SINAMICS S120

2SP1 ECS Motor Spindle

Configuration Manual 02/2011

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Configuration Manual

(PMSS), 02/2011

6SN1197-0AC04-0BP1

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation for the specific task, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be adhered to. The information in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of the Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Motor documentation

The motor documentation is organized in the following categories:

- General documentation e.g. catalogs
- Manufacturer/service documentation e.g. Operating Instructions and Configuration Manuals

More information

Information on the following topics is available under the link:

- Ordering documentation/overview of documentation
- Additional links to download documents
- Using documentation online (find and search in manuals/information)

http://www.siemens.com/motioncontrol/docu

Please send any questions about the technical documentation (e.g. suggestions for improvement, corrections) to the following e-mail address:

docu.motioncontrol@siemens.com

My Documentation Manager

The following link provides information on how to create your own individual documentation based on Siemens content, and adapt it for your own machine documentation:

http://www.siemens.com/mdm

Training

The following link provides information on SITRAIN - training from Siemens for products, systems and automation engineering solutions:

http://siemens.com/sitrain

FAQs

You can find Frequently Asked Questions in the Service&Support pages under **Product Support**:

http://support.automation.siemens.com

Technical Support

For technical support telephone numbers for different countries, go to:

http://www.siemens.com/automation/service&support

Internet addresses for drive technology

Internet address for motors: http://www.siemens.com/motors

Internet address for products: http://www.siemens.com/motioncontrol

Internet address for SINAMICS: http://www.siemens.com/sinamics

Target group

This documentation addresses machine manufacturers, commissioning engineers and service personnel.

Benefits

The Configuration Manual supports you when selecting motors, calculating the drive components, selecting the required accessories as well as when selecting line and motor-side power options.

Standard scope

The scope of the functionality described in this document can differ from the scope of the functionality of the drive that is actually supplied.

- Other functions not described in this documentation might be able to be executed in the drive. However, no claim can be made regarding the availability of these functions when the equipment is first supplied or in the event of servicing.
- The documentation can also contain descriptions of functions that are not available in a particular product version of the drive. The functionalities of the supplied drive should only be taken from the ordering documentation.
- Extensions or changes made by the machine manufacturer are documented by the machine manufacturer.

For reasons of clarity, this documentation does not contain all of the detailed information on all of the product types. This documentation cannot take into consideration every conceivable type of installation, operation and service/maintenance.

EC Declarations of Conformity

The EC Declaration of Conformity for the EMC Directive can be found on the Internet at

http://support.automation.siemens.com

There – as a search term – enter the number **15257461** or contact your local Siemens office.

Danger and warning notices

⚠ DANGER

- Commissioning is absolutely prohibited until it has been completely ensured that the machine, in which the components described here are to be installed, is in full compliance with the specifications of Directive 98/37/EC.
- Only appropriately qualified personnel may commission the SINAMICS units and the motor spindles.
- This personnel must carefully refer to the technical customer documentation belonging to the product and be knowledgeable and observe the specified information and instructions on the hazard and warning labels.
- Operational electrical units and motor spindles have parts, components and electric circuits that are at hazardous voltage levels.
- When the machine or system is operated, hazardous axis movements can occur.
- All of the work carried-out on the electrical machine or system must be carried-out with it in a no-voltage condition.
- SINAMICS units are generally designed for operation on low-resistance, grounded power supplies (TN systems).
- SINAMICS drive units with motor spindles can only be connected to the line supply via residual-current operated circuit breakers if it has been verified (in accordance with EN 61800-5-1) that the SINAMICS unit is compatible with the residual-current operated circuit breaker.

⚠ WARNING

- Perfect and safe operation of these units and motors assumes professional transport, storage, mounting and installation as well as careful operator control and servicing.
- The information provided in Catalogs and quotations additionally applies to special versions of units and motors.
- In addition to the danger and warning information/instructions in the technical customer documentation supplied, the applicable domestic, local and plant-specific regulations and requirements must be carefully taken into account.

⚠ CAUTION

- It is not permissible that temperature-sensitive parts - e.g. cables or electronic components - are in contact or mounted to the motor spindle.
- When attaching the connecting cables, you must ensure that
  - they are not damaged
  - they are not under tension, and
  - they cannot come into contact with any rotating parts.

CAUTION

- As part of routine tests, SINAMICS units with motor spindles are subject to a voltage test in accordance with EN 61800-5-1. While the electrical equipment of industrial machines is being subjected to a voltage test in accordance with EN60204-1, Section 19.4, all SINAMICS drive unit connections must be disconnected/withdrawn in order to avoid damaging the SINAMICS drive units.
- It is not permissible to directly connect the motor spindles to the three-phase line supply as this will destroy the motor spindles.

Note

- When operational and in dry operating rooms, SINAMICS units with motors spindles fulfill the Low-Voltage Directive.
- In the configurations specified in the associated EC Declaration of Conformity, SINAMICS units with motor spindles fulfill the EMC Directive.

ESDS instructions and electromagnetic fields

⚠CAUTION

An **e**lectrostatic-**s**ensitive **d**evice (ESDS) is an individual component, integrated circuit, or module that can be damaged by electrostatic fields or discharges.

ESDS regulations for handling boards and equipment:

When handling components that can be destroyed by electrostatic discharge, it must be ensured that personnel, the workstation and packaging are well grounded!

Personnel in ESD zones with conductive floors may only touch electronic components if they are
– grounded through an ESDS bracelet and
– wearing ESDS shoes or ESDS shoe grounding strips.

Electronic boards may only be touched when absolutely necessary.

Electronic boards may not be brought into contact with plastics and articles of clothing manufactured from man-made fibers.

Electronic boards may only be placed on conductive surfaces (table with ESDS surface, conductive ESDS foam rubber, ESDS packing bag, ESDS transport containers).

Electronic boards may not be brought close to data terminals, monitors or television sets. Minimum clearance to screens > 10 cm).

Measurements may only be carried-out on electronic boards and modules if
– the measuring instrument is grounded (e.g. via a protective conductor) or
– before making measurements with a potential-free measuring device, the measuring head is briefly discharged
(e.g. by touching an unpainted blank piece of metal on the control cabinet).

⚠DANGER

It may be dangerous for people to remain in the immediate proximity of the product – especially for those with pacemakers, implants or similar – due to electric, magnetic and electromagnetic fields (EMF) occurring as a consequence of operation.

The machine/system operator and the people present near the product must observe the relevant guidelines and standards! These are, for example, in the European Economic Area (EEA) the Electromagnetic Fields Directive 2004/40/EC and the standards EN 12198-1 to 12198-3 and in the Federal Republic of Germany the Employer's Liability Insurance Association Regulations for the Prevention of Industrial Accidents BGV 11, with the relevant rule BGR 11 "Electromagnetic Fields".

Then a risk assessment must be carried out for every workplace, activities for reducing dangers and exposure for people decided upon and implemented, as well as determining and observing exposure and danger areas.

Information regarding third-party products

NOTICE
This document contains recommendations relating to third-party products. This involves third-party products whose fundamental suitability is familiar to us. It goes without saying that equivalent products from other manufacturers may be used. Our recommendations are to be seen as helpful information, not as requirements or regulations. We cannot accept any liability for the quality and properties/features of third-party products.

Environmental compatibility

- Environmental aspects during development

  When selecting supplier parts, environmental compatibility was an essential criteria.

  Special emphasis was placed on reducing the envelope dimensions, mass and type variety of metal and plastic parts.

  Effects of paint-wetting impairment substances can be excluded (PWIS test)

- Environmental aspects during production

  Supplier parts and the products are predominantly transported in re-usable packing. Transport for hazardous materials is not required.

  The packing materials themselves essentially comprise paperboard containers that are in compliance with the Packaging Directive 94/62/EC.

  Energy consumption during production was optimized.

  Production has low emission levels.

- Environmental aspects for disposal

  Motors must be disposed of carefully taking into account domestic and local regulations in the normal recycling process or by returning to the manufacturer.

  The following must be taken into account when disposing of the motor:

  Oil according to the regulations for disposing of old oil (e.g. gear oil when a gearbox is mounted)

  Not mixed with solvents, cold cleaning agents of remains of paint

  Components that are to be recycled should be separated according to:

  – Electronics scrap (e.g. encoder electronics, sensor modules)
  – Iron to be recycled
  – Aluminum
  – Non-ferrous metal (gearwheels, motor windings)

Residual risks of power drive systems

When carrying out a risk assessment of the machine in accordance with the EU Machinery Directive, the machine manufacturer must consider the following residual risks associated with the control and drive components of a power drive system (PDS).

1. Unintentional movements of driven machine components during commissioning, operation, maintenance, and repairs caused by, for example:
   - Hardware defects and/or software errors in the sensors, controllers, actuators, and connection technology
   - Response times of the controller and drive
   - Operating and/or ambient conditions not within the scope of the specification
   - Parameterization, programming, cabling, and installation errors
   - Use of radio devices / cellular phones in the immediate vicinity of the controller
   - External influences / damage
2. Exceptional temperatures as well as emissions of light, noise, particles, or gas caused by, for example:
   - Component malfunctions
   - Software errors
   - Operating and/or ambient conditions not within the scope of the specification
   - External influences / damage
3. Hazardous shock voltages caused by, for example:
   - Component malfunctions
   - Influence of electrostatic charging
   - Induction of voltages in moving motors
   - Operating and/or ambient conditions not within the scope of the specification
   - Condensation / conductive contamination
   - External influences / damage
4. Electrical, magnetic and electromagnetic fields generated in operation that can pose a risk to people with a pacemaker, implants or metal replacement joints, etc. if they are too close.
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly.

More extensive information concerning the residual risks associated with the PDS is provided in the relevant chapters of the technical user documentation.

Table of contents

Safety instructions

1

The specific issues relating to the functional safety of the motor spindle are explained in this Chapter. These functional safety issues involve defining and monitoring the spindle and tool-related speed limit values.

Table 1- 1 Safety measures required

Measures required for protection against electric shock	Measures for protection against potentially hazardous motion
The spindle has the appropriate design. This means that there are no different measures required than are otherwise applied for motors. Measures are not specifically described here.	With reference to safe stopping, there are no different measures required than are otherwise applied for motors. **Specific for motor spindles:** **Functional safety** by defining and monitoring the spindle and the tool-related **speed limits**.

1.1 Protection against potentially hazardous motion

In the following text, at several locations, reference will be made to the SINUMERIK Safety Integrated® safety package. The requirements relating to machine safety and the possibilities of using Safety Integrated® for machine tools is described in the associated Safety Integrated® - Application Manual, especially in Chapters 1 and 5.

The 2SP1 motor spindle fulfills all of the relevant EU directives. It is also possible, beyond this, to use the Safety Integrated® option. These are certified according to the Employer's Liability Insurance Association type examination.

Depending on the operating mode (e.g. setting-up, production) of the machine, motor spindles, just like feed drives, represent a specific, potential hazard. This must be taken into account when designing and engineering the machine.

Protective measures

The protective goals of the EC Machinery Directive must be fulfilled by applying suitable protective measures. It is important that the machine is correctly used.

In order to implement these protective goals, in addition to being knowledgeable about the applicable standards and directives, it is also necessary to carefully observe the information and instructions in this Configuration Manual (refer to the following Table).

Table 1- 2 Target group-specific documentation for the 2SP1 motor spindle

Target group	Task of the target group	Relevant documentation
Machine manufacturers/planners	• Carry out a risk analysis • Draw up a safety concept • Provide the necessary safety equipment at the machine • Instruct the operating company about the "correct use" of the machine and spindle	Configuration Manual and Operating Instructions
Company operating the machine	• Inform/train employees about the "correct use" of the spindle and the application of the safety functions and how they work • Reference to residual risks	Operating instructions

When applied to the motor spindle, potentially hazardous motion is involved if the maximum permissible speed for the spindle and/or tool is exceeded (see chapter Speed limits, diagrams "Adapting the shutdown speed to various tools" and "Control-related speed peaks").

Speed monitoring

Table 1- 3 Possible strategies to monitor the speed

Degree of reliability of the speed monitoring which is strived for	Features and requirements of the technology used
Standard	Can be implemented (without additional technology) using the **existing** operating and machine **technology**
Safe	Must be implemented in a **safety-related fashion** (e.g. through two channels).
	Must correspond to the required control category (according to **EN 954-1**).
	Must be **authorized/certified** for specific machines.

When using a machine tool spindle, the machinery construction OEM is always responsible in taking the appropriate measures to detect and to avoid speeds that are not permitted and their associated effects – and to instruct the company using the machine about these measures.

When an inadmissible speed occurs, then the spindle must be stopped. In this case, the limit value is interpreted as that value where the maximum permissible speed is exceeded. This limit value depends on the following factors:

- Operating state (setting-up or automatic mode)
- Tool that is currently being used (refer to chapter Speed limits, diagram "Adapting the shutdown speed to various tools")
- Maximum permissible spindle speed (see Chapter speed limits, diagram "Control-related speed peaks")

Table 1- 4 Measures to prevent the maximum speed being exceeded and its effects

Level of the measures	Example of safety measures
Preventing the speed being exceeded	• Monitoring the spindle speed • Activating tool-specific limit values • Monitoring operational and cutting parameters • Monitoring the tool condition
Controlling the effect when the speed is exceeded	• Providing machine panels, which can withstand the maximum impact of pieces thrown off at the maximum assumable energy level • Ensure that these machine panels can only be opened at a defined low spindle speed • Automatic stopping when faults/errors occur

Future-oriented strategies, which are applied to limit risks, distinguish themselves by the fact that they are practical and safe measures and designed to avoid faults and errors. This means that the machinery construction company has a certain degree of flexibility in appropriately reducing the costs involved to control faults and errors.

Safety Integrated® as a measure to avoid faults

Safety Integrated® is an efficient measure, which is optionally available at the fault prevention level. It can be used to monitor the drive functions.

The basic principle of Safety Integrated® is based on a two-channel monitoring function. This means that the requirements from the EC Machinery Directive can be simply and cost-effectively fulfilled.

Example of Safety Integrated®:

It is possible to safely limit the maximum energy of broken tool pieces that have been flung out by activating the tool-specific limit values with Safety Integrated® – therefore significantly reducing the costs involved to achieve the appropriate strength of the machine panels.

Table 1- 5 Excessive speed - avoiding faults using Safety Integrated®

Fault class	Avoided by ...
Excessive spindle speed	• "Safely reduced speed" • Safe spindle stopping when faults occur
Excessive tool speed (for tools whose maximum speed lies below the maximum spindle speed)	• "Safely reduced speed" as a function of the tool being used • The tool is detected in a safety-related fashion by "safely reading" the tool coding, or • The tool is detected in a safety-related fashion by reading the tool coding and making a comparison with the program parameters • Safety-related stopping of the spindle

1.2 Speed limits

The spindle is designed for a maximum operating speed. This is specified in Chapter Technical data and characteristics (Page 139) as the "max speed". The operating company can use this speed in operation.

Maximum operating speed

The maximum operating speed is the highest speed that the spindle can be operated at. This speed can be saved in the control and part programs.

Shutdown speed

The speed limit, where the system is shutdown if this value is exceeded, is designated in this document as **"Shutdown speed"**.

The machinery construction manufacturer (OEM) defines this taking into account the supplementary conditions that apply to the spindle and tool. The shutdown speed should be defined so that shutdown does not occur during normal operation and, on the other hand, the spindle system and tool are not overloaded due to speed peaks that are permitted. The spindle must be shutdown if erroneous functions occur and the speed is exceeded. The speed can be monitored using standard technology or also with safety-related technology (see chapter Protection against potentially hazardous motion, table "Possible strategies to monitor the speed").

Adapting the shutdown speed to various tools

If the maximum speed, which is permitted for the tool currently being used, lies below the maximum operating speed of the spindle, then the speed monitoring and the shutdown speed must be adapted to the particular tool.

⚠WARNING

The shutdown speed may only be set a maximum of 15% above the maximum operating speed of the spindle.

The shutdown speed may not be set higher than the permitted maximum speed of the tool. The maximum operating speed, programmed for the tool, must be limited to a value, which lies a minimum of 5% below the shutdown speed (refer to the following diagram).

