAD-Z.: 105-0682-2004-01/C,D,E)

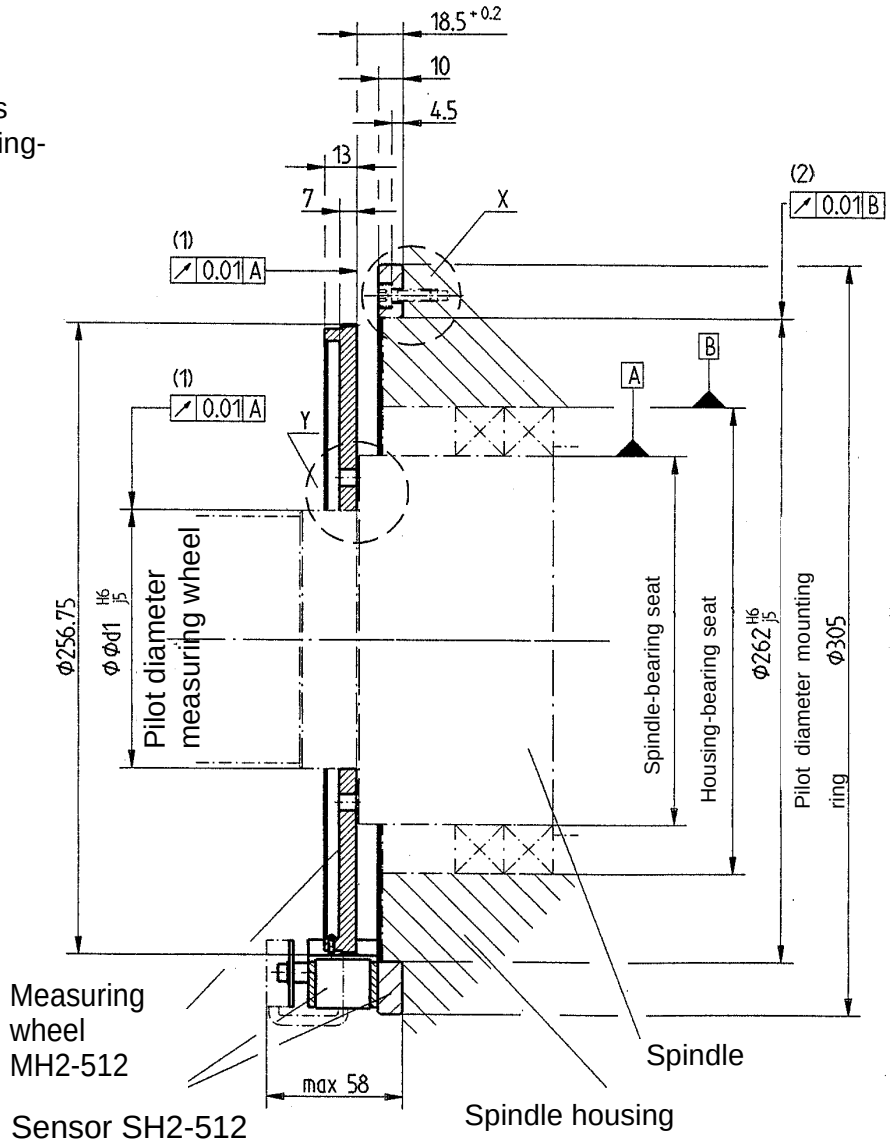
Form and position tolerances:
(1) maximum concentricity and plane tolerances of the measuring wheel centering to shaft-bearing seat
A = 0.01 mm
(2) maximum concentricity tolerances of the mounting ring pilot to the housing-bearing seat
B = 0.01 mm

Φd1 - Available bore hole dia. with measuring wheel MH

Φd2 H6 - Available hole circle dia. for fixing bore holes

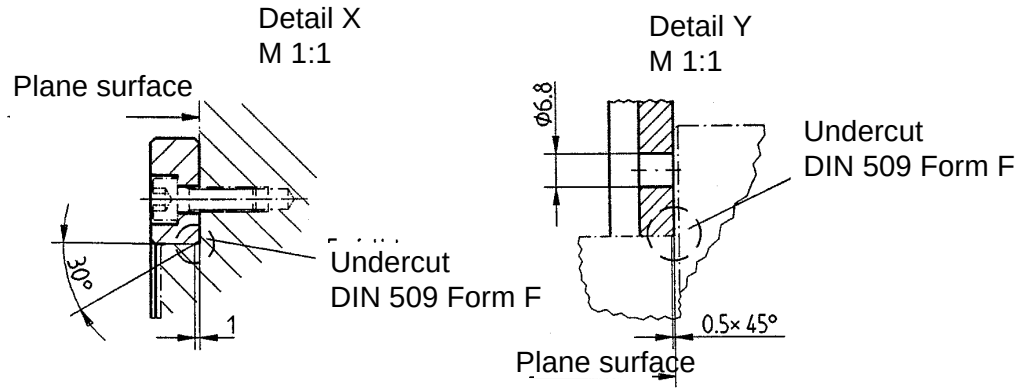
Wheel MH2-512-5-XXX Y

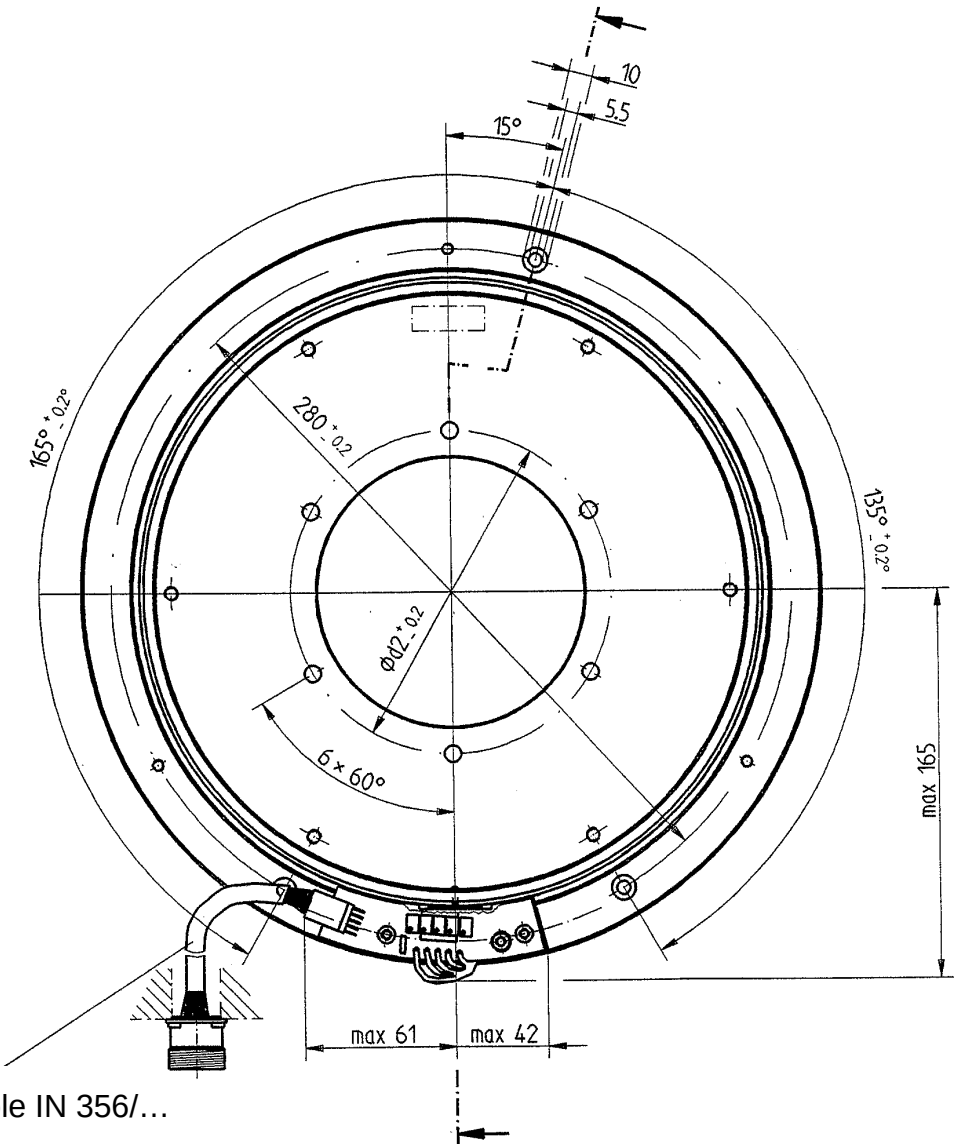
Φd1 H6 [mm]	E (Φd2=112)	D (Φd2=132)	C (Φd2=200)
Φ80 H6	x	x	
Φ85 H6	x	x	
Φ90 H6	x	x	
Φ95 H6	x	x	
Φ100 H6	x	x	
Φ105 H6		x	
Φ110 H6		x	x
Φ115 H6		x	x
Φ120 H6		x	x
Φ125 H6			x
Φ130 H6			x
Φ135 H6			x
Φ140 H6			x
Φ145 H6			x
Φ150 H6			x
Φ155 H6			x
Φ160 H6			x
Φ165 H6			x
Φ170 H6			x
Φ175 H6			x
Φ180 H6			x