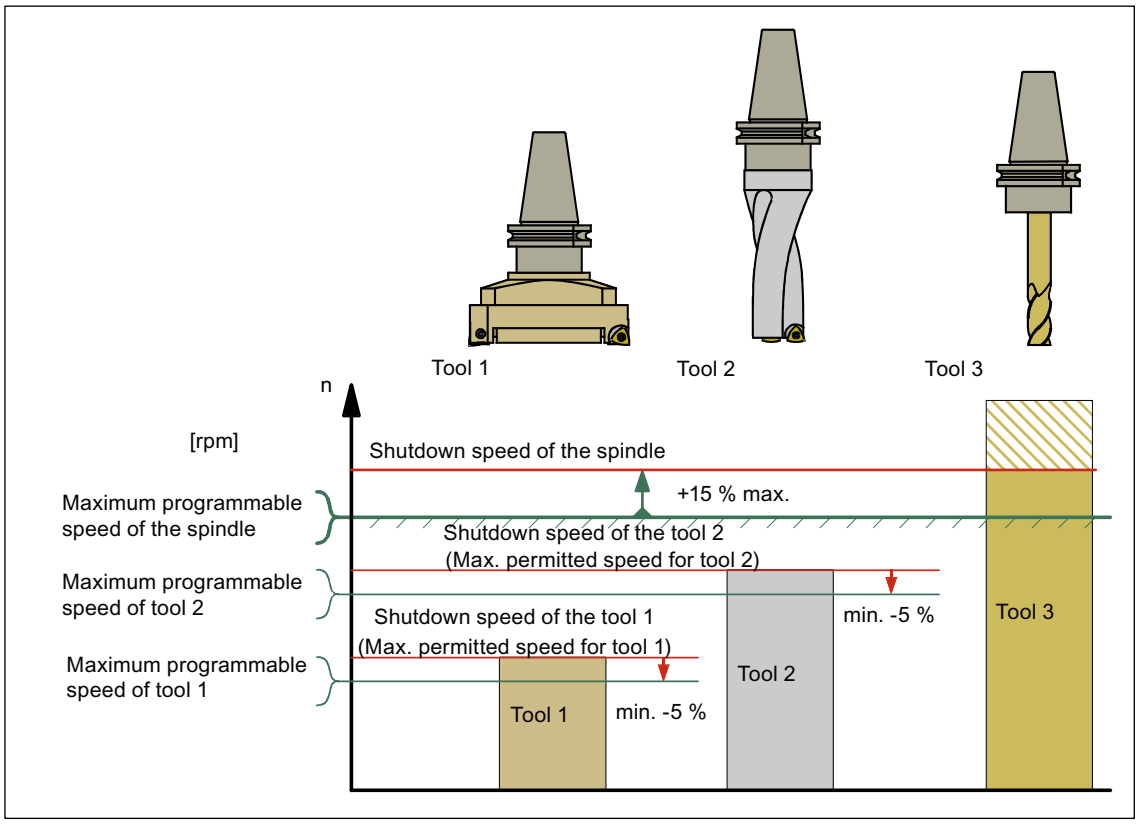


Figure 1-1 Adapting the shutdown speed to various tools

CAUTION

If various shutdown speeds are programmed for various tools, then this must be adapted to the tool using the Tool Manager. The machinery construction manufacturer (OEM) is responsible in clearly indicating to the operating company that it is necessary to adapt the shutdown speed to the actual tool being used.

Critical speed

The critical speed is the speed where resonance vibration is excited in the complete mechanical structure.

Control-related speed peaks

The spindle speed is obtained as the result of a control (closed-loop) process. Depending on the particular controller setting and the load condition, it oscillates around the programmed setpoint. When the spindle is operated, it is therefore normal that the spindle shaft assumes speeds which briefly lie above the programmed operating speed. However, even if mechanical critical speeds are even briefly exceeded, this can result in excessive material stressing and in turn damage. This means that tools and spindle systems must be able to withstand normal speed peaks as a result of control operations.

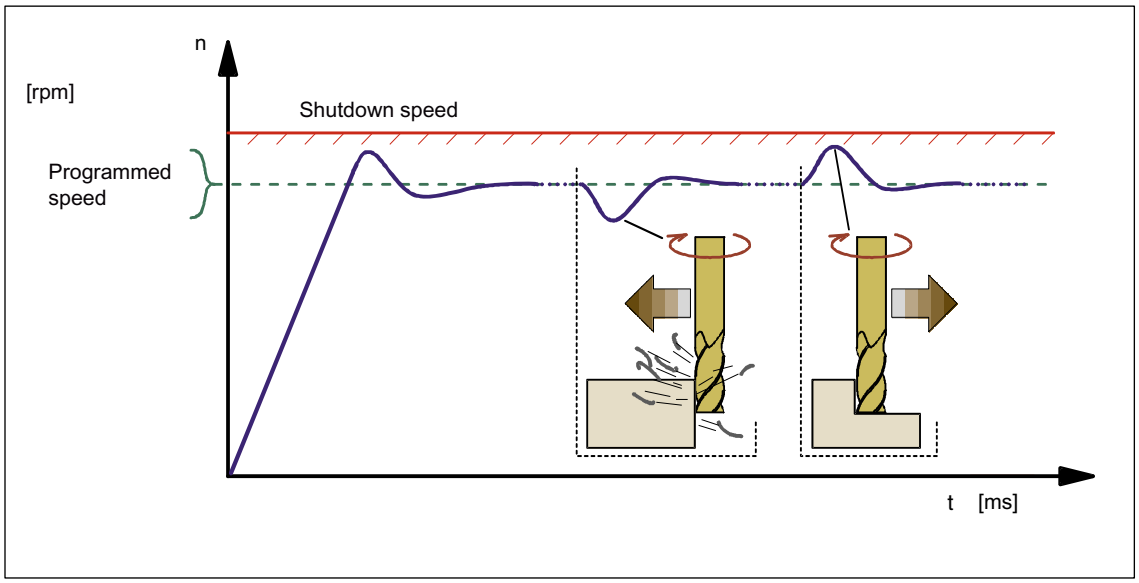


Figure 1-2 Control-related speed peaks

In order to ensure the appropriate degree of safety at all permitted operational speeds, the **speed peaks** must be taken into account when designing the machine (e.g. the natural resonance of the spindle support) and when selecting the tools.

This is the reason that the subjects relating to natural resonance and centrifugal force strength, discussed in Chapter Mechanical data (Page 37), do not refer to the speed programmed for normal operation, but always refer to the **shutdown speed** which is higher.

1.3 Responsibility for providing information to the company operating the machine

Some of the information provided in this Configuration Manual must also be communicated to the machinery construction company (OEM).

It is the clear responsibility of the machinery construction company (or the company which markets the machine) to communicate the appropriate information and instructions to the company actually operating the machinery. Refer to the following table for a summary.

Table 1- 6 Overview: Important information for the company operating the machine

Subject	Chapter
Instructing the company, operating the machine, about measures to detect and to avoid inadmissible speeds and their effects	Protection against potentially hazardous motion
Adapting the shutdown speed to the tool	Speed limits
In order to achieve the normal bearing lifetime, it is absolutely necessary that the air sealing system is correctly operated	Features and operating conditions
The necessity to check the bearing load	Load capacity of the spindle bearings
Reference to possible damage when overloading the bearings	Load capacity of the spindle bearings
Note regarding the highest programmable angular acceleration = (15000 rpm): 0.5 s	Maximum angular acceleration when the spindle is accelerating
Note that it is strictly forbidden to adjust the position of the clamping state sensors	Clamping system and tool change
Note on the preconditions that tools must fulfill for operation on the 2SP1 motor spindle	Tools
Reference to the potential hazards and potential damage when using tools which are not suitable	Tools

FAQ 2

2.1 What has to be observed after the equipment has been supplied?

⚠ CAUTION

1. Do not allow the crate containing the spindle to drop.
2. Do not allow the crate containing the spindle to topple over.
3. Always place the crate containing the spindle down horizontally.
4. Only lift the crate using suitable lifting equipment (fork-lift truck with the appropriate fork or crane).
5. The spindle may only be transported in the original crate.
6. When transporting the crate contained the spindle, always ensure that it is in a horizontal position.
7. After the spindle has been delivered, keep it in the closed packaging in which it was supplied (wooden crate/foil) in a dry and temperature-controlled room (10 °C to 35 °C).
8. Keep the packaging sealed until the spindle is just about to be installed in the machine.
9. You can stack a maximum of three crates on top of one another.

Figure 2-1 Transport crate in which the spindle is shipped

2.2 How is the shipment checked?

1. Place the crate containing the spindle down horizontally.
2. Remove the packaging straps using the appropriate metal shears.
3. Remove the crate cover (tools are not required).
4. Carefully open the foil.
5. Check the contents for completeness.
6. Check the contents for any transport damage.
7. Pack the spindle back into the foil.
8. Close the crate with the cover and store it (see Chapter What has to be observed after the equipment has been supplied? (Page 23)).

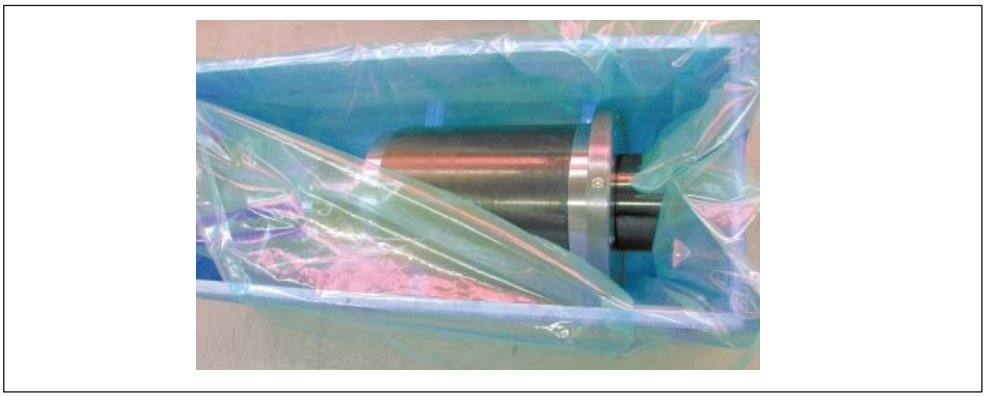


Figure 2-2 To check the shipment open the transport foil

2.3 How is the spindle unpacked?

1. Attach the eyebolts supplied (1) to the threads provided.
2. Attach the hoisting equipment to the eyebolts.
3. Lift out the spindle horizontally from the crate and place it down on wooden V-shaped blocks.

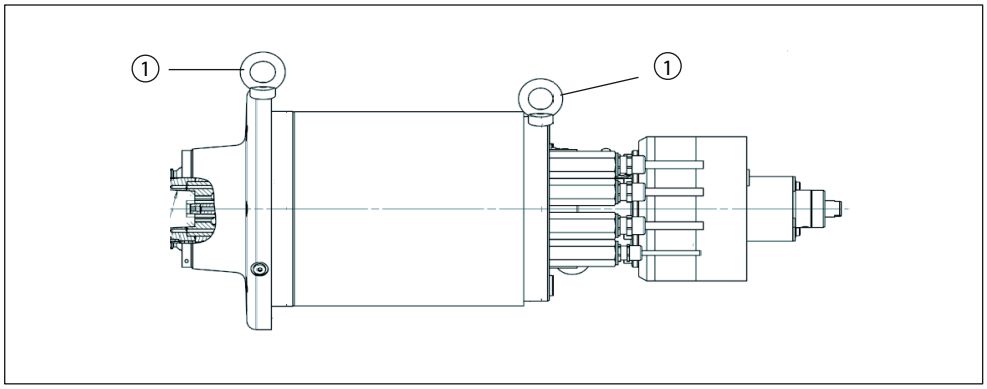


Figure 2-3 Attaching the eyebolts (1)

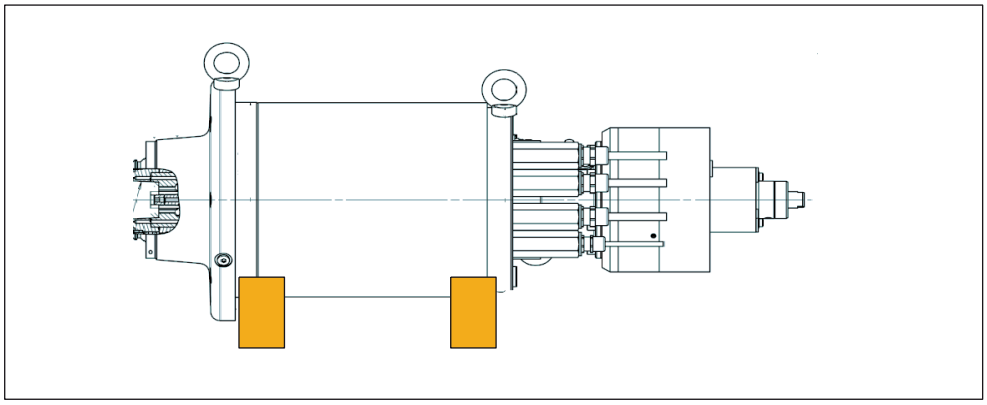


Figure 2-4 Locate the spindle on the wooden V-shaped blocks in a horizontal position

⚠ CAUTION
Do not lift the spindle using the shaft (this will damage the bearings).

2.4 How is the spindle placed down vertically?

1. Screw two eyebolts onto the bearing cover.
2. Cover the spindle head with a protective sleeve (for the spindle sleeve design, refer to Fig "Protective sleeve").
3. Attach the hoisting gear to the eyebolts at the bearing flange and lift carefully, see following diagram, Drawing A.
4. Carefully bring the spindle unit into the vertical position above the protective sleeve, see the following drawing B. Prevent it from slipping. When bringing the spindle into the vertical position, force must not be introduced into the shaft.
5. Set down the spindle unit with the protective sleeve in the vertical position, see following diagram, Drawing C.

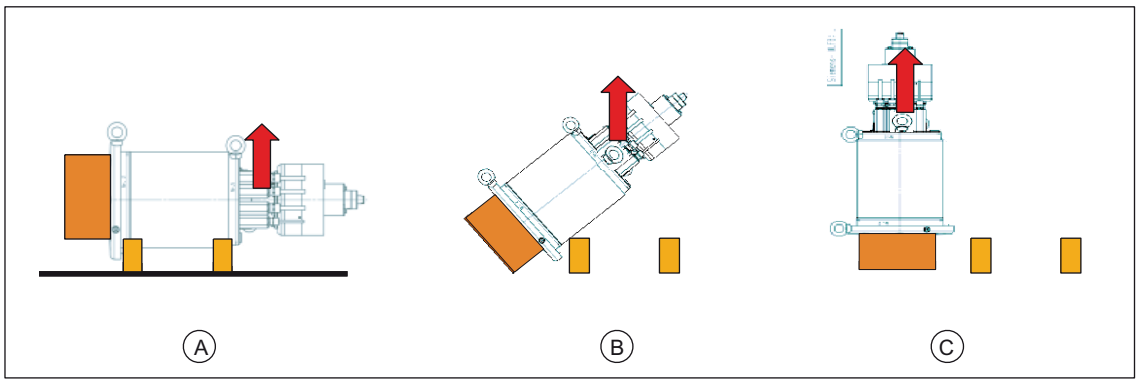


Figure 2-5 Bringing the spindle into the vertical position

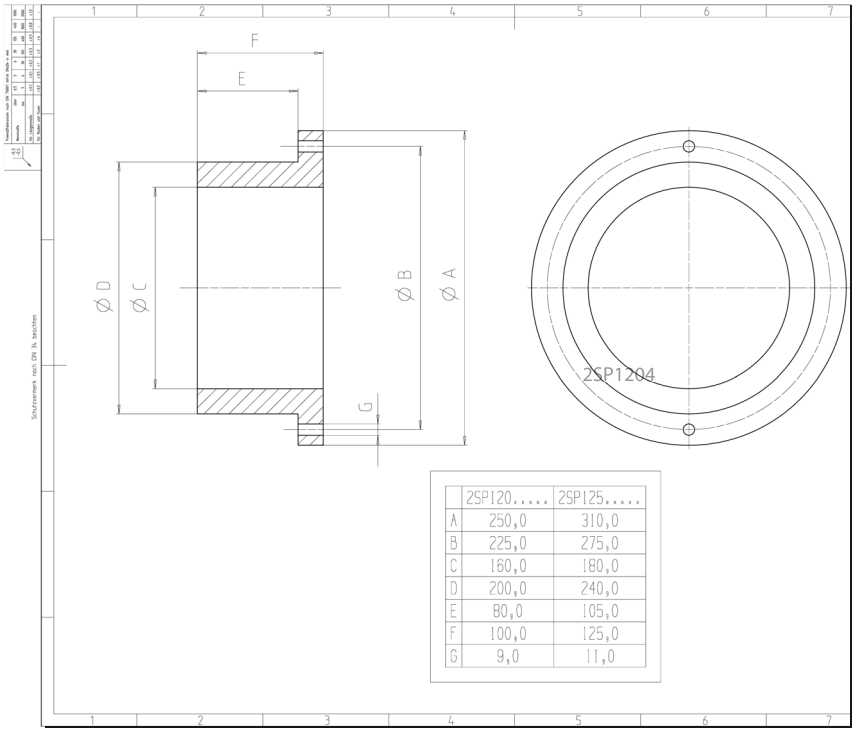


Figure 2-6 Protective sleeve

2.5 How is the spindle installed and mounted?

1. Prepare the installation location:
   - The installation location must be dry and dust-free
   - All of the required tools must be available and ready
   - Only use suitable tools
2. Attach the eyebolts to the threads provided.
3. Clean the spindle stem and slightly oil the jointing surfaces.
4. Horizontally/vertically install the spindle using the assembly equipment.

CAUTION
1. Use guide rods to secure and support. 2. When installing horizontally, also observe the alignment of the sealing air relief downwards. 3. Do not compress or crush the power cable. 4. Do not apply any constraining force when jointing (this could damage the bearings). 5. Tighten the flange retaining bolts with a tightening torque of 125 Nm.

2.6 What media need to be connected after installation?

- Fix the inlet/outlet hoses for the motor cooling. Observe the correct in/out assignment. The supply pressures and flow rates must be checked against the specifications.
- Connect the hose for the sealing air. Ensure that the supply pressure is correct.
- Fix the hoses for "release tool" and "clamp tool" (hydraulic or pneumatic). The supply pressures and flow rates must be checked against the specifications.

NOTICE
It is not permissible to close-off the "clamp tool" hole. Remove the plugs used when transporting.

- Connect the hose for the tool purge air. Ensure that the supply pressure is sufficient corresponding to the specifications.
- Connect the hose for the optional internal tool cooling. Observe the max. pressure specification, excess pressure will cause damage.
- Connect the hose for the optional external tool cooling. Observe the max. pressure specification, excess pressure will cause damage.
- For a detailed description, refer to Chapter Supplying the various media (Page 81).

2.7 What electrical connections need to be made after installation?

- Electrical connections may never be made with the system under voltage (i.e. when it is live).
- Connect the power cables corresponding to the UVW marking (refer to the electrical data).
- Connect the signal cable for the rotary encoder and motor temperature. Observe the coding to align the connector (refer to sensors). Joint connections must move easily.
- Connect the signal cables to the clamping status monitoring (observe the assignment of the sensors). Observe the coding to align the connector (refer to sensors). Joint connections must be easy to rotate.

2.8 What must be checked before the spindle is commissioned?

- Check that the shaft can be easily rotated by hand. For synchronous spindles, the slot notching (permanent magnet rotor) must be able to be felt.
- Check the setting dimension of the tool interface. For dimensions and settings please refer to the operating instructions.
- Check the tool pull-in force using the pull-in force measuring unit (e.g. OTT Power-Check, OTT-JAKOB Spanntechnik GmbH, http://www.ott-jakob.de). Pull-in forces, refer to the operating instructions.
- Check the switching logic for "clamp tool" and "release tool" (refer to the control). Checking the "clamped without tool" state: Function check with the tool removed. Check the function of the other clamping states using the pull-in force measuring unit ("0" setting value for OTT power check). Check the "draw bar in the release position" by manually releasing and making a function check at the sensor and the PLC.
- Check that the sealing air outlet is available at the sealing gap at the spindle nose.
- Check the tightness of the rotary gland before connecting/switching on the cooling lubricating medium using compressed air (air is discharged at the tool interface; no air is discharged at the leakage opening of the rotary gland). The check must be made in the "tool released" state.

2.9 What must be observed when starting to work with the spindle?

Starting work

1. Check the tool interface to ensure that it is clean and, if necessary, clean it.
2. Switch on the supply media (air, water).
3. When commissioning for the first time and when starting the machine from cold, observe the running-in and warm operating regulations, refer to Chapter Warming-up phase of the motor spindle (Page 46) or the operating instructions.

NOTICE
The spindle should already be in the warm operating state if the upper speed range is used.

Running-in the spindle after longer non-operational periods

See Chapter Warming-up phase of the motor spindle (Page 46) or the operating instructions.

Function of the spindle

3

Area of application

The 2SP1 motor spindle is a high-speed directly-driven tool spindle for milling and drilling operations.

Figure 3-1 2SP1 motor spindles

Features

The 2SP1 motor spindle is integrated in the SINAMICS drive system just the same as the feed and main spindle motors.

The drive motor and the tool adapter of the spindle form a mechanical unit which has a common bearing system. This eliminates all of the generally used mechanical transmission elements, such as belts or toothed couplings. Users have many advantages over conventional spindles with mechanical transmission elements due to the fact that the 2SP1 motor spindle has no mechanical transmission elements and has a compact design:

- **High speeds** because there are no mechanical transmission elements
- **Smooth running properties** as a result of the good balancing
- **Good speed stability**, good closed-loop speed control
- **High accuracy of the closed-loop position control**
- **Lower weight**, more compact dimensions
- **Lower mechanical design costs**, as all of the functions are integrated
- **High degree of compatibility to the electrical drive system** as the spindle, drive converter and NC are engineered and supplied from a single source

3.1 Overview of the functionality

The 2SP1 motor spindle is ready to be built-in – and the functions relevant for operating a milling spindle and for drilling are already completely integrated in the system. This guarantees perfect interaction of the individual function elements and minimizes the mechanical design costs for the machinery construction company (OEM).

Table 3- 1 Technical data

Function	2SP1202 2SP1204	2SP1253 2SP1255
Max. speed	15000 rpm	10000 rpm
Enclosure	Cartridge with flange mounting	Cartridge with flange mounting
Operating position	Horizontal/vertical	Horizontal/vertical
Tool adapter	HSK A63	SK 40 for tools with non-symmetrical T sliding blocks [T-slot stones]
Tool clamping device	• Released using a pneumatic cylinder, 6 bar • Clamped using a cup-spring assembly	• Released using a pneumatic cylinder, 6 bar • Clamped using a cup-spring assembly
Tool taper cleaning	Compressed air through the draw bar 5 ... 6 bar	Compressed air through the draw bar 5 ... 6 bar
Water cooling	• Max. 5 bar, 10 l/min • Max. 25 % anti-corrosion agent Clariant Antifrogen N or Tyfocor • Filter unit 100 µm	• Max. 5 bar, 10 l/min • Max. 25 % anti-corrosion agent Clariant Antifrogen N or Tyfocor • Filter unit 100 µm
Recommended coolant inlet temperature	Approx. 25 °C (depending on the ambient temperature)	Approx. 25 °C (depending on the ambient temperature)
Standard protection - temperature monitoring	• Motor thermal sensor KTY84-130 • PTC for full thermal protection • NTC PT3-51F • NTC K227	• Motor thermal sensor KTY84-130
Insulation of the stator winding according to EN 60034-1 (IEC 60034-1)	Temperature class 155 /F) for a coolant inlet temperature of 25 °C	Temperature class 155 /F) for a coolant inlet temperature of 25 °C
Degree of protection according to IEC 60034-5	IP64 (in the working range) IP53 (behind the spindle flange)	IP64 (in the working range) IP53 (behind the spindle flange)
Bearing lubrication	Maintenance-free, permanently lubricated	Maintenance-free, permanently lubricated
Bearing seal at the front	Sealing air 1 ... 1.5 m^3/h, filter mesh 8 µm	Sealing air 1 ... 1.5 m^3/h, filter mesh 8 µm
Encoder system	Hollow-shaft measuring system, incremental, sin/cos 1 Vpp (256 pulses/rev) with zero mark	Hollow-shaft measuring system, incremental, sin/cos 1 Vpp (256 pulses/rev) with zero mark

Function	2SP1202 2SP1204	2SP1253 2SP1255
Clamping status monitoring analog	• Tool clamped • Draw bar in the release position • Clamped without tool	---
Clamping status monitoring digital	• Position of release piston	• Tool clamped • Draw bar in the release position • Clamped without tool
Connections for the media • Cooling • Sealing air • Air purge • Release tool • Clamp tool	 • 2 x hose connector, ∅12/10 mm • 1 x G1/8" radial / ∅ 5 mm axial • 1 x G1/4" • 1 x G3/8" • 1 x G1/8"	 • 2 x G1/2" (∅ 9 mm) • 1 x G1/8" (∅ 8 mm) • 1 x G1/4" • 1 x M16 x 1.5 • 1 x G1/8"
Electrical connections	• Power via cable 1.5 m • Sensors via a signal connector	• Power via cable 1.5 m • Sensors via a signal connector

Table 3- 2 Technical data, options

Function	2SP1202 2SP1204	2SP1253 2SP1255
Increased max. speed	18,000 rpm	15,000 rpm (with HSK A63)
Internal tool cooling	• 50 bar, up to 54 l/min • Filter mesh 50 µm acc. to -/16/13/ ISO 4406 • 1 x G1/4" cooling-lubricating medium • 1 G1/8" leakage	• 50 bar, up to 54 l/min • Filter mesh 50 µm acc. to -/16/13/ ISO 4406 • 1 x G1/4" cooling-lubricating medium • 1 G1/8" leakage
External tool cooling	• Ring with 6 adjustable nozzles • 5 bar • Filter mesh 50 µm acc. to -/16/13/ ISO 4406	--
Tool clamping device	• Released using a hydraulic cylinder, 80 bar • Clamped using a cup-spring assembly • 1 x G1/4", release tool • 1 x G1/4", clamp tool	---
Tool interface	---	BT 40, CAT 40, HSK A63

3.2 Drive motor

An integrated built-in motor drives the 2SP1 motor spindle. This built-in motor has a high torque and its rotor is directly mounted onto the tool spindle. The electric power is only fed to the stationary outer jacket of the motor. The rotating inner part of the motor does not require any electrical power.

The motor spindles are available in various speed classes. They are designed for dynamic load operations and can quickly follow changing torque requirements.

Synchronous / induction motor

Depending on the frame size, the following motor versions are available:

- Motor spindle as synchronous motor
- Motor spindle as induction motor (option)
  - The induction motor version is prepared so that the torque can be adapted to the machining situation, for both the star and delta connection types. The company operating the spindle can select the connection type as required (refer to Chapter Installation conditions (Page 37).

Types of construction

The motor spindle is available in 2 types of construction in order to address various power requirements:

- Short design
- Long design

3.3 Cooling concept

2SP1 motor spindles have integrated ducts to liquid-cool the stationary stator of the drive motor. The stator that draws the electric drive power represents the main source of heat loss of the spindle unit. This is the reason that the cooling system is extremely closely coupled to the stator of the drive motor from a thermal standpoint. However, the sources of power losses that are some distance away are also adequately cooled as a result of the integrated cooling ducts.

The spindle unit must be supplied with the cooling medium through a feed and return line. The coolant absorbs the heat loss of the spindle and as a result, its temperature increases. The coolant is cooled-down to the original intake temperature outside the spindle using an external cooling or heat exchanger system. The cooling or heat exchanger system is the responsibility of the machinery construction OEM. A pump must be used to provide the necessary cooling pressure in the inlet line. This external pump is also the responsibility of the machinery construction company.

Refer to Chapter Cooling medium (Page 82) for detailed basic data required to dimension and design the coolant supply.

3.4 Supply

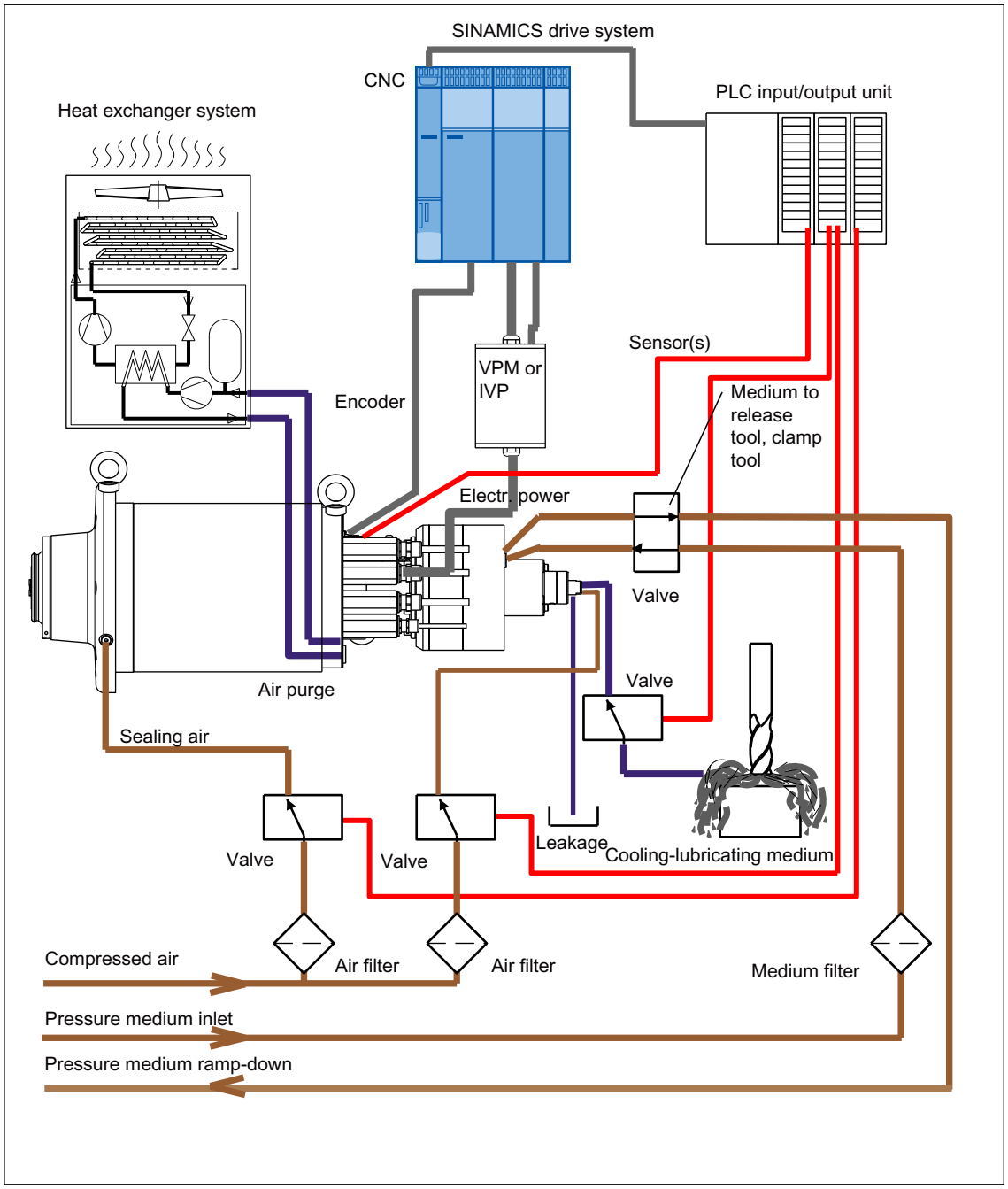


Figure 3-2 Supplying the spindle

2SP1 motor spindles have integrated function elements to operate and control the various operations and sequences. The following media must be provided for the spindle, either through suitable cables or hoses:

- **Electric power** for the **drive motor** (the consumption depends on the power)
- **Cooling liquid** (continuous flow; load depends on the load)
- **Compressed air or hydraulic oil** to actuate the tool clamping system – depending on the release unit type, either pneumatically or hydraulically operated (media only flows when releasing and clamping the tool)
- **Air purge** to clean the tool cone (this air is only used when releasing and ejecting the tool)
- **Sealing air** to protect the bearings from dirt accumulating (this air is continually used)
- **Optional cooling-lubricating medium supply** for internal tool cooling (the flow depends on the actual process)
- **Optional cooling-lubricating medium supply** for external tool cooling (the flow depends on the actual process)
- **24 V electrical supply** for the sensors to monitor the tool clamping state (power is continually drawn)
- **Power supply** for the **rotary encoder** (for SIEMENS drive converters, this is integrated in the encoder interface)

The requirements regarding the conditioning of the various media, and which are required to design and dimension the various units and equipment, are described in detail in Chapter Supplying the various media (Page 81) and Chapter Technical data and characteristics (Page 139).