MBa512mM.tif (aus CAD-Z.: 105-0682-2003-01/C,D,E)

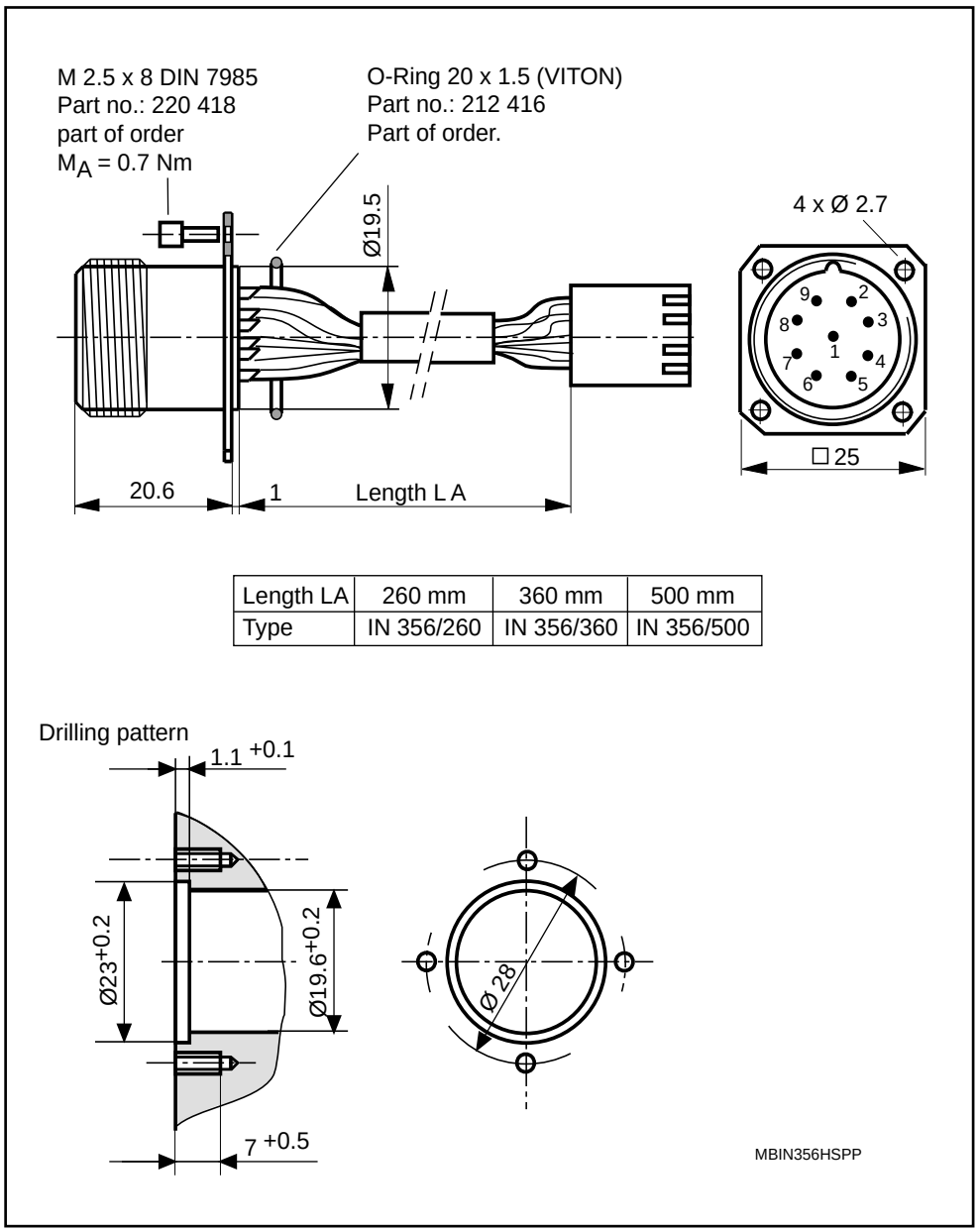
Figure 2.5: General and connecting dimensions of the position encoder with measuring wheel MH2-512 and sensor SH2-512 with mounting ring





Sensor connecting cable IN 356/…

MBb512mM.tif (aus CAD-Z.: 105-0682-2003-01/C,D,E)



Length LA	260 mm	360 mm	500 mm
Type	IN 356/260	IN 356/360	IN 356/500

Figure 2.6: Dimensions of sensor connecting cable IN356/…

2.2. Technical data

Data of the measuring wheel and sensor

Designation / Sensor type / Wheel type	SH2-128-5-… MH2-128-5-…	SH2-256-5-… MH2-256-5-…	SH2-512-5-… MH2-512-5-…
Permissible mechanical maximum speed in min^{-1}	60 000	30 000	15 000
Permissible ambient temperature range in °C			
Permissible humidity of ambient atmosphere per DIN 40 040	Humidity classification F		
Mandatory protection category after installation	IP 54		
Perm. axial changes in distance between where sensor is screwed on on the spindle box and the wheel plane surface on spindle	+0.4 -0.2	+0.4 -0.2	+0.7 -0.3
Supply voltage	DC 5 V ±5% (Current must be limited to 200 mA!)		
Balance quality per VDI 2060	Q1		

Figure 2.7: Compilation of technical data for the measuring wheel and sensor

Position encoder data in connection with drives

Designation / Sensor type / Wheel type		SH2-128-5-… MH2-128-5-…	SH2-256-5-… MH2-256-5-…	SH2-512-5-… MH2-512-5-…
Absolute position measuring accuracy with centric installation				
additional position measuring error with eccentric installation		0.02 deg. per 0.01 mm eccentricity	0.01 deg. per 0.01 mm eccentricity	0.005 deg. per 0.1 mm eccentricity
Maximum speed in combination with drive controller in min^{-1}	KDA/TDA RAC	25000	25000	12500
	DDS/DKS DKR	50000	25000	12500