Mechanical data

4

2SP1 motor spindles allow operating companies to fully utilize the benefits of high-speed machining. At high speeds, the components involved in the machining operation are subject to significant levels of stress. This means that the machine must be mechanically designed to withstand the high speeds and the user must coordinate the tools and the process conditions with the load capability of the spindle.

4.1 Observing the shutdown speed

Even if the critical speed is briefly exceeded, the following can occur:

- Vibration of the spindle carrier (support structure)
- The centrifugal strength of the tools can be exceeded
- Damage due to mechanical overload

⚠ CAUTION
The **shutdown speed** should be used **as basis for load assumptions and strength requirements.** It is not permissible to use the speed which can be programmed for operation (refer to Chapter Speed limits (Page 18)).

4.2 Installation conditions

The spindle is integrated into the machine assembly as a complete unit. The static and especially the dynamic properties are obtained from the interaction between the spindle itself and the spindle carrier of the machine.

Degree of protection

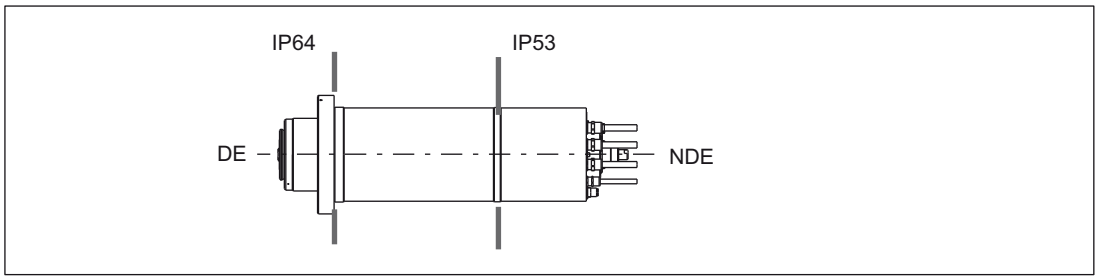


Figure 4-1 Degree of protection of the 2SP120 spindle

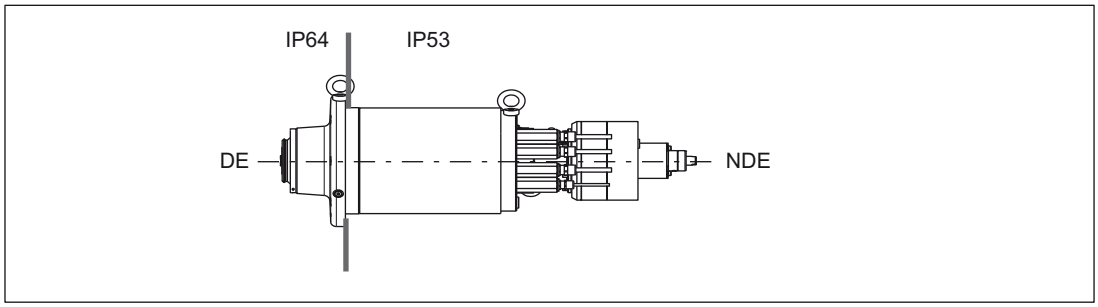


Figure 4-2 Degree of protection of the 2SP125 spindle

CAUTION
The degree of protection refers to the ingress of water (DIN ISO EN 60034, Part 10). Cooling-lubricating mediums that contain oil, can creep and/or are aggressive, can penetrate more than water.

Table 4- 1 Degree of protection in front of and behind the mounting flange

	In front of the mounting flange (DE)	Behind the mounting flange (NDE)
Degree of protection	IP64	IP53
Description	At the drive end, the spindle has a labyrinth seal and a connection for the sealing air. This protects the spindle against the ingress of water spray and dirt. It is not permissible that cooling water acts directly on the labyrinth seal. The specifications for the sealing air must be carefully observed, refer to Chapter Using compressed air (Page 86).	The spindle support design must guarantee suitable protection behind the mounting flange against the effects from the machining area.

Installing the spindle

The spindle must be installed in the machine so that liquids and dirt in the form of dust from the machining area cannot be permanently deposited on the spindle.

CAUTION
It is not permissible that spray water or other liquids are directly pointed at the sealing gap (labyrinth seal) or openings in the spindle (refer to the following diagram). It is not permissible that foreign bodies are drawn through the spindle. This is the reason that it is not permissible to have a pressure difference between the drive and drive-out sides.

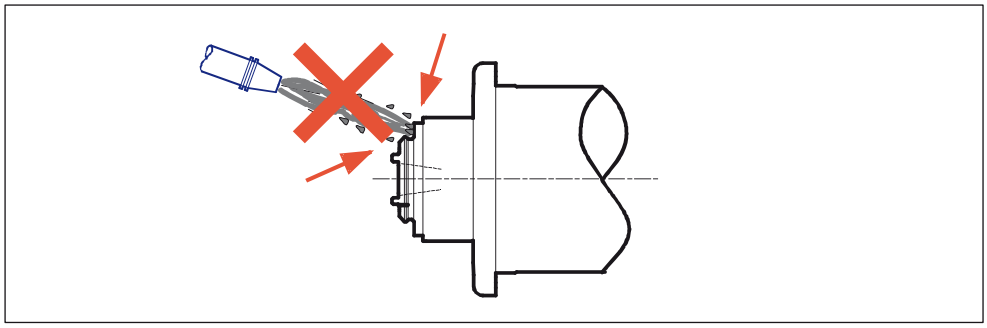


Figure 4-3 The jet of cooling-lubricating medium may not be directly aimed at the labyrinth seal

NOTICE

Horizontal installation

When the spindle is mounted horizontally, the relief (compensating) holes for the sealing air, located at the spindle nose, must face downwards.

Orientation help: The position of the eyebolt thread, located at the retaining flange, when viewing the nose of the spindle from the front, must be inclined at a certain angle to the right (refer to the following two diagrams).

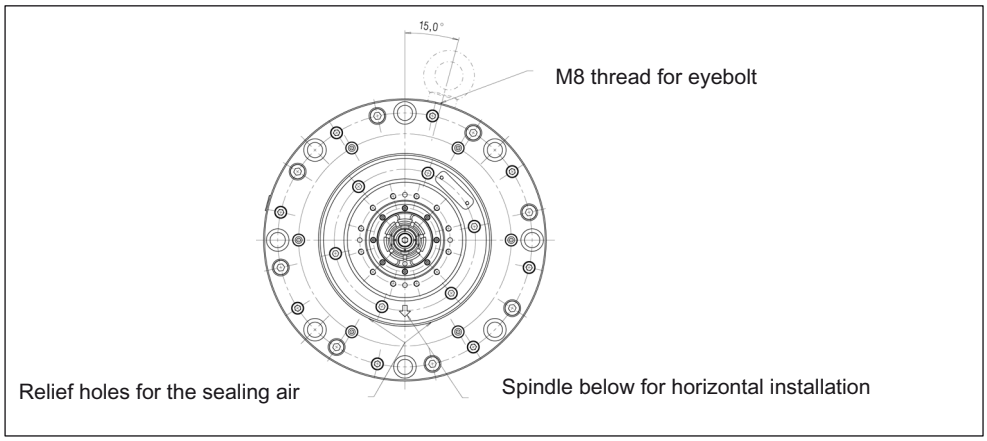


Figure 4-4 Installation position of the 2SP120x spindle

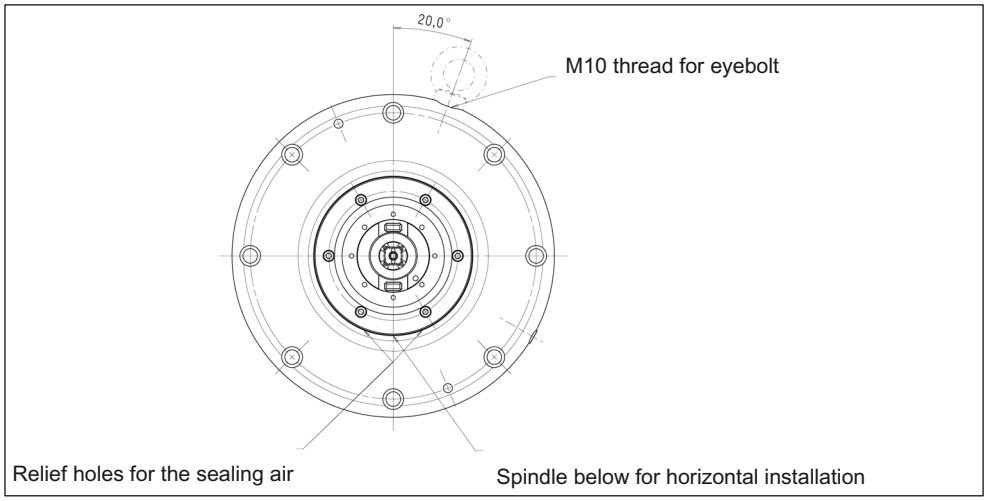


Figure 4-5 Installation position of the 2SP125x spindle

The spindle must be mounted so that the motor spindle is not subject to any compulsive forces. If the housing is subject to tension, this can result in a slight deformation and an increased stress on the roller bearings. This will have a negative impact on the smooth running characteristics, operating temperature and therefore the lifetime.

Axial holes (on the rear bearing cover) and radial holes (on the flange and at the rear bearing cover) are provided on the spindle for eyebolts, which are used when the spindle is installed.

4.2.1 Mechanical requirements placed on the spindle support

Load situation of the spindle support

The spindle is subject to an alternating force caused by the residual imbalance of the shaft and the tool. The residual imbalance transfers tilting and lateral forces to the spindle mounting flange so that in the principle, the following associated vibration types can be excited (see the diagram below):

- Tilting vibration (NDE swivels with respect to the DE)
- Lateral vibration (lateral movement of the spindle)

The forces excited by the residual imbalance increase with speed.

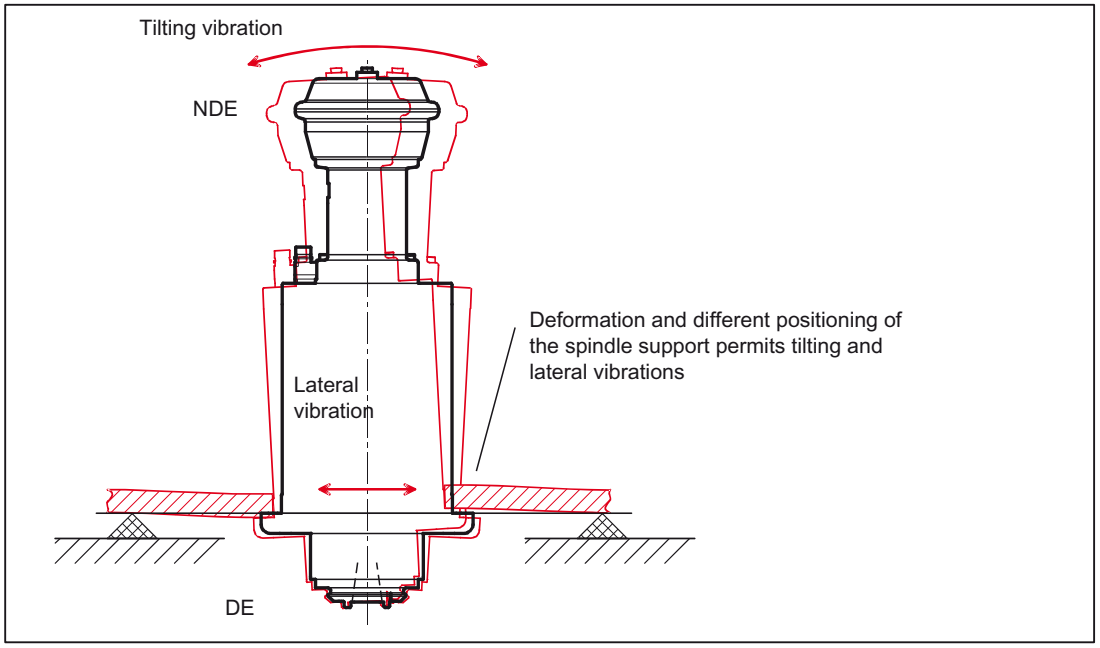


Figure 4-6 Types of vibration which can be excited due to imbalance

The alternating stressing frequency precisely corresponds to the rotating frequency of the spindle.

$f = 1\ min/60s \cdot N$

With f: exciting frequency in [Hz], N: speed in rpm

Vibrational behavior: Mechanical design requirements placed on the spindle support

The spindle support must have a stiff design so that no natural resonance points of the appropriate vibration types can be generated over the complete speed range up to the shutdown speed. **The lowest resonant frequency must lie above the rotating frequency of the shutdown speed which can be excited by an imbalance condition.** In this frequency range, the spindle support must be able to absorb the tilting and lateral forces caused by the residual imbalance, without being deformed.

At the front (DE), the spindle is connected to the machine assembly through the mounting flange. This must be taken into account in the mechanical design of the spindle support, especially when it comes to suppressing the tilting vibration of the rear (NDE) end of the spindle, which is relatively far away from the mounting flange.

Notes regarding the design of the spindle support

The following points should be carefully observed when designing the spindle support to accept the motor spindle:

- **Material thickness**

  The area of fit around the mounting flange is extremely important due to the high force density required to counteract the tilting vibration. The material thickness and strength must be adequately dimensioned.

- **Lateral stability of the flange plane**

  The plane of the mounting flange must be embedded so stiffly in the machine that in the frequency range up to the shutdown speed, no vibrational types are possible with lateral movement of the mounting flange. Designs, where the plane of the mounting flange is located far beyond the plane of the guide element of the spindle slide, are especially critical when it comes to a shift in the flange plane due to torsional rotation and deformation of the spindle support.