Figure 2.8: Compilation of technical data in combination with drives

2.3. Type codes

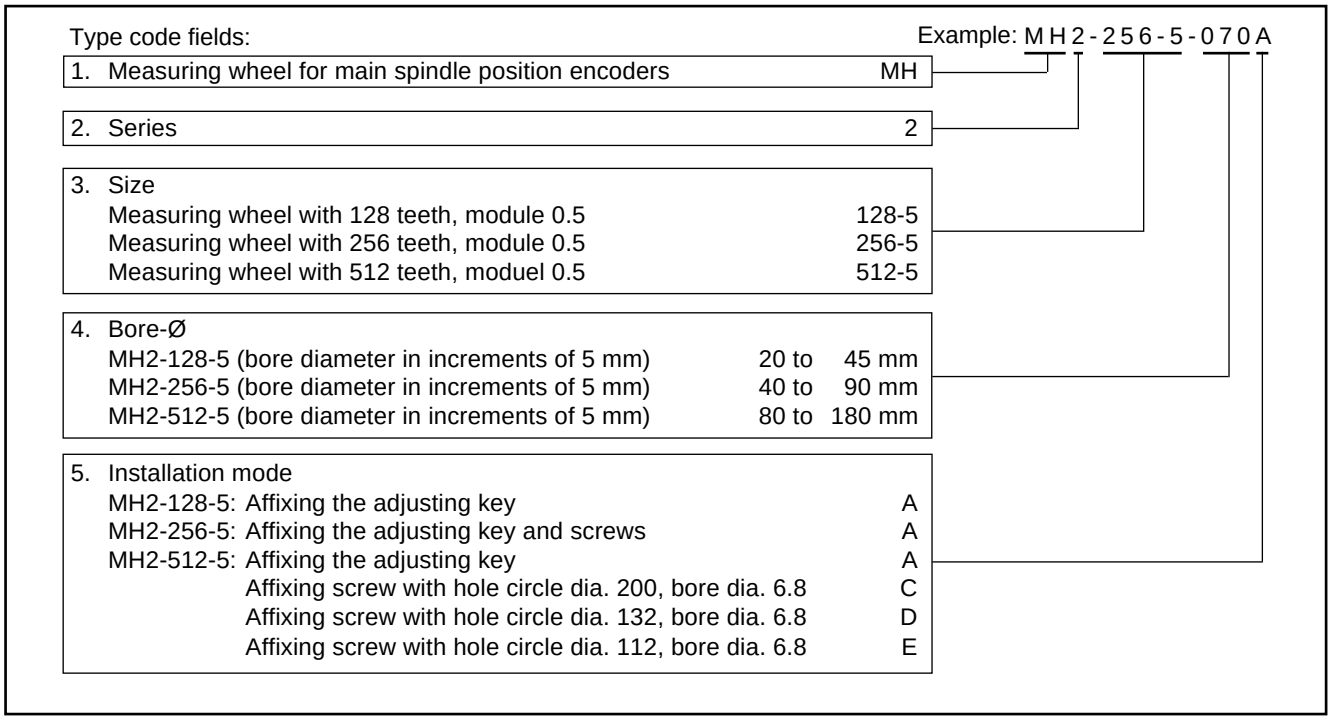


Figure 2.8: Type codes for measuring wheel MH2

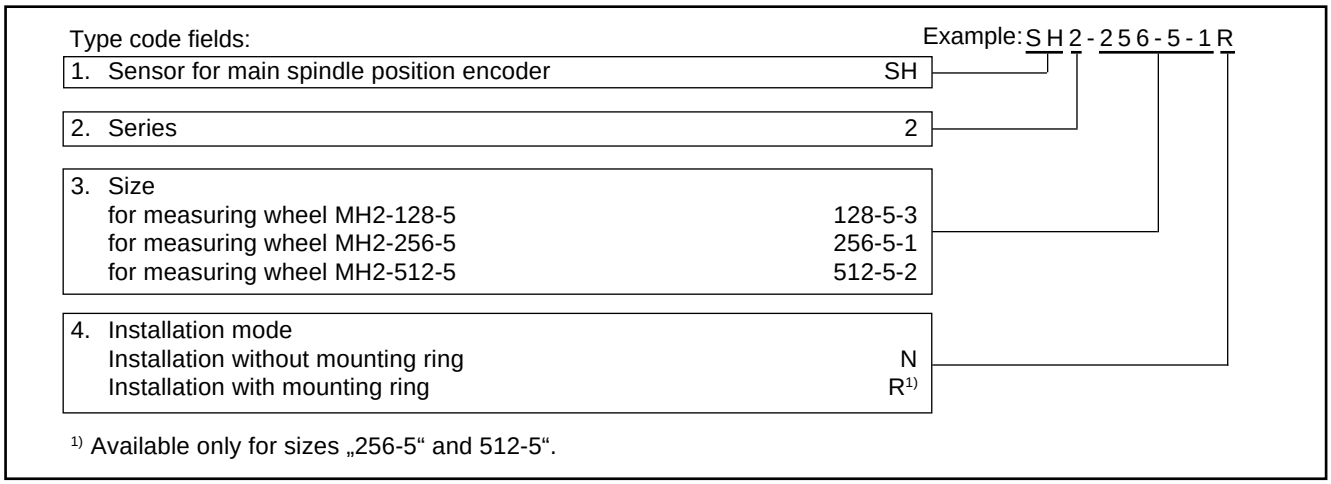


Figure 2.9: Type codes for sensor SH2

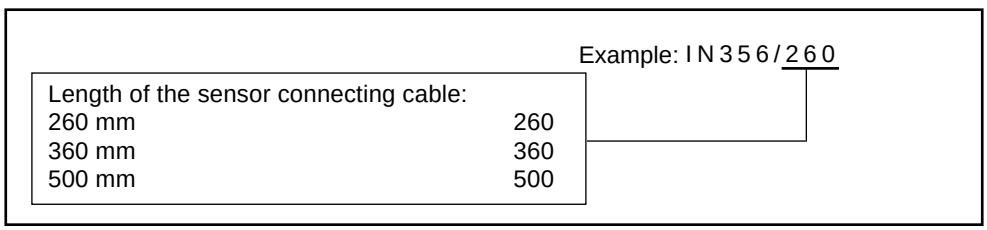


Figure 2.10: Type codes for the sensor connecting cable

3. Electrical data

Depending upon the spindle drive, the high-resolution main spindle position encoder can be used as either a motor feedback (as in the 1MB frameless spindle motor), or as a spindle feedback (as in spindles with 2AD main spindle motors). In both cases, it signals spindle position to the main spindle drive.

Terminal connection diagram

The terminal connection diagrams for these feedback connections are the same regardless of motor type (1MB or 2AD). These diagrams are summarized and can be found in the document entitled: „Electrical connections of main spindle drives, project planning manual," doc. no. 209-0042-4111. They apply to all main spindle drives and can be easily located using the search code (see below for example). These plans are, therefore, absolutely necessary when developing the machine circuit diagrams!

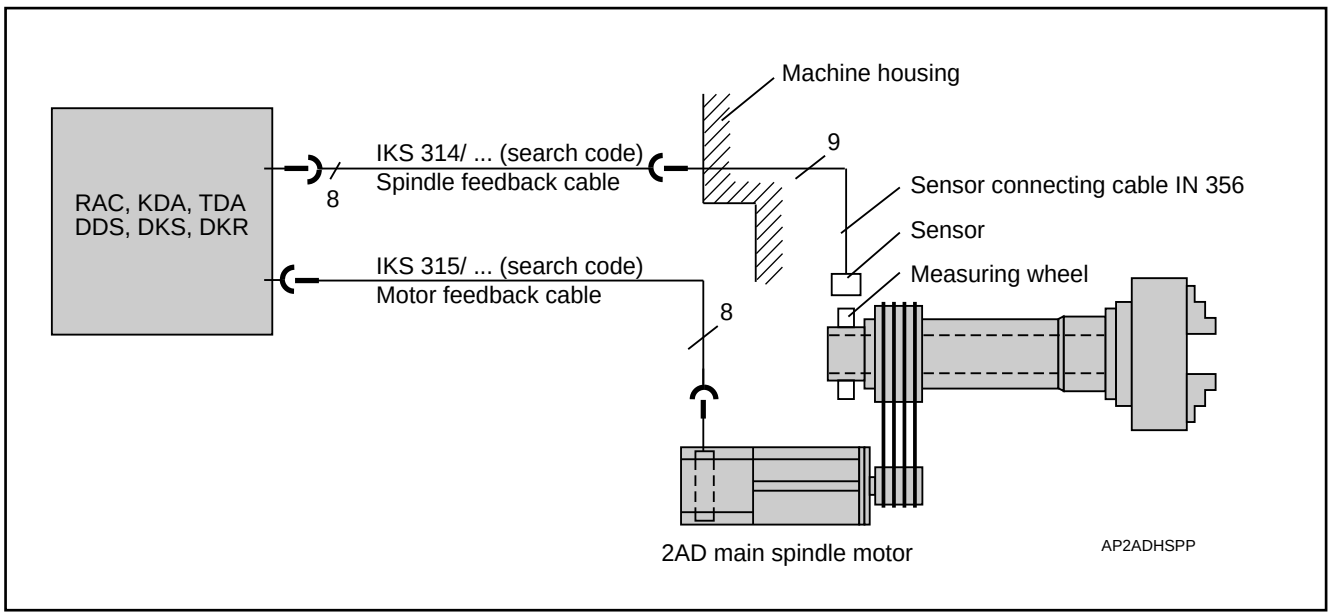


Figure 3.1: Schematic terminal diagram for spindle drives with 2AD

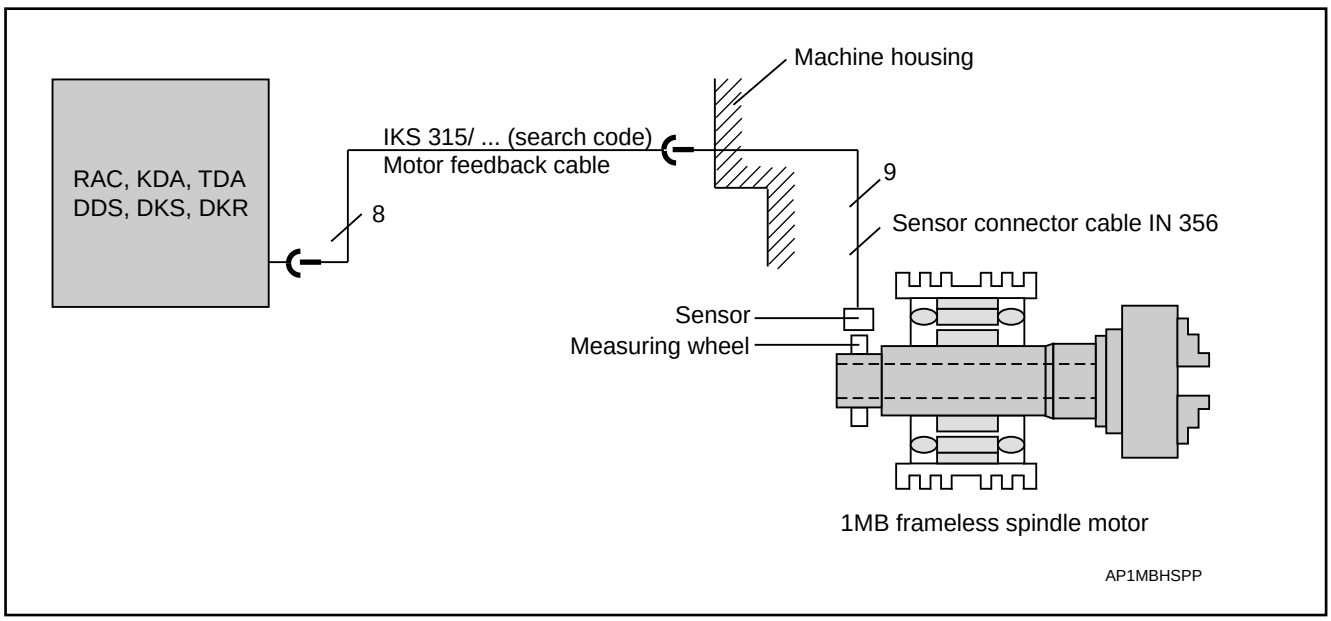


Figure 3.2: Schematic terminal diagram for spindle drive with 1MB

4. Installation

4.1. Prior to installation

Handling

The high-resolution main spindle position encoder is a high-precision component. Adhere to the following guidelines when handling it.

Handle measuring wheel and sensors with care!

Even the most minor damage to the gear teeth make them unusable.

To avoid damage:

- **store parts in the package**
- **do not remove parts from packaging before they are to be installed**

To avoid accidents, never turn the spindle without the prescribed measuring wheel mountings (see section 4.2., installing the measuring wheel).

Installation aids

- set of hexagonal screw drivers
- torque wrench (0.7 … 6 Nm)
- 0.2 mm feeler gauge (in the case of sensors without mounting rings)
- toothed wheel encoder testing unit ZTG1 (in the event a function test needs to be run), and feedback cable IKS 315

What is delivered

- Measuring wheel MH2-…-5-….
- Sensor SH2-…-5-..
- Sensor connecting cable IN 356/… including
  – O-ring 20 x 1.5 (Viton)
  – 4 metric M screws 2.5 x 8 DIN 7985

Identification

See section 5.

Verifications

- Is there any visible damage on the components of the encoder?
- Measuring wheel:
  Does the fixing point for the measuring wheel correspond to the fixing dimensions (see measuring wheel Figures 2.1 through 2.5) with respect to diameter d1, concentricity and plane course (see Figure 4.1 or 4.2).
- Sensor without mounting ring:
  Do dimensions l3 and r (see Figure 4.4) on the spindle housing agree with the fixing dimensions (see sensor Figure 2.1, 2.2 or 2.4)?
- Sensor with mounting ring:
  Does the inside diameter of the mounting ring agree with the pilot diameter d3 (see Figure 4.3)?
  Does dimension l2 (see Figure 4.3) on the spindle housing agree with the fixing dimensions (see sensor type Figure 2.3 or 2.5)?

4.2. Installing the position encoder

Measuring wheel

- Clean the measuring wheel drill hole and its fixing point on the spindle!
- Push the wheel onto its fixing point on the spindle without canting it.
- The measuring wheel must be attached to the spindle with a pressure force of $F_A \geq 2000$ N!