- **Observe the fit and tolerance**

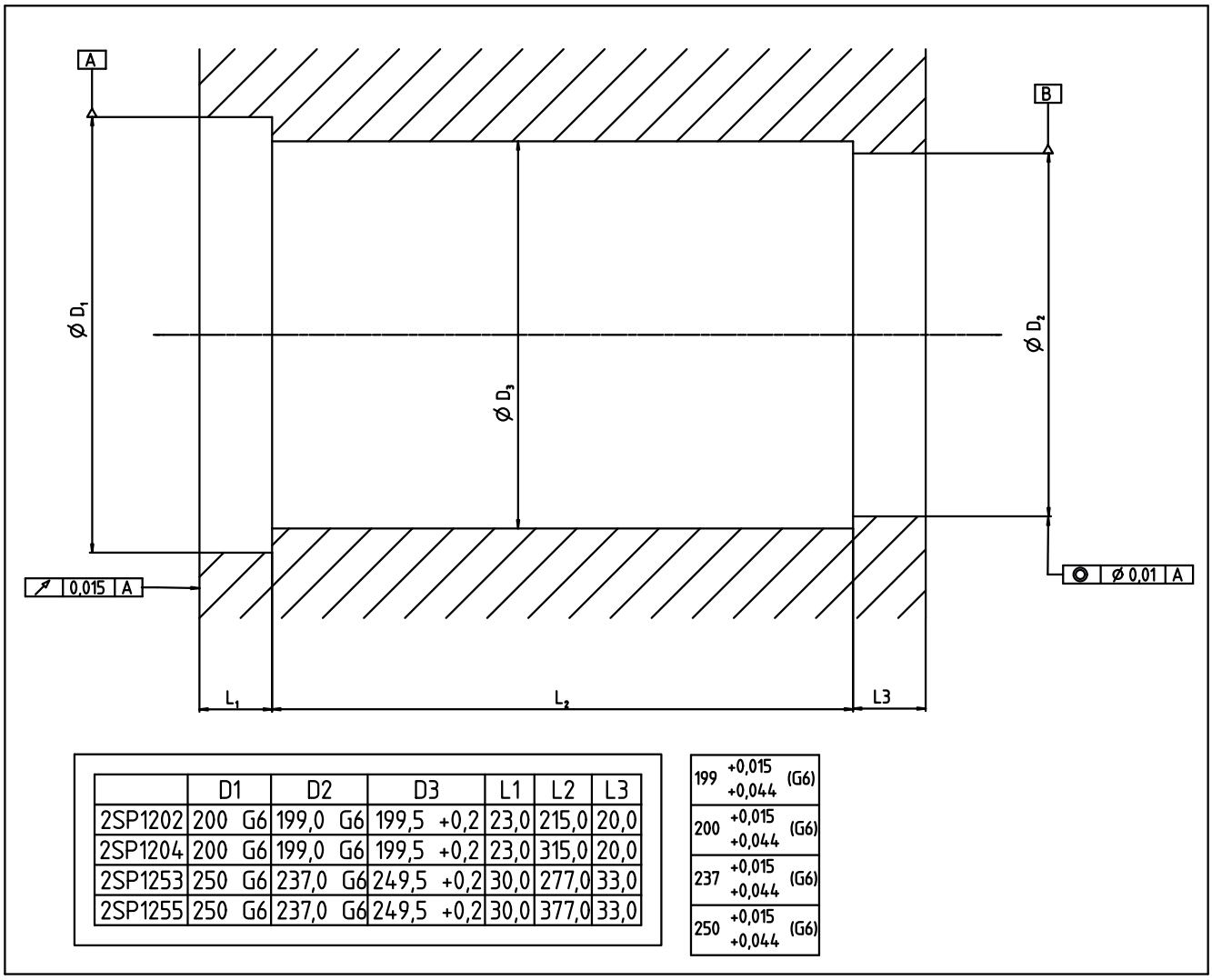
  The mounting flange of the spindle must have a geometrically precise fit in the spindle support and should be as dynamically stiff as possible. The design (shape) and the tolerances to accept the mounting flange, which are documented in the drawings, must be precisely maintained. For dimension drawings, see Chapter Technical data and characteristics. For the recommended tolerance for the spindle support, see the diagram "Installing the spindle in the spindle support".

- **Bracing the spindle support using guide elements**

  The guide elements (linear guides) which brace the spindle support with respect to the machine bed, should provide an adequately wide basis to brace against tilting vibration (see the diagram "Example: Tilting vibration for extended spindle mounting").

- **Short length for extended spindle mounting**

  The resonant frequency for an extended spindle mounting can reduce the resonant frequency of tilting vibration in an undesirable way (see the diagram "Example: Tilting vibration for extended spindle mounting"). This means that the length which extends between the spindle mounting flange and the point where the spindle support is retained at the machine bed should be kept as short as possible. This is also the reason that the spindle support should not have a high mass close to the flange plane which does not directly serve to make the support assembly stiff.



	D1	D2	D3	L1	L2	L3
2SP1202	200 G6	199,0 G6	199,5 +0,2	23,0	215,0	20,0
2SP1204	200 G6	199,0 G6	199,5 +0,2	23,0	315,0	20,0
2SP1253	250 G6	237,0 G6	249,5 +0,2	30,0	277,0	33,0
2SP1255	250 G6	237,0 G6	249,5 +0,2	30,0	377,0	33,0

199	+0,015 +0,044	(G6)
200	+0,015 +0,044	(G6)
237	+0,015 +0,044	(G6)
250	+0,015 +0,044	(G6)

Figure 4-7 Installing the spindle in the spindle support

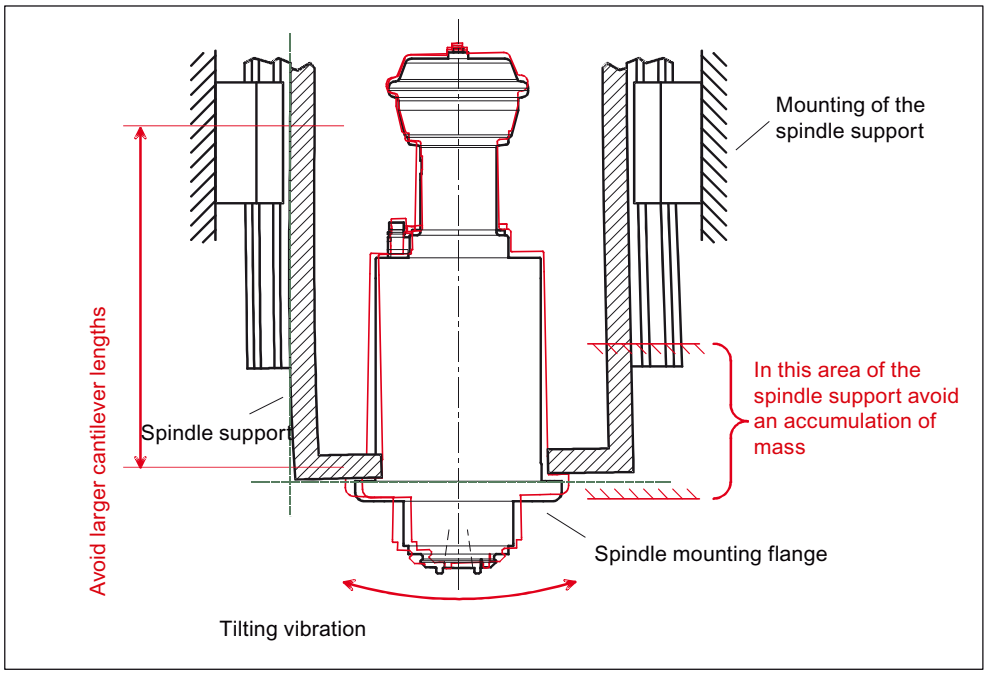


Figure 4-8 Example: Tilting vibration for extended spindle mounting

- **Mechanical bracing for unsupported lengths**

  Longer unsupported lengths should be avoided. If the spindle mounting flange is extended, then appropriate ribs and transverse reinforcing elements should be used. These reinforcing measures should be designed so that they counteract any tilting vibration (see diagram "Types of vibration that can be excited due to imbalance").

- **No additional components *mounted directly* on the spindle**

  In order that the natural frequency of the tilting vibration is not undesirably reduced, it is not permissible to mount or anchor any components *directly* on the spindle. For example, connecting strain relief elements for drag cables.

Numerical techniques, such as the FEM-based modal analysis have proven themselves to be helpful when evaluating a mechanical design regarding its vibrational characteristics. For additional support, please contact your local Siemens office.

4.2.2 Support at the NDE

2SP1 motor spindles are available in several power classes. For the high-speed versions with high torques, an additional direct mechanical support between the NDE and the spindle support is required.

Refer to Chapter Technical data and characteristics (Page 139), Table "Geometrical data for 2SP120x" and "Geometrical data for 2SP125x" for the spindle types where support at the NDE is specified.

Function of the support

The direct support between the NDE and the spindle support has the function to stabilize the spindle against tilting vibration so that **the lowest resonance frequency lies above the rotational frequency of the shutdown speed.**

Properties and characteristics of the support

The support design must therefore be as stiff as possible to counteract the tilting vibration shown in Fig. "Example: Tilting vibration for an extended spindle flange". Furthermore, the support close to the NDE should have a lightweight design. An increase of the effective spindle weight at the NDE increases the moment of inertia of the tilting vibration and therefore undesirably reduces the resonance frequency. FEM-supported modal analysis can help to evaluate the mechanical design.

4.3 Spindle bearings

The 2SP1 motor spindle shaft runs in high-precision spindle bearings. They offer excellent precision and are designed for the loads that occur at high speeds. Hybrid bearings are used for spindle types that operate at even higher speeds.

Special significance was placed on the ruggedness of the bearings. They have proven themselves over many years in applications - from JobShop environments up to three-shift operations in series production.

4.3.1 Features and operating conditions

The high precision spindle bearings accept the radial and axial forces from the process without any play. Thermal loading of the spindle shaft has no effect on the mechanical tension. The bearings have excellent smoothing running characteristics and the lowest level of roughness.

Radial eccentricity (run-out) at the tool adapter, refer to Chapter Technical data and characteristics (Page 139).

The spindle's own sealing air system

The bearings are equipped with an integrated seal. At the DE of the spindle, the seal to the working area is supported using the spindle's own sealing air system, see Chapter Supplying the various media (Page 81).

NOTICE
In order to achieve the specified bearing lifetime, it is absolutely necessary that the sealing air system operates correctly. The machinery construction company is responsible in explaining this to the company operating the spindle.

Bearing lubrication

The bearings of 2SP1 motor spindles have permanent grease lubrication. This is the reason that they are maintenance-free. A re-lubrication device is not required.

NOTICE
The permanent grease lubrication must not be negatively influenced or polluted by other materials and substances.

4.3.2 Warming-up phase of the motor spindle

Warming-up phase of the motor spindle (temperature distribution)

An uneven temperature distribution can have a negative impact on the bearing lifetime.

When commissioning for the first time and when starting the machine from cold, the run-in and warming-up specifications (also see the operating instructions) must be observed.

NOTICE
The spindle should already be in the warm operating state if the upper speed range is used.

Table 4- 2 Warming-up phase of the motor spindle

Speed	Operating time
25% of the maximum speed	2 min.
50 % of the maximum speed	2 min.
75 % of the maximum speed	2 min.
	Ready for operation

The machinery construction company can include a motor spindle warm-up cycle in the operating control software.

Longer periods of time where the spindle is not operational (spindle running-in)

NOTICE
A spindle must be run-in if it has not been used for more than one week.

Table 4- 3 Running-in the spindle after longer non-operational periods

Speed	Operating time
25% of the maximum speed	5 min.
50 % of the maximum speed	5 min.
75 % of the maximum speed	5 min.
	Ready for operation

Longer storage times

NOTICE
If the motor spindle has been stored for longer periods of time, the procedure for storing spindles, described in the operating instructions, must be carefully observed.

4.3.3 Load capacity of the spindle bearings

Bearing overload

NOTICE
High-speed bearings are sensitive to overload conditions. **This is the reason that in operation and at standstill, overload conditions must be avoided.**

Table 4- 4 Possible damage due to bearing overload and how it is avoided

Overload situation	Damage	Possibilities of avoiding an overload situation
Applying force when assembling and disassembling	Immediate bearing damage	Machinery construction company and operating company: • Assembly forces must not be applied to the spindle shaft and therefore to the bearings. The operating instructions must be carefully observed. Machine manufacturer: • Design the space in which the spindle is to be mounted so that it can be easily accessed • Provide equipment for assembly and disassembly • Provide the operating company with the appropriate mounting/installation equipment and resources
The effect of force due to a collision	The bearings are immediately damaged or the bearing lifetime is significantly reduced	Operating company: • Check new workpiece programs using a slow path velocity • Visualize the programmed tool paths on the control side
Overload when a tool breaks	The bearing lifetime is reduced	Operating company: • When a tool breaks, the spindle should be quickly brought to a standstill

The machinery construction company (OEM) is responsible in informing the operating company about potential damage if the spindle is overloaded.

4.3.4 Lifetime of the spindle bearings

Grease lifetime

In many applications, the grease lifetime is, with respect to the fatigue lifetime, the decisive factor which has to be taken into account therefore determining the spindle bearing lifetime. The grease lifetime decreases with increasing speed (refer to the following diagram).

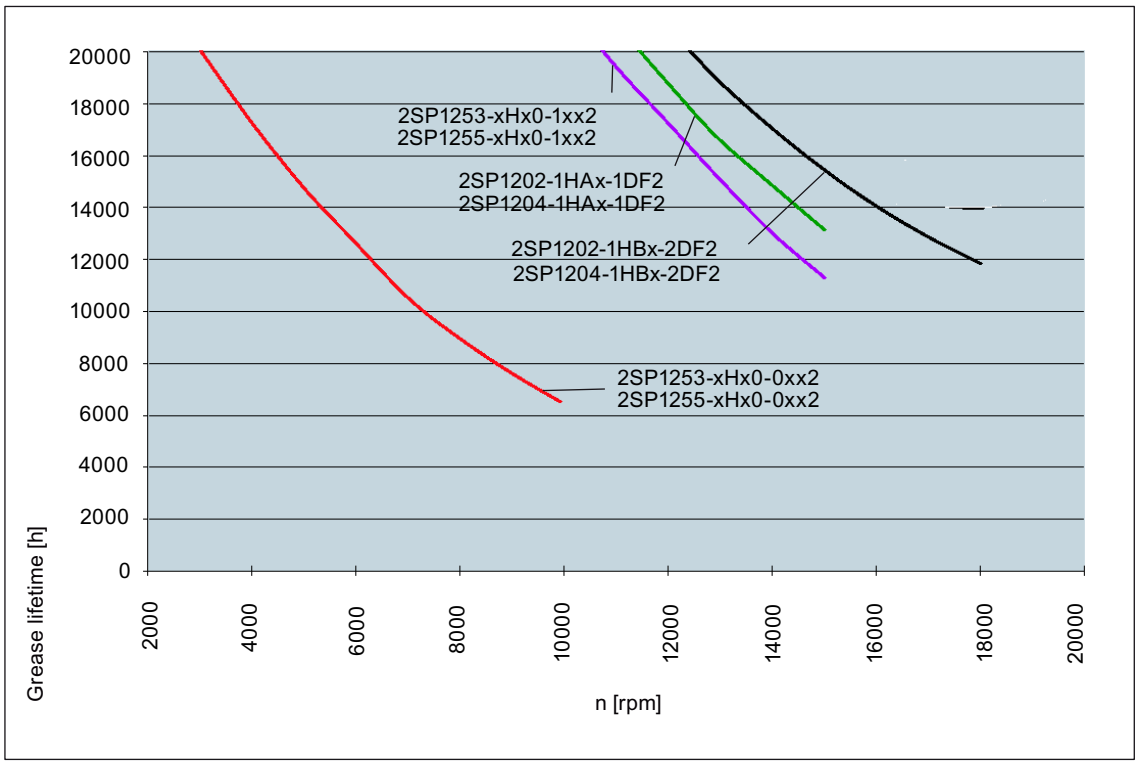


Figure 4-9 Grease lifetime

A prerequisite for reaching the specified grease lifetime is that the permitted bearing temperatures are maintained.

The following must therefore be observed:

- The spindle cooling must be operated in compliance with the specifications
- It is not permissible that the bearing load is exceeded
- The maximum permissible ambient temperature in the operating state must not be exceeded

Table 4- 5 Determining the probable grease lifetime

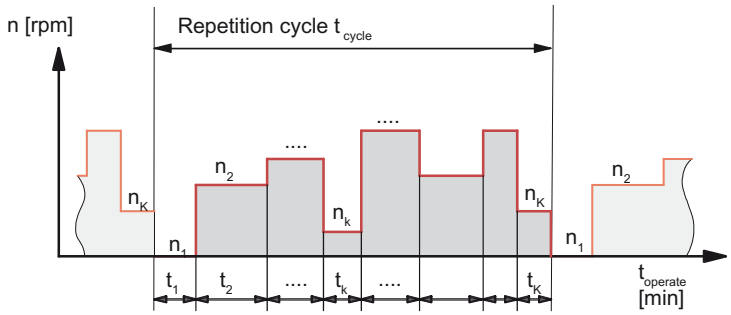
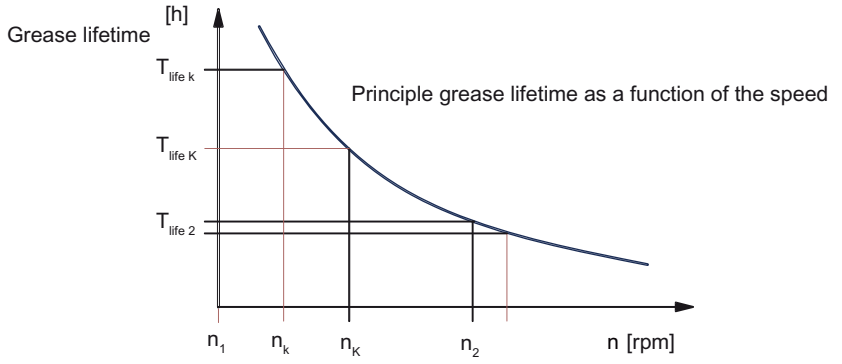
Sequence	Description, formulas
1. Subdivide spindle operation into constant speed phases	
1. Determine the relative duration of the speed phases (relative proportion of the time in the cycle)	$t_{rel\,k} = \frac{t_k}{t_{cycle}}$
1. Determine the individual grease lifetime $T_{use\,k}$ of the individual phases	
1. The individual lifetimes are added in a weighted fashion to obtain the overall grease lifetime	$T_{use\,total} = \frac{1}{\frac{t_{rel\,1}}{T_{life\,1}} + \frac{t_{rel\,2}}{T_{life\,2}} + \ldots + \frac{t_{rel\,k}}{T_{life\,k}} + \ldots + \frac{t_{rel\,k}}{T_{life\,k}}}$

Table 4- 6 Explanations

t_{cycle}	Cycle time
$t_{operate}$	Operating time
t_{rel}	Relative duration of a speed phase
$T_{life\,total}$	Total lifetime
T_{life}	Lifetime of a phase

4.3.5 Maximum angular acceleration when the spindle is accelerating

For extreme rates of angular acceleration and extremely short accelerating times, the rollers of the spindle bearings can slide rather than rotate. This has a negative impact on the bearing lifetime and must be avoided. The acceleration programmed for spindle acceleration (and also braking) must be selected so that as a maximum, it corresponds to an angular acceleration of 15,000 rpm in 0.5 s.

$\dot{N} \leq \frac{15000\ \text{rpm}}{0.5\ \text{s}}$ $\dot{N}$: programmed angular acceleration

The machinery construction company is responsible in clearly informing the operating company that higher levels of angular acceleration must not be programmed.

4.3.6 Stiffness

The mechanical stiffness at the tool adapter with respect to radial and axial forces is documented in the data sheets, Chapter Technical data and characteristics (Page 139). The natural bending of the tool additionally shifts the cutting edge if radial forces are present. For narrow profile tools, the natural bending of the tool is significantly greater than the shift of the tool adapter.

4.3.7 Axial shaft growth

The spindle shaft is subject to a geometrical shift in the axial direction. This shift is known as shaft growth.

The shaft growth comprises the following elements:

- Thermally-related shaft growth
- Speed-related shaft growth

The shaft growth is independent of the tool being used.

Thermally-related shaft growth

In the thermal stabilization phase, while the spindle warms up, the spindle shaft temperature increases up to its steady-state condition. This means that during this thermal stabilization phase, the tool adapter shifts forward (due to thermal expansion). After the warm-up phase has been completed, the spindle shaft essentially has a constant operating temperature so that the tool adapter no longer moves as a result of thermal expansion.

Speed-related shaft growth

Due to the geometrical arrangement of the roller bearing assemblies, the rolling bearing contact point shifts in the bearing ring as a function of the speed. This causes the tool adapter to shift forward. This shift is a function of the speed and increases with increasing speed. This shift reverses as the speed decreases.

When required, this shaft growth can be equalized by correcting the Z axis. We recommend that the thermally-related shaft growth and the speed-related shaft growth are determined by machining sample workpieces. The appropriate correction tables can then be drawn-up for the Z axis position.

4.4 Tools and tool adapters

4.4.1 Tools

The interaction between the motor spindle and the tools which are used has a decisive influence on the productivity and quality of the machining operation. When selecting the appropriate tools, the safety information and instructions relating to high speeds must be carefully observed.

As a result of the high speed, 2SP1 motors spindles allow excellent surface qualities and high productivity to be achieved. However, when incorrectly used, the high speeds can also represent potential risks and significant wear. It is especially important that the tools are carefully selected.

Only use tools that are in a perfect condition

The following properties in operation are only achieved when tools, which must be in a perfect condition, are correctly used:

- Perfect machining results
- Low vibration levels
- Low wear of the spindle bearings
- Low noise emission
- Safety of operating personnel and the machine

This is the reason that it must always be ensured that only tools in a perfect condition are in the tool magazine – and that these tools were checked to ensure that they are suitable for operation with the particular spindle. The machinery construction company is responsible in clearly informing the operating company about the potential danger and damage of using unsuitable tools.

Prerequisites for tools

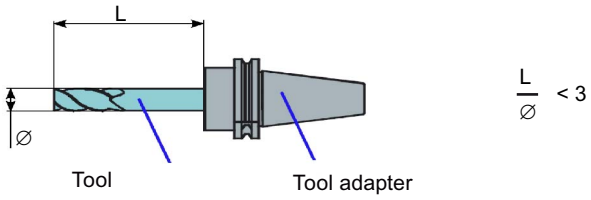
The tools must fulfill the following prerequisites:

1. The tool must be **released/certified** for high speeds and centrifugal forces.
2. It is not permissible that the tool reduces the **natural frequency** of the spindle unit to below the critical rotating frequency.
3. The **cutting forces** and the intrinsic weight of the tool may not overload the bearings.
4. Ratio between the length and diameter not greater than 3:1.
5. The tool must be perfectly **balanced**.

For a detailed description of the specified prerequisites, refer to the following table.

Table 4- 7 Prerequisites for tools

	Description
High speeds and centrifugal forces	Depending on the tool diameter, at high speeds, extremely high centrifugal forces occur at the tool. Only those tools may be used, without any restrictions, whose permitted speed lies above the shutdown speed of the spindle. If a tool breaks at high speed, parts will be flung-out at a high velocity and can cause significant damage. Example: If a piece of a tool having a radius of 40 mm and a speed of 10,000 rpm is flung-out, then this reaches a velocity of 150 km/h. **Using tools with the permitted speed < the shutdown speed** The following conditions must be observed: • Speed monitoring (refer to Chapter Speed limits (Page 18)) The threshold of the shutdown speed must lie below the permitted maximum tool speed. If various shutdown speeds are used for different tools, then these must be matched to the tool using the Tool Manager. For example, the speed monitoring function can be implemented by defining gear stages (refer to Chapter Safety instructions (Page 15)). • Limiting the programmable speed (refer to Chapter Speed limits (Page 18)) The programmable maximum operating speed must lie at least 5 % below the shutdown speed.

	Description
Do not allow the natural frequency of the spindle unit to drop below the critical rotational frequency	The resonant frequencies of the spindle support and spindle must always lie above the speed permitted for the particular tool. As a result of a clamped tool, resonant frequencies can be noticeably and undesirably reduced. The danger associated with reducing the resonant frequencies is especially critical for: • Long tools • Heavy tools • Tools with a large radius Generally, the best smooth running characteristics are achieved when short tools are used; these result in lower bearing stressing. This means that the tools must be clamped so that their effective length is as short as possible. The spindle manufacturer cannot define generally applicable limit data for tools. The reason for this is that the resonant frequencies of the spindle support and spindle are not determined just by the spindle alone, but mainly how the spindle is actually mounted in a mechanical assembly. The machinery construction company (OEM), which is responsible for mounting/installing the spindle, is responsible in providing the operating company with information and data about the permissible range of dimensions and weights of tools. In principle, an acceleration test with the tool to be tested provides useful data. In this case, the tool is slowly accelerated up to the maximum permissible speed and is kept at a high speed for approximately one minute. The accelerating ramp should be slow. If the spindle runs smoothly without any vibration during the acceleration phase and at the maximum speed, then the tool can be released for operation. If a significant amount of noise or vibration occurs while the tool is being accelerated or at maximum speed, the acceleration test should be immediately stopped and the tool being tested should be classified as unsuitable or "not released for a specific speed".
Cutting forces and own weight	A worn cutting edge can cause the cutting force to be increased a multiple number of times. This not only has a negative impact on the machining process but also on the bearing lifetime as the permissible bearing loads are exceeded. We therefore recommend that the condition of the cutting edge is continually monitored.
Ratio between the length and diameter	Tools should be used where the ratio between L and diameter ∅ does not exceed a value of 3:1 and where the total weight of the tool insert lies below 4.5 kg. The spindles are designed so that with these tools, the critical speeds lie above the maximum spindle speed. If tools are used whose dimensions deviate from this data, then the speed should be calculated. In addition to the speed being limited by the critical speeds of the spindle/tool system, attention must also be paid to the fact that the technological data of the machining process could limit the speed. 

	Description
Balancing	Only precision-balanced tools in compliance with Q 6.3 may be used. Standards to be complied with: • VDI Directive 2056 • DIN EN ISO 15641 **Caution:** **The system must be balanced after inserting a tool insert in the tool holder. It is not permissible to individually balance the tool insert and tool holder without balancing the complete assembly.** Tool wear can have a noticeable and negative impact on the balance quality. If vibration and noise levels increase while the tool is being used, then the tool should be checked for wear and then carefully re-balanced.

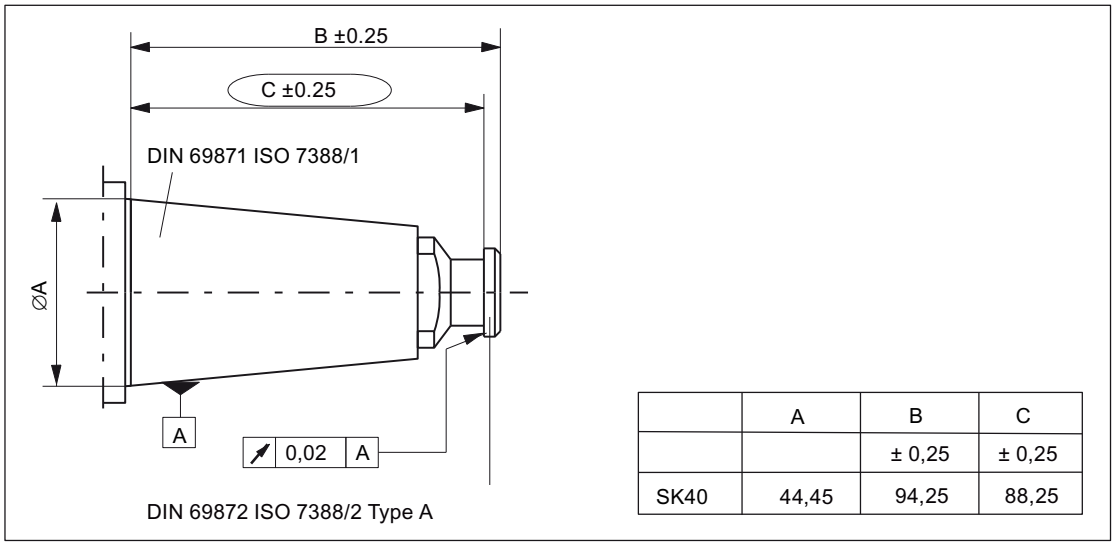
4.4.2 Tool adapters

2SP1 motor spindles are available with several tool adapters.

Table 4- 8 Tool adapters

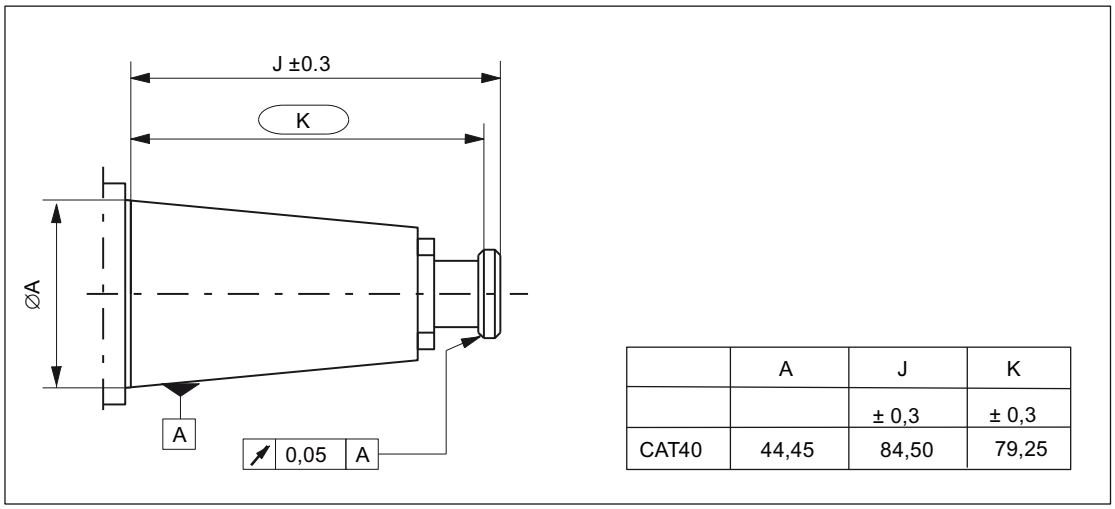
Type	Standard	for speed	Comments
SK40 - non-symmetrical	DIN 69872, ISO 7388/1/2 Type A	≤10000 rpm	2SP125
CAT40 - non-symmetrical	ANSI B5.50-78, ISO 7388/1/2 Type B	≤10000 rpm	2SP125
BT 40 - non-symmetrical BT/PT 30°	MAS 403-1982, BT/PT30 ° Version E1	≤10000 rpm	2SP125
BT 40 - non-symmetrical BT/PT 45 °	MAS 403-1982 BT/PT45 ° Version F1	≤10000 rpm	2SP125
HSK A63	DIN 69893-1, ISO 12164-1	≤18000 rpm ≤15000 rpm	2SP120 2SP125

Drawings, dimension tables and tolerance data, refer to Chapter Technical data and characteristics (Page 139).



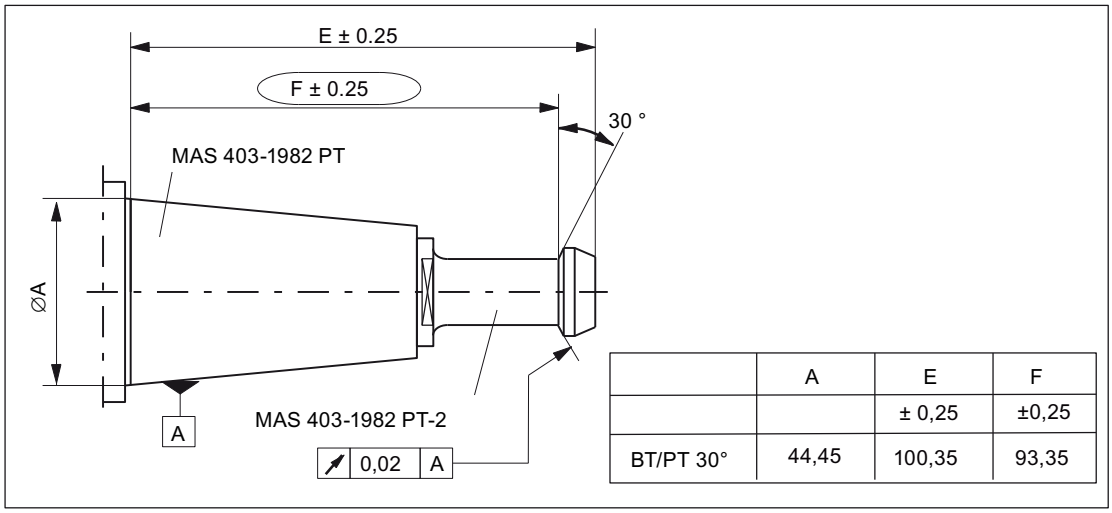
	A	B	C
		± 0,25	± 0,25
SK40	44,45	94,25	88,25