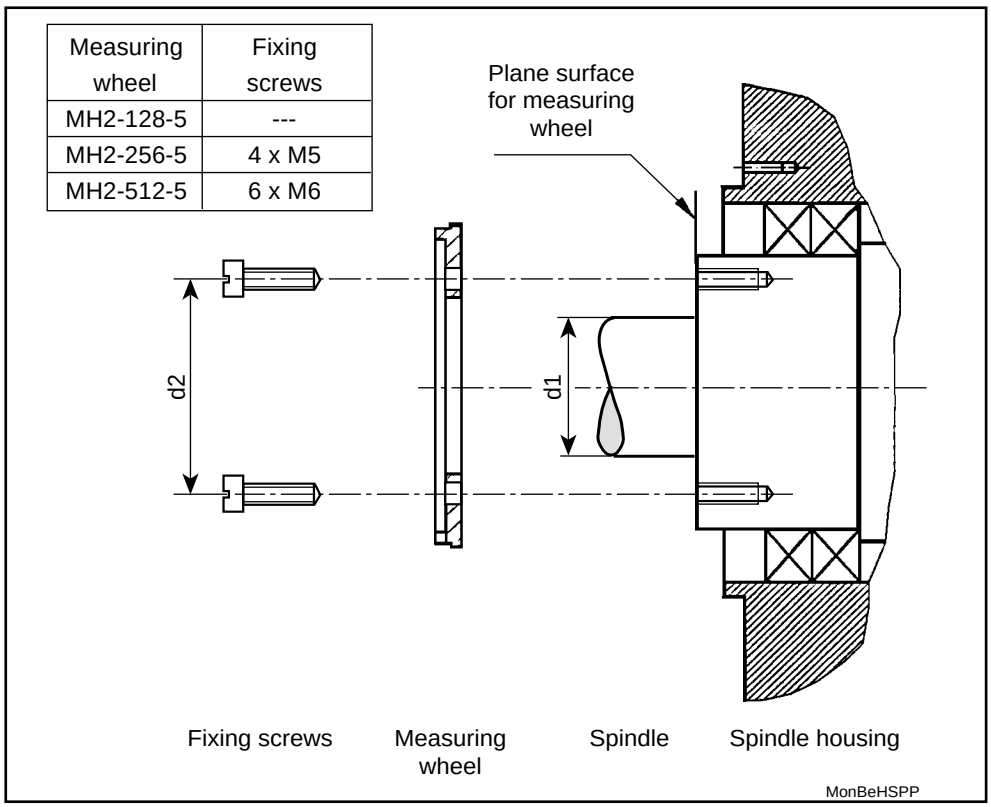


Figure 4.1: Installing the measuring wheels using fixing screws

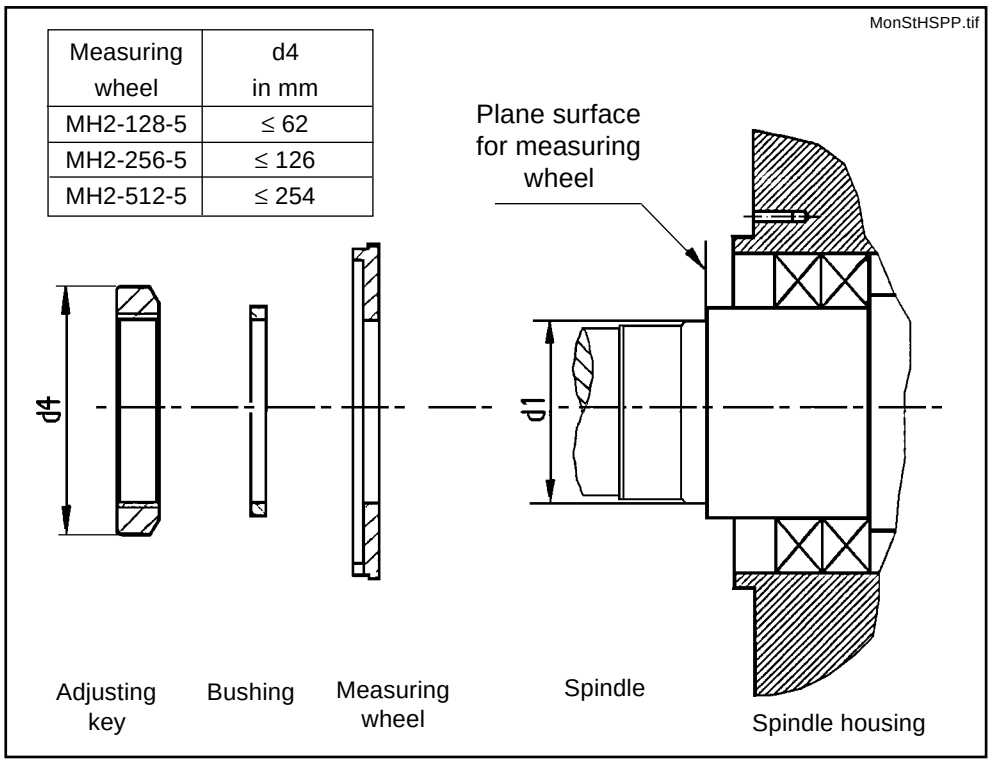


Figure 4.2: Installing the measuring wheel using an adjusting key

Sensor with mounting ring

Screw the sensor with mounting ring onto the spindle housing using three fixing screws (M_A = 6 Nm).

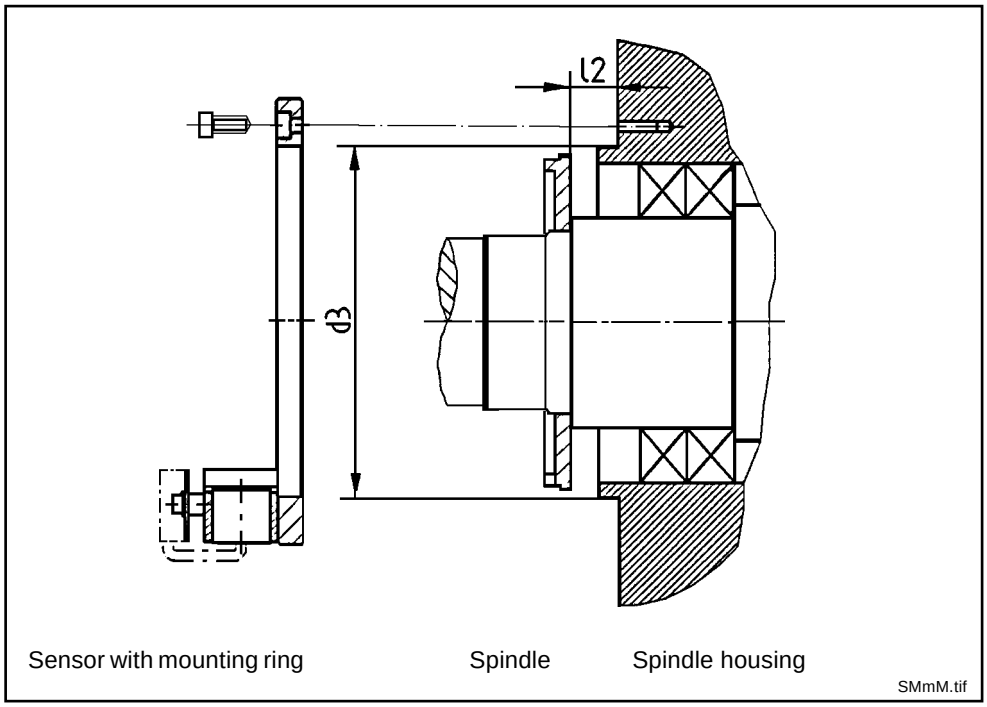


Figure 4.3: Installing the sensor with mounting ring

Sensor without mounting ring

First, screw the sensor only loosely onto the spindle housing using two fixing screws.

Do not now turn the spindle with the already mounted measuring wheel!

The sensor may bear on the stationary measuring wheel during mounting!