Figure 4-10 SK40



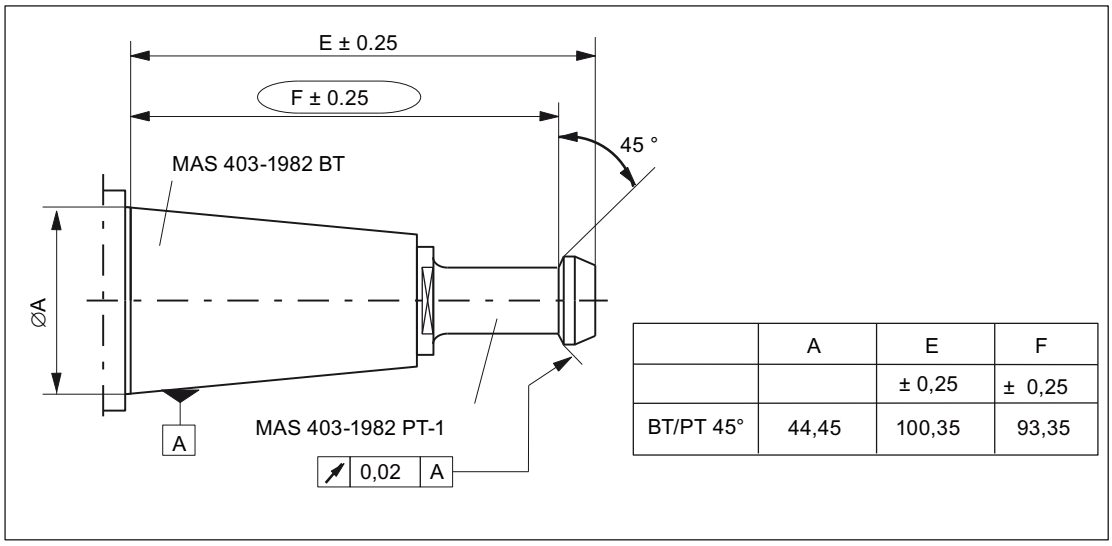
	A	J	K
		± 0,3	± 0,3
CAT40	44,45	84,50	79,25

Figure 4-11 CAT40



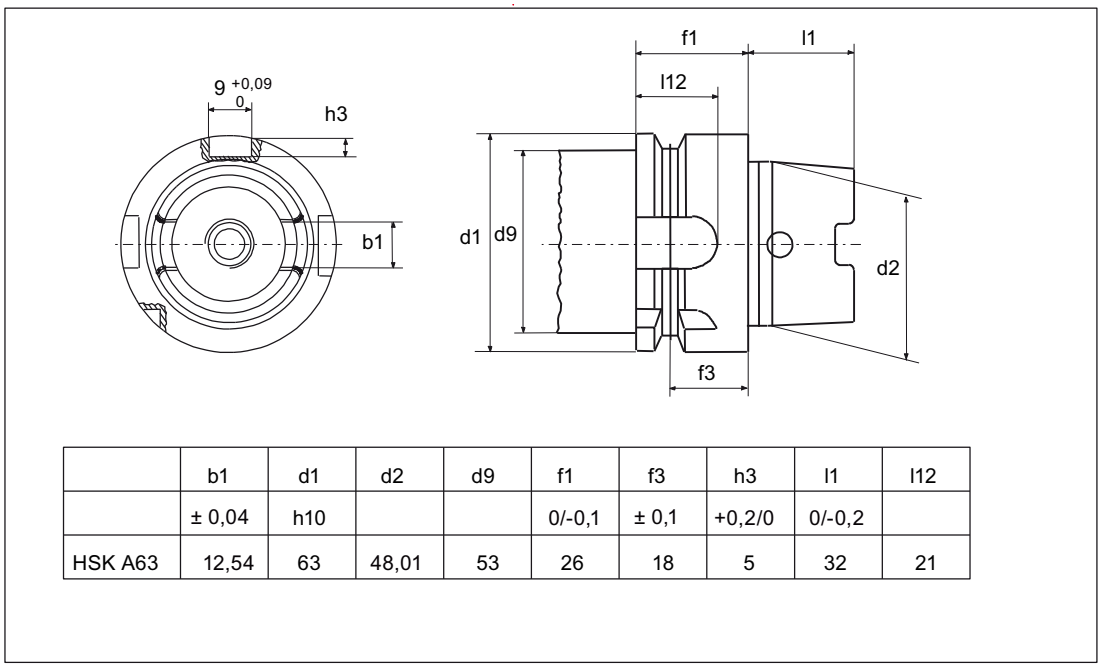
	A	E	F
		± 0,25	±0,25
BT/PT 30°	44,45	100,35	93,35

Figure 4-12 BT/PT 30°



	A	E	F
		± 0,25	± 0,25
BT/PT 45°	44,45	100,35	93,35

Figure 4-13 BT/PT 45°



	b1	d1	d2	d9	f1	f3	h3	l1	l12
	± 0,04	h10			0/-0,1	± 0,1	+0,2/0	0/-0,2	
HSK A63	12,54	63	48,01	53	26	18	5	32	21

Figure 4-14 HSK A63

Tool changer

A tool is changed depending on the machine tool using either a gripper or by directly gripping and placing the tool into a tool magazine.

CAUTION
In order to reliably prevent the spindle colliding with adjacent tools in the tool magazine or in the tool gripper, depending on the particular spindle, certain minimum clearances should be maintained (refer to the following Table and diagram).

Table 4- 9 Minimum clearances for various tool interfaces

Motor spindle	Tool interface	Minimum clearance [mm]
2SP120x-1Hxxx-xDF2	HSK A63	A ≥ 100.0
2SP125x-xHx0x-1Dx2	HSK A63	A ≥ 100.0
2SP125x-xHx0x-0xx2	SK40	A ≥ 100.0

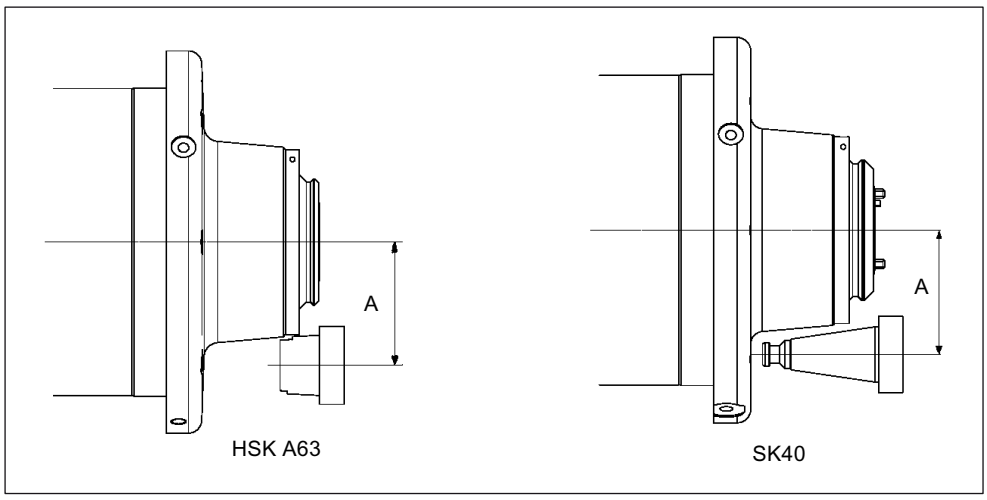


Figure 4-15 Minimum clearance = dimension A

4.5 Clamping system and tool change

4.5.1 Clamping system

2SP1 motor spindles are equipped with a clamping system for automatic tool changing. This clamping system is integrated in the spindle shaft and rotates with the spindle.

The clamping system is designed for max. five tool change cycles per minute.

The pull-in force is provided by the spring system which rotates with the spindle. The tool is safely and reliably maintained in the clamped position even when the power fails and while the spindle is rotating. The magnitude of the pull-in force is described in Chapter Technical characteristic data (Page 139).

Clamping state sensors

The spindle is equipped with sensors to monitor the clamping state. The various clamped states are detected by sensing the axial position of the clamping or actuation system.

Table 4- 10 Sensors to monitor the clamped state 2SP1 20

Sensor	Signal	Type	Comments
S1	Dependent on the measured voltage	Analog sensor	Basic equipment
S4	Position of the release cylinder	NO contact	Basic equipment

Table 4- 11 Sensors to monitor the clamped state 2SP1 25

Sensor	Signal	Type	Comments
S1	Draw bar in the release position	NO contact	Basic equipment
S2	Tool is clamped	NO contact	Basic equipment
S3	Collet is clamped without a tool inserted	NO contact	Basic equipment

Electrical data of the sensors, refer to Chapter Clamping state sensors (Page 112) .

Evaluation of the sensors to control the to change, see Chapter Control (Page 119).

⚠ WARNING

The mounting position of the clamped state sensors is carefully adjusted in the factory. It is not necessary for end users to move the position of the sensors and it is also strictly forbidden. The machinery construction company is responsible in informing the operating company that it is not permissible to adjust the position of the sensors.

4.5.2 Tool change

⚠ CAUTION

It is only permissible to insert and release the tool when the motor spindle is at a standstill (zero speed). The tool must be inserted up to the contact surface of the clamping taper.

The clamping system is either actuated pneumatically or hydraulically using a pneumatic or hydraulic cylinder.

Note

The air line between the compressed air source and the pneumatic/hydraulic cylinder must have an adequate cross-section in order to keep the times to establish pressure and reduce pressure of the pneumatic/hydraulic cylinder short.

Recommended cross-section for the air line to the pneumatic cylinder: 8 mm.

Recommended cross-section for the oil line to the hydraulic cylinder: 5 mm.

For longer compressed air lines using drag chains we recommend that the flow-related pressure loss and the associated time to establish pressure in the cylinder is theoretically estimated.

The details and the waiting times to be maintained, the control of the mechanical sequences of the clamping and release operations are described in Chapter Clamping state sensors (Page 120).

The operating and hydraulic fluid flow data of the pneumatic/hydraulic cylinder are described in Chapter Compressed air (Page 86)Hydraulic (option, only for 2SP120) (Page 91).

Values for clamping and release pressures, see Chapter Technical data and characteristics (Page 139), Table "supply data".

4.5.3 Tool change with the standard clamping system

Release tool

Pressure is applied to the cylinder to **release** the tool. The actuation device releases the tool from the tool adapter so that it can be removed by the tool changing gripper without any force being required.

Sensor S1 is adjusted so that for tools in compliance with the standard it supplies the "draw bar in the release position" signal.

When removing the tool, the appropriate control diagram must be taken into account:

Chapter automatic tool change for 2SP120x, diagram "Control diagram for an automatic tool change with S1 and S4"

Chapter manual tool change for 2SP125x, diagram "Control diagram for a manual tool change with S2"

Chapter automatic tool change for 2SP125x, diagram "Control diagram for an automatic tool change with S1, S2 and S3"

⚠ CAUTION

The released tool is only loosely located in the tool adapter. It must be removed after it has been released. If it is not removed, then it can simply fall out and cause damage.

Jammed tools cannot be reliably detected using sensor S1.

Inserting and clamping the tool

The tool is **drawn-in and clamped** just using disk springs.

For this operation, for spindles with pneumatic cylinder, the air in the cylinder must first be released. In order to shorten the tool change times, compressed air can be additionally applied to the rear of the piston.

For spindles with hydraulic cylinder, the piston side must be relieved (the pressure reduced) using an appropriate valve - and pressure (hydraulic pressure) applied to the rear of the piston.

For 2SP120x, the voltage of analog sensor S1 is measured to determine that the tool has been correctly clamped.

For 2SP125x, digital sensor S2 indicates whether the tool has been correctly clamped.

While **inserting** a tool, the release pressure must be switched through to the pneumatic or hydraulic cylinder until sensor S1 signals that the clamping system is ready for tool insertion. The tool can only be inserted after this signal is present.

⚠ CAUTION

The gripper must completely introduce the tool into the tool adapter. It must prevent the tool from either sliding or dropping-out until the clamped state has been achieved (e.g. an appropriate signal from sensor S1 for 2SP120x motor spindles or from sensor S2 for 2SP125x until a specific voltage level has been achieved).

⚠ CAUTION

It is only permissible that the spindle rotates if the cylinder piston has withdrawn from the spindle shaft and has not contact with it. This means that it is not permissible that a release pressure is applied to the pneumatic or hydraulic cylinder!

When the release pressure is applied to the cylinder, the stationary cylinder piston makes contact with the rotating clamping system of the spindle shaft. If it would be in contact while the spindle is rotating, this would damage the clamping system. This is the reason that spindle rotation may only be enabled if there is no release pressure and the sensor system clearly indicates that a tool has been safely and reliably clamped. While the spindle is rotating, the pressure feed to release the tool must be safely and securely shut-off.

⚠ CAUTION

Spindle rotation not without a clamped tool!

If a clamping operation is carried-out without a tool being ready at the front for insertion, then the collet and draw bar retract to behind their normal clamping position. This status is permitted - however, it is not permissible that the spindle rotates at a high speed. Only slow spindle speeds of below 100 rpm are permissible to position the spindle.

4.5.4 Changing tools for the HSK A63 Type C holding clamping system

Release tool

Pressure is applied to the cylinder to **release** the tool. The actuation mechanism releases the tool from the tool adapter.

Sensor S1 is adjusted so that for tools in compliance with the standard it supplies the "draw bar in the release position" signal.

When removing the tool, the appropriate control diagram must be taken into account:

Chapter automatic tool change for 2SP120x, diagram "Control diagram for an automatic tool change with S1 and S4"

For a holding clamping system, the tool is still held with a defined holding force in the tool holder using springs. A tool can only be removed after first overcoming the holding force. To do this, force must be applied by the tool changer.

Inserting and clamping the tool

While **inserting** a tool, the release pressure must be switched through to the pneumatic or hydraulic cylinder until sensor S1 signals that the clamping system is ready for tool insertion. The tool can only be inserted after this signal is present.

For a holding clamping system, when the tool is inserted, it is initially only held in the tool holder by the holding function of the springs without the tool being clamped in the tool holder. The tool change gripper no longer has to hold the tool after it has been inserted as this function is handled by the holding clamping system.

The tool is **drawn-in and clamped** just using disk springs.

For this operation, for spindles with pneumatic cylinder, the air in the cylinder must first be released. In order to shorten the tool change times, compressed air can be additionally applied to the rear of the piston.

For spindles with hydraulic cylinder, the piston side must be relieved (the pressure reduced) using an appropriate valve - and pressure (hydraulic pressure) applied to the rear of the piston.

For 2SP120x, the voltage of analog sensor S1 is measured to determine that the tool has been correctly clamped.

⚠ CAUTION

It is only permissible that the spindle rotates if the cylinder piston has withdrawn from the spindle shaft and has not contact with it. This means that it is not permissible that a release pressure is applied to the pneumatic or hydraulic cylinder!

When the release pressure is applied to the cylinder, the stationary cylinder piston makes contact with the rotating clamping system of the spindle shaft. If it would be in contact while the spindle is rotating, this would damage the clamping system. This is the reason that spindle rotation may only be enabled if there is no release pressure and the sensor system clearly indicates that a tool has been safely and reliably clamped. While the spindle is rotating, the pressure feed to release the tool must be safely and securely shut-off.

Holding function

The clamping set is equipped with a holding function for the tool. As soon as the clamping set is in the tool change position, the tool is held in the change position with a defined force of 270 N. In case of automatic tool change, you must ensure that the tool changer is suitable for the extraction forces.

Acceleration in various axial directions as well as purge air or coolant for cleaning the tool produce forces on the tool that can be greater than the retention force and, thus, cause the tool to be forced out. The user must always take steps to ensure that the forces that act are less than the retention force.

Especially fast release cylinders can accelerate the tool to such a degree that the tool pulse is sufficient to overcome the holding position of the clamping set. The settings for the release operation must also be adapted to this situation.

The holding function is not permissible for vertical applications.

For tool changing with a horizontally arranged spindle, the wear at the contact surfaces due to the tool tilting, must be carefully taken into consideration, refer to the following diagram.

NOTICE

Vertical applications with holding clamping set are not permissible.