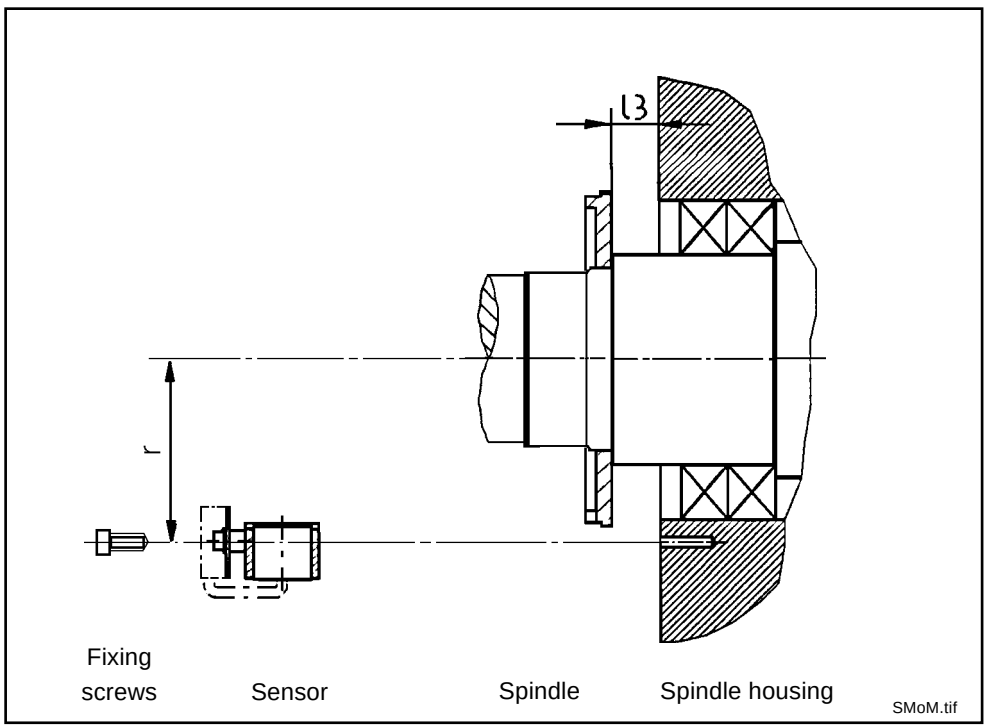


Figure 4.4: Installing a sensor without a mounting ring

Detach the loosely mounted sensor from the measuring wheel. Turn the wheel so that the zero-impulse (grooved pin next to the gear teeth) is not within sensor range. Guide the feeling gauge (0.2 mm) carefully between the measuring wheel and the clearance blocks that are on the sensor housing. With slight pressure, lean the sensor housing with feeler gauge against the toothed wheel. The feeler gauge guarantees that a defined clearance is maintained.

Tighten the fixing screws (M_A = 2.9 Nm). Pull the feeling guide carefully out in an axial direction.

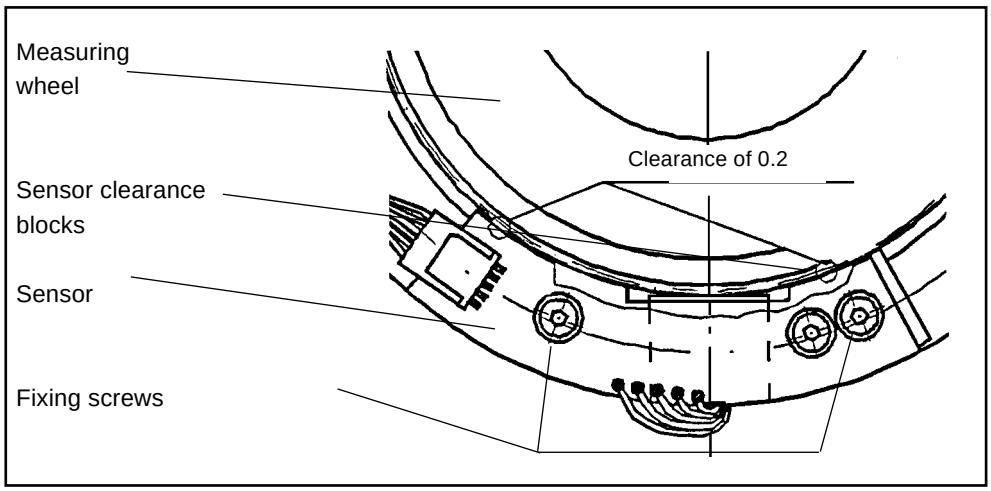


Figure 4.5: Adjusting the clearance between sensor and measuring wheel

Sensor connecting cable

Screw the socket with O-ring onto the spindle housing (tightening torque of the four screws: M_A = 0.7 Nm). Plug the connector onto the sensor circuit board!

Do not damage the sensor connecting cable! It must not rub against any rotating parts!

Install it spatially separated from power conducting lines!

4.3. Checks after installation

Danger of damage!

Do not let the teeth of the measuring wheel touch either the spindle housing or the sensor!

- Carefully check the clearance of the measuring wheel by turning the spindle 360°!
- Check the concentricity and plane course of the measuring wheel!

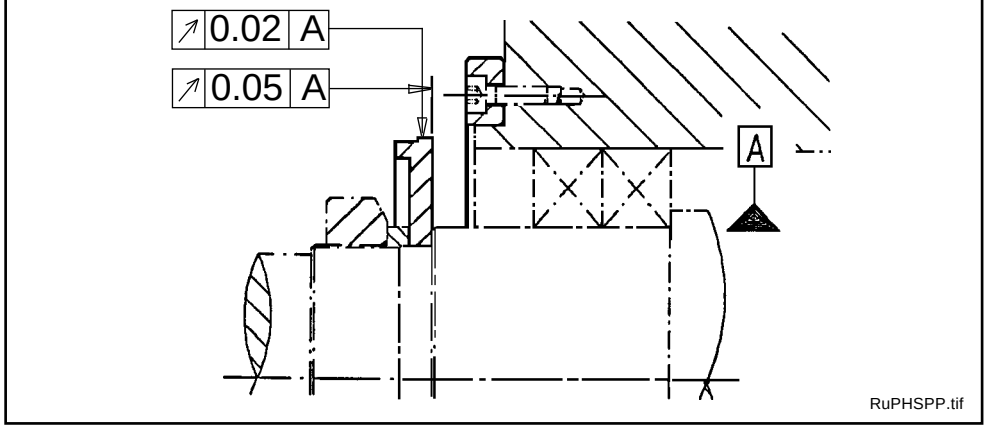


Figure 4.6: Checking concentricity and plane course

The concentricity and plane course tolerances of the spindle and the measuring wheel can add up during installation in such a way that the listed values are exceeded. In this case, remove the measuring wheel, rotate it, and re-install it.

- Check dimensions l2 (see Figure 4.3) and l3 (see Figure 4.4) with respect to the measuring wheel!

4.4. Testing unit ZTG1

Testing unit ZTG1

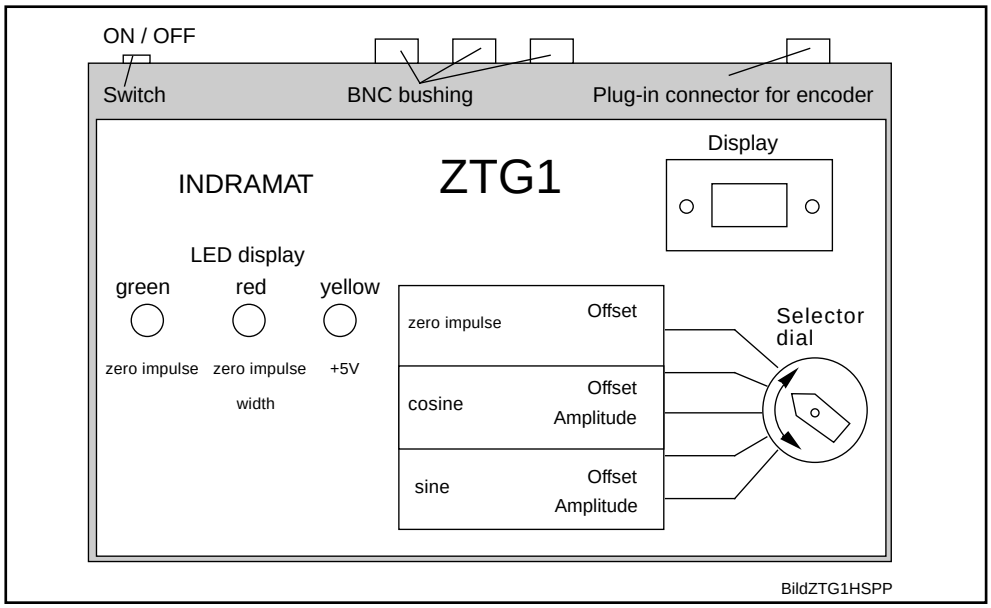


Figure 4.7: View onto the ZTG1 with allocation of terms

4.4.1. Connections

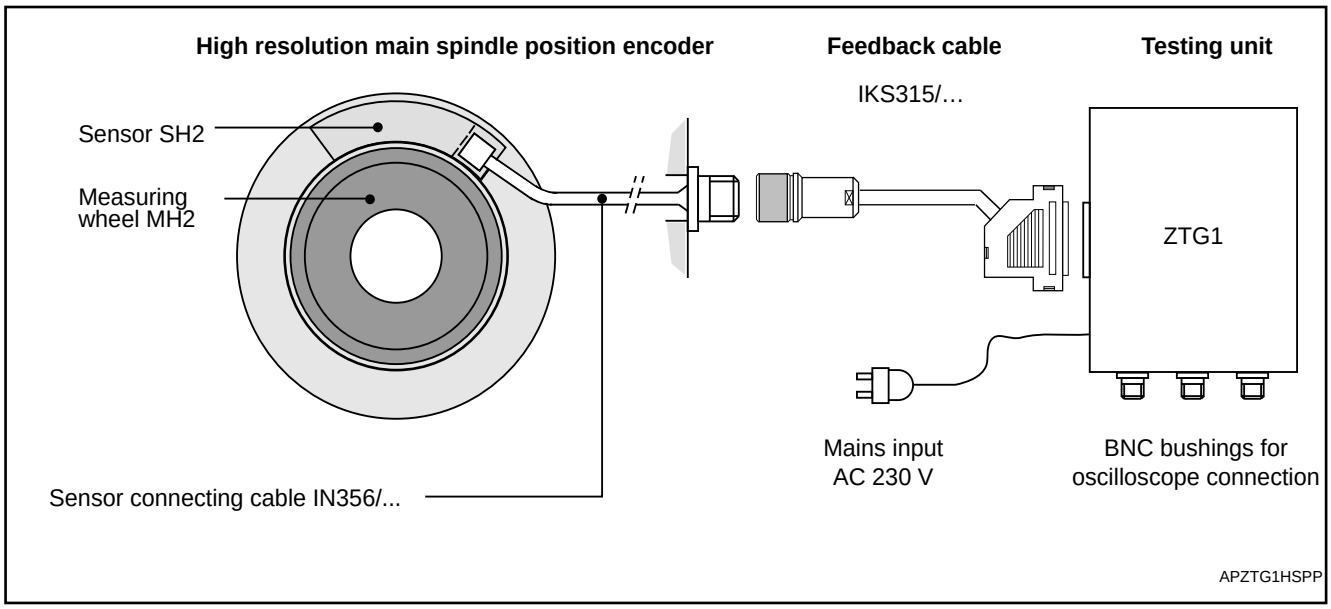


Figure 4.8: Checking functions with the encoder testing unit ZTG1

- Connect sensor and testing unit ZTG1 with each other over sensor connecting and motor feedback cables (IKS 315).
- Connect ZTG1 to the 220 V mains and turn mains switch on.
  The yellow LED ”+5V“ must light up.

Wait approximately three minutes after switching the ZTG1 on. This is due to transient thermal reactions in the sensor!

4.4.2. Test procedures

Checking the amplitude

- Turn the selection dial to “amplitude“ or “cosine“ or “sine“.
- Turn the spindle by hand (approx. 10 … 50 min^{-1}).
- Read and record the display and compare to the command value range (see Figure 4.9).

Checking the offset values

- Turn selection dial to “offset“ of “cosine“ or “sine“.
- Turn the spindle by hand (approx. 10 … 50 min^{-1}).
- Read and record the display and compare with command value range (see Figure 4.9).
- Turn selection dial to ”zero impulse“, “offset“.
- Adjust the spindle so that the zero impulse indicator is outside of the sensor range. Do not turn spindle!
- Read and record the display and compare with command value range (see Figure 4.9).
- Turn spindle by hand (approx. 10 … 50 min^{-1}).
  The green LED „zero impulse“ display should flash briefly when the zero impulse indicator is moved past the sensor. The red LED „zero impulse width“ display must not light up.

		Command values (in V) at		**Display in V**	**Value within command value range?**
		ϑ_{Motor}≈20°C	ϑ_{Motor}≈150°C	ϑ_{Motor}≈……	(yes/no)
Amplitude	cosine	7.0 … 8.0	3.5 … 4.5		
	sine	7.0 … 8.0	3.5 … 4.5		
Offset	cosine	-0.5 … +0.5	-1.5 … +1.5		
	sine	-0.5 … +0.5	-1.5 … +1.5		
	0 impulse	-0.5 … +0.5	-1.5 … +1.5		
LED (green)	”0 impulse“	Quick flashing with slowly turning spindle?			Yes / No (Errorr)
LED (red)	”0 impulse“ width	Lights up with slowly turning spindle?			No / Yes (Error)

Figure 4.9: Checklist for testing a main spindle position encoder with ZTG1

Function tests checked out?

The spindle is now ready for commissioning!

Function tests did not check out?

If the amplitude values are not within the permissible value range, then the clearance of sensor to measuring wheel must be readjusted (see Figure 4.5).

Do not release the screws that have been varnished over!
This could cause a defect in the sensor!

The amplitude values drop the greater the distance between sensor and measuring wheel!

- If the amplitude values continuously range at zero, then check the feedback or sensor connecting cable! (See document “Electrical connections of main spindle drives, Project planning manual, doc. no.: 209-0042-4111).
- If the offset values exceed the permissible range, even though the amplitude values are within the permissible range, then exchange the sensor.
- If the green LED „zero impulse“ display does not light up:
  a) The zero impulse indicator on the measuring wheel could either be damaged or broken off!
  Remedial action: replace measuring wheel!
  b) The sensor could be defective.
  Remedial action: replace sensor!
  c) The sensor has been improperly installed.
- If the red LED „zero impulse width“ lights up:
  a) The manually set spindle speed could be too low.
  b) The zero impulse indicator on the measuring wheel could be damaged.
  Remedial action: replace measuring wheel!
  c) The sensor is defective.
  Remedial action: replace sensor!

Faults cleared?

Re-run the function tests (see the beginning of section 4.4.2.).

5. Identification

Sensor

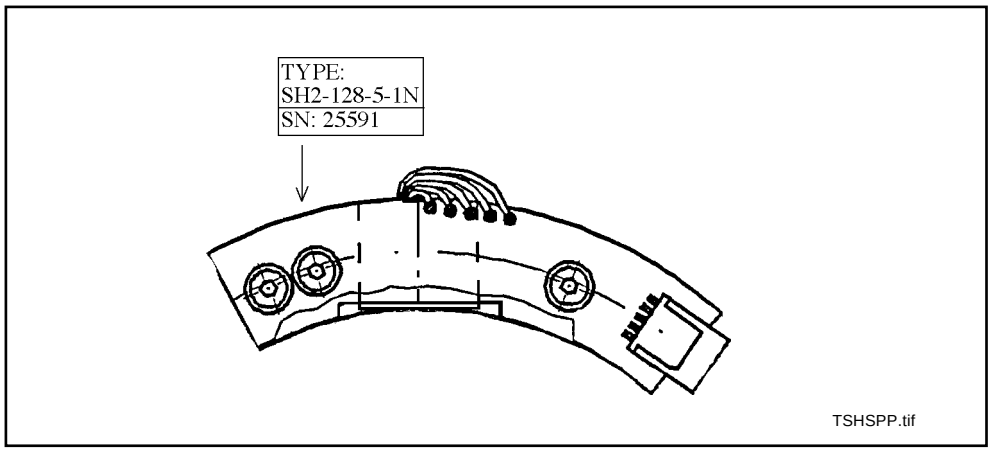


Figure 5.1: Sensor rating plate and fixing point (example)

Sensor connecting cable

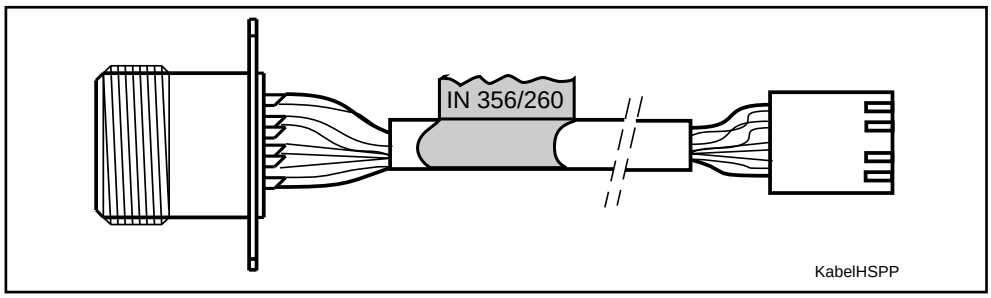


Figure 5.2: Cable identification on the sensor connecting cable (example)

Measuring wheel

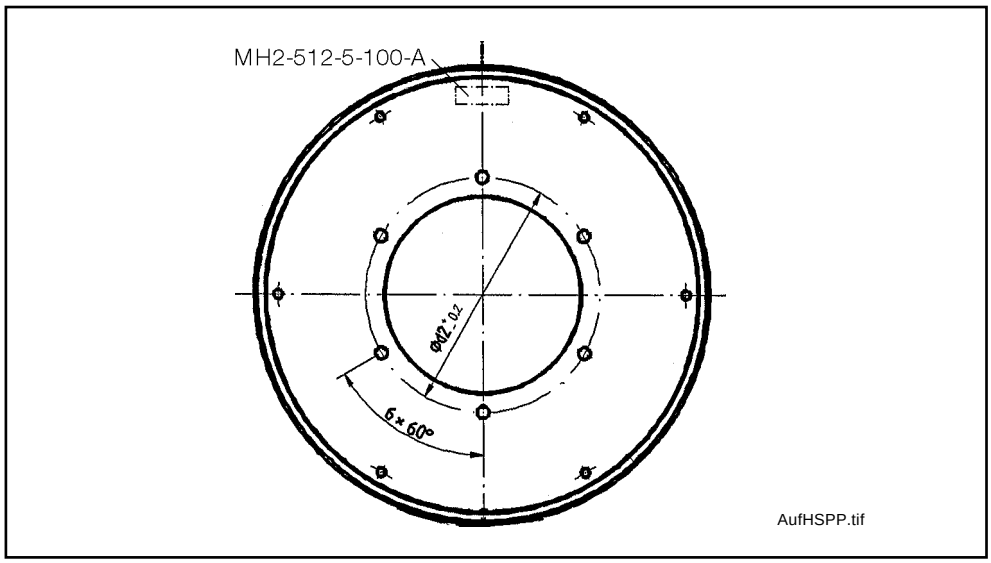


Figure 5.3: Inscription on the measuring wheel (example)

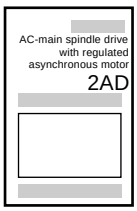
6. Index

Notes

7. Summary of supplementary documentation

Selection
(details, ordering)

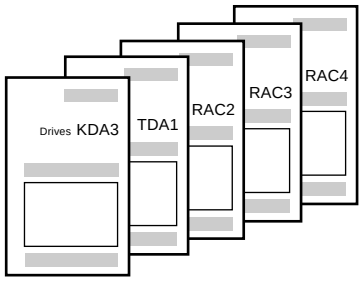
AC main spindle drives
with regulated 2AD main spindle motor



Selection data
- Summary of the AC main drive system
- Power ratings
- AC main spindle drive functions
- Selection protocol and order lists
- Product availability

Doc. no.: 9.567.013.4

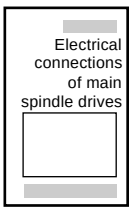
Project planning
(construction, mounting, installation)



Main spindle drives

Project planning
- Planning the control cabinet
- AS programming module
- Delivery, storage, transportation
- Assembly and installation guidelines

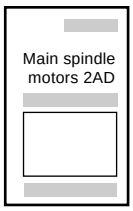
KDA 3.2, Doc. no. 209-0042-4110
TDA 1.1, Doc. no. 209-0042-4112
RAC 2, Doc. no. 209-0042-4115
RAC 3, Doc. no. 209-0042-4116
RAC 4, Doc. no. 209-0042-4113



Electrical connections of main spindle drives

Project Planning
- general guidelines for the electrical connections
- circuit diagrams for feedback and NC connections of all main spindle drives
- circuit diagrams for the power connections of all main spindle drives

Doc. no. 209-0042-4111



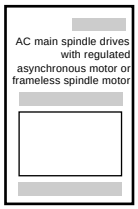
Main spindle motor

Project planning
- Machine construction
- Delivery, storage, transportation
- Assembly and installation

Doc. no. 209-0042-4122

Main spindle drive applications
(Commissiong, operating, diagnostics)

AC main spindle drives with regulated asynchronous motor or frameless spindle motor

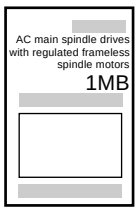


Applications
- Commissioning the AC main spindle drives
- Operating the drives
- The functions of the drives
- Diagnostics and fault clearance
- Overview of parameters and interfaces

Doc. no. 209-0041-4109

Figure 7.1: Summary of supplementary documentation

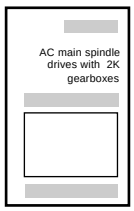
AC main spindle drives with regulated 1MB frameless spindle motors



Selection data
- Summary of the AC main drive system
- Power levels
- AC main spindle drive functions
- Selection protocols and order lists
- Product availability

Doc. no. 9.567.012.4

AC spindle drives with regulated 2AD asynchronous motors and 2K planetary gearboxes

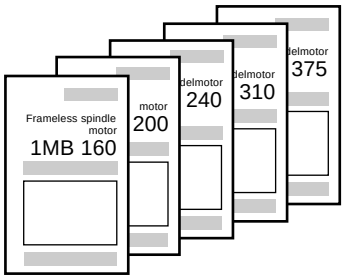


Selection data
- Summary of the main spindle drive system
- Power levels
- Order guidelines

Doc. no. 9.567.022.4

Selection (details, ordering)

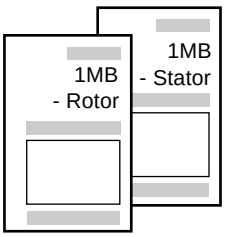
You have this document ...



Frameless spindle motor

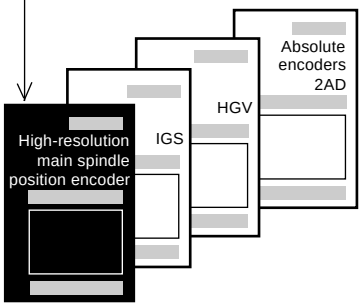
Project planning
- Machine construction plans
- Integrating into the cooling system
- Electrical and coolant connections
- Delivery

1MB 160, Doc. no. 9.576.014.4
1MB 200, Doc. no. 9.576.016.4
1MB 240/241, Doc. no. 9.576.015.4
1MB 310/312, Doc. no. 9.576.008.4
1MB 375, Doc. no. 9.576.007.4



Installation guidelines
- Delivery, handling, transport
- Assembly
- Cooling guidelines

Stator, Doc. no. 9.600.063.4
Rotor, Doc. no. 9.600.062.4



Supplementary documentation
- High-resolution main spindle position encoder Project planning Doc. no. 209-0042-4119
- Incremental encoder output - IGS Doc. no. 9.568.015.4
- High-resolution encoder branching - HGV Doc. no. 9.568.010.4
- Built-on absolute encoder for 2AD 132, 2AD 160, 2AD 180 Dok.Nr. 9.568.020.4

Project planning (construction, assembly, installing the machine)

Applications of the main spindle drive (Commissiong, operating, diagnostics)


Indramat