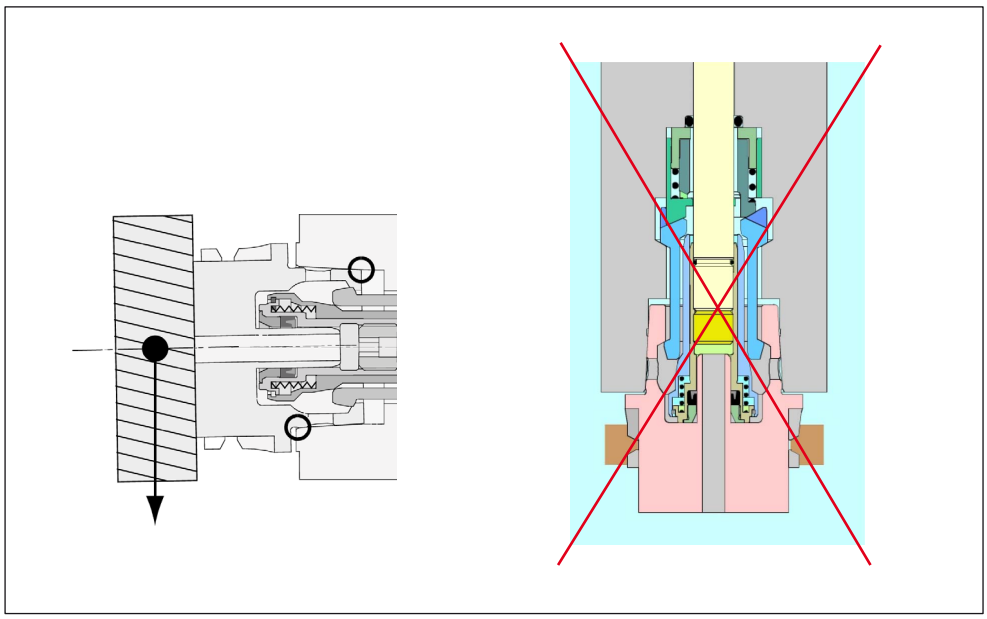


Figure 4-16 Holding clamping system HSK A63 Type C

4.6 Operating modes

The spindle can be operated in the closed-loop speed and position controlled mode. The positioning accuracy and the control behavior of the spindle depend on the following secondary conditions:

- Low resonance of the spindle support
- The tool is free of any natural vibration
- Degree of variation of the tool moment of inertia
- Clock cycle times of the closed-loop control

Permissible vibrations

Over the complete speed range, the maximum permissible radial vibration velocity is limited to:

3 mm/s: in no-load operation

6 mm/s: in continuous operation

10 mm/s: briefly (max. 5 sec)

For the axial vibration velocity, half of the values apply.

When accepting, the spindle was balanced with a reference tool to = 1 mm/s under no-load conditions. The acceptance is not realized in the installed state, corresponding to VDI 2056.

The measured values (machining-end value A, drive-end value B) are documented in the respective acceptance report.

If a subsequent check is made in the field and the vibration quality measured, then this must be done with a precisely balanced tool (Q = 2.5). The vibration value determined when accepted is used as a nominal quantity (refer to the acceptance report).

When it is installed it is possible that vibration velocities are measured that deviate from those in the acceptance report due to the influence of the machine tool.

NOTICE
Vibration levels above 10 mm/s are not permissible for safety reasons - even if the machining result is OK. The spindle must be shut down immediately.

Electrical data

5

5.1 Definitions

Mechanical limit speed n_{max}

The maximum permissible speed n_{max} is the max. permissible speed depending on the max. mechanical speed and the max. permissible electrical speed.

S1 duty (continuous operation)

Operation with a constant load the duration of which is sufficient so that the machine goes into a thermal steady-state condition.

S6 duty (intermittent load)

An operation that comprises a sequence of identical duty cycles; each of these duty cycles comprises a time with constant motor load and a no-load time. Unless otherwise specified, the load period refers to a duty cycle of two minutes.

S6 - 40 %: 40 % load operation, 60 % no-load operation

Maximum torque M_{max}

Torque which is briefly available for dynamic operations (e.g. when accelerating). The following formula is used to calculate this:

$M_{max} \approx 2 \cdot M_N$ (for more precise values, see the data sheets, Chapter Technical data and characteristics (Page 139))

NOTICE
For motor spindles with synchronous motor, the max. permissible motor current may not be exceeded, as this could destroy the rotor.

At higher speeds, i.e. in the constant power range, the maximum available torque M_{max} at a specific speed n is approximated according to the following formula:

$$M_{max}\,[Nm] \approx 9.6 \cdot \frac{P_{max}\,[W]}{n\,[rpm]}$$

Characteristics, see Chapter P/n and M/n diagrams (Page 144).

5.2 Motor

The drive motor of the 2SP1 motor spindle is integrated onto the spindle shaft between the two spindle bearings. The rotor is electrically passive and does not require any power feed. The drive converter provides the power for the motor and is fed to the stator winding. The losses associated with converting the electrical power into the mechanical power, which are unavoidable, mainly occur in the motor stator. This means that the stator is equipped with a cooling system, which ensures the necessary cooling thus preventing the machine assembly from reaching excessively high, damaging temperatures.

NOTICE
The 2SP1 motor spindle has been designed for sinusoidal currents (line supply/motor). Other drive converter current waveforms (at the motor side) - e.g. squarewave or trapezoidal - are not permissible.

5.2.1 Advantages of a direct drive

The drive motor does not have its own bearings. Its rotor is a component of the spindle shaft and is located in the bearings of the spindle shaft. This type of drive is also known as a direct drive. For direct drives, there are no mechanical couplings between the motor shaft and the spindle shaft with the associated weak points.

When compared to mechanically-coupled drives, direct drives have the following advantages:

- **Ruggedness** even at high speeds
- The spindle rotor **does not have any play** with respect to the drive motor and this results in **high precision** in C axis operation
- **Low noise emission** and **high smooth running qualities**
- **Stable balancing**

The torque is contactlessly transmitted to the rotor which means that there is no mechanical wear. The high availability and ruggedness thus achieved mean that the drive motor does not require any maintenance therefore counter-acting the potential disadvantage associated with the fact that this type of motor is not quite so accessible.

5.2.2 Synchronous and induction motor versions

Table 5- 1 Motor versions

Standard design	Synchronous motor
Option	Induction motor

Both of these motor versions have their own specific advantages and place certain requirements on the AC drive converter. The machinery construction company (OEM) should be aware of this when designing his machine.

Selecting the motor versions

As far as power and torque are concerned, the synchronous motor is superior to the induction motor. It is more powerful and has noticeably less power loss than an induction motor. For synchronous motors, the motor shaft is subject to a lower thermal stressing which is important as it is more difficult to cool motor shafts. In the case of SINAMICS S120, the functionality of the field weakening of the synchronous motor is already included in the standard functional scope. Overvoltage protection is achieved by using the IVP function or the VP module.

The 2SP1 motor spindle is therefore offered, as standard, with synchronous motor.

Note

The induction motor option should only be considered for cases where the spindle is to be fed from third-party drive systems which are not suitable for operating synchronous motors in the field weakening range.

Table 5- 2 Comparison of the advantages of synchronous and induction motors

Advantages of synchronous motors	Advantages of induction motors
Lower thermal stressing of the spindle shaft due to the permanent rotor magnetization	Field weakening is also possible when using third-party drive converters
Higher efficiency	Protective measures against motor overvoltages are not required
Higher torque and higher power for a comparable frame size	Compatible to older drive converter systems

5.2.3 General motor characteristics

Field weakening

In addition to reducing the counter voltage, field weakening also reduces the maximum torque. When field weakening is used, the power yield is split-up into a constant torque range and a constant power range.

Limiting the power using the reactive power drawn

As the speed increases, the reactive power (electrical) drawn by the motor increases. This reactive power demand in turn reduces the mechanical power. This means, in the uppermost speed range, the constant spindle power can no longer be maintained, but decreases with increasing speed. The power limiting is defined in the power diagrams using the "limiting characteristic". The level of the power limiting depends very heavily on the operating mode (star-delta) and the motor type (synchronous or induction motor). For synchronous motors, the spindle power always remains constant up to the maximum speed.

Refer to Chapter Technical data and characteristics (Page 139) for power diagrams of the individual motors.

- **Constant maximum torque**

  Field weakening is not activated in the lower speed range and the rms magnetic flux is constant as long as the required voltage, which is proportional to the speed, does not exceed the maximum drive converter output voltage. This means that a constant torque is available in this range.

- **Constant maximum power**

  The motor voltage reaches the maximum drive converter output voltage in the upper speed range of field weakening. This means that the magnetic flux must be reduced linearly with the speed. For induction motors, this is realized by reducing the flux-generating current, and for synchronous motors, by impressing a current or magnetic field which opposes the permanent magnet field. This means that the permanent magnet field is therefore "weakened". The torque also decreases proportionally with the flux which decreases with the speed. The mechanical power, as product of speed and torque, remains constant.

- **Limited maximum power (only for induction motors)**

  The reactive power requirement that increases with the speed can, depending on motor type, in the uppermost speed range result in a reduction of the available maximum power.

Influence of the DC link voltage

The speed at the start of field weakening and the power limiting depend on the magnitude of the DC link voltage.

Information regarding the DC link voltage is provided in the SINAMICS S120 Equipment Manual.

For synchronous motors, the spindle power always remains constant up to the maximum speed.

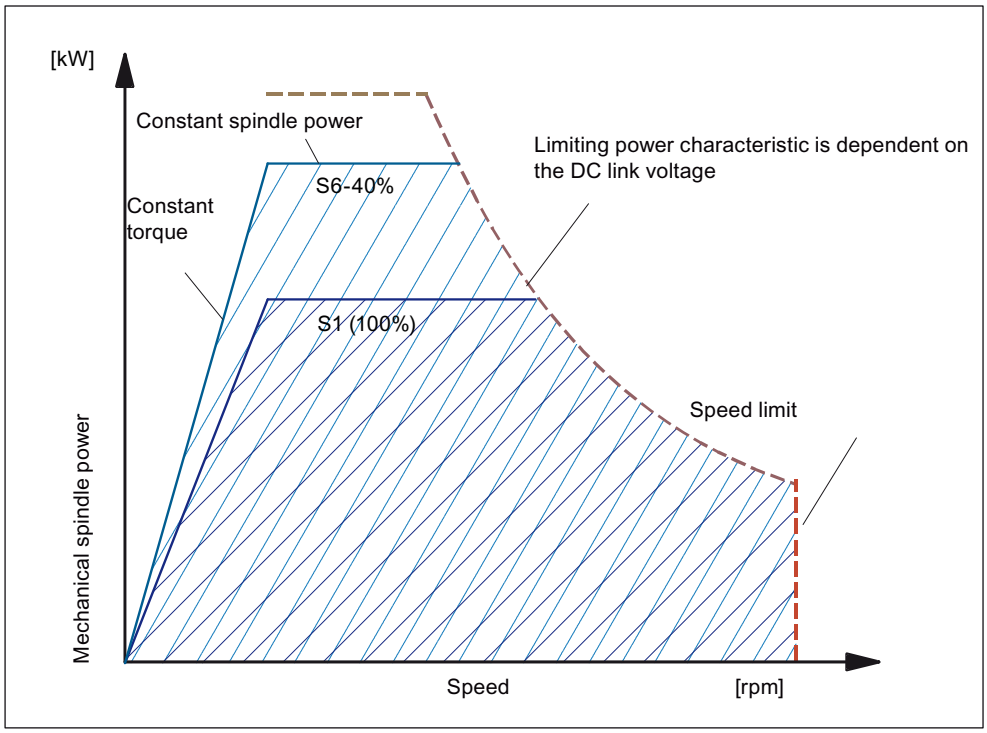


Figure 5-1 Principle speed-power diagram (using an induction motor as an example)

5.2.4 Suitable drive converter/system environment

SINAMICS S120 drive system

The 2SP1 motor spindle is matched to the SINAMICS drive system. The angular information of the sin-cos encoder is multiplied in the encoder interface of the drive system. Different multiplication factors are offered. If a higher positioning accuracy (e.g. C axis) and load stiffness are required, then the equipment with a multiplication factor of 2048 is recommended.

Infeed

2SP1 motor spindles can always be operated with an Active Line Module (ALM) or Smart Line Module (SLM). The specified configuring and power data refer to operation with ALM. This data should be corrected, if necessary, when operated from unregulated infeed modules with other DC voltages.

Table 5- 3 Output voltages of the drive system

Drive system	Infeed module	Line voltage	DC link voltage	Output voltage
		V_{line}	V_{dclink}	V_{mot}
SINAMICS S120 380 - 480 V 3 AC	ALM	400 V	600 V	425 V
	SLM	400 V	528 V	380 V
	SLM	480 V	634 V	460 V

The SINAMICS S120 drive system impresses a field weakening current which means that the motor spindle can operate above the voltage limiting characteristic without field weakening. The method used by the drive system to impress the field weakening current has a significant influence on the curve characteristic.

5.2.5 Overvoltage protection (only for synchronous motors)

Description of functions

For 2SP1 motor spindles using synchronous motors with EMF V = 830 V up to 2000 V (V_{rms} = 570 V to 1400 V) voltage protection is required in order to limit the drive system DC link voltage if a fault develops.

If the line voltage fails at maximum motor spindle speed or if the drive converter pulses are canceled as a result of the power failure, the synchronous motor regenerates at high voltage back into the DC link. The voltage protection detects a DC link voltage that is too high (DC > 830 V) and short-circuits the three motor supply cables. The energy remaining in the motor spindle is converted into heat as a result of the short-circuit and causes the motor spindle to quickly brake.

Voltage limiting

For SINAMICS S120, the following can be used as voltage protection:

- the IVP function (Internal Voltage Protection) in conjunction with
  - a CSM for secure voltage supply and
  - and a Braking Module with the appropriate braking resistor
- the VPM (Voltage Protection Module)

Integration and system prerequisites of the IVP function

The IVP function is only capable of functioning in conjunction with SINAMICS S120 booksize and/or SINUMERIK solutionline. Available as standard function from software release 2.5 and higher

System requirements:

- SINAMICS S120 booksize (6SL31xx-xxxxx-xxxx3), software release 2.5
- Line Module capable of regenerative feedback with a regenerative power that, as a minimum, corresponds to the maximum S1 power used.
- Adequately dimensioned Motor Module with I_{max} > 1.8x motor short-circuit current
- Additional DC link-buffered 24 V supply (CSM) to supply the control and Motor Modules
- Braking Module with braking resistor

For detailed information, see the SINAMICS S120 /FH1/ Function Manual.

Integration and system prerequisites of the VPM

The VPM must be installed between the motor and drive system (at a maximum distance from the drive system of 1.5 m). Use shielded motor feeder cables.

System prerequisites

- SINAMICS S120 booksize (6SL31xx-xxxxx-xxxx3)
- SINUMERIK 840D sl from software release 1.3 and higher

The VPM is not included with the 2SP1 motor spindle and must be separately ordered. The associated documentation is provided in the References.

Assignment table for the VPM

Table 5- 4 Assignment of the spindle - VPM

Order designation	VP/IVP module	Maximum speed n_{max} [rpm]	Rated current I_N [A]	Rated torque M_N [Nm]
2SP1202-1xA	VPM 120	15000	30	42
2SP1202-1xB	VPM 120	18000	42	42
2SP1204-1xA	VPM 120	15000	60	84
2SP1204-1xB	VPM 120	18000	79	78
2SP1253-1xA	VPM 120	10000	45	80
2SP1253-1xB	VPM 120	15000	60	80
2SP1255-1xA	VPM 120	10000	85	150
2SP1255-1xB	VPM 120	15000	105	150

5.2.6 Star-delta (only for induction motors)

When induction motors are used, it is possible to select one of the following operating modes:

- Star connection
- Delta circuit configuration

Circuit to implement star-delta switchover

For induction motors, all six connection leads of the three winding phases are fed out to be able to select the various operating modes.

The changeover is carried-out outside the spindle using switching devices and equipment that are not included with the motor spindle (i.e. these devices are not included in the scope of supply.

NOTICE
When changing over the circuit configuration (star-delta), the appropriate data set for the closed-loop motor control must also be changed-over. A changeover may only be made when the spindle is in a no-load condition and with the power module pulses inhibited.

For information about the circuit to implement the star-delta changeover, refer to the following diagram and SINAMICS S120 Function Manual (FH1).

Using the star circuit configuration

The star-circuit configuration offers some advantages at low speeds. The maximum torque in the star circuit configuration is approximately twice as high as in the delta circuit configuration. However, due to the higher reactive power requirement of the star circuit configuration, the available torque in the uppermost speed range is significantly restricted. This means that the star circuit configuration should only be activated when machining which requires a **high torque in the lower speed range.** An example of such a machining operation is roughing.

Using the delta circuit configuration

Although the delta circuit configuration provides, in the lower speed range, a lower maximum torque than the star circuit configuration, the torque remains available up to high speeds. This means that the delta circuit configuration should be activated for **all machining operations which are carried-out in the medium and high speed ranges**.

Connection diagram for Y/D changeover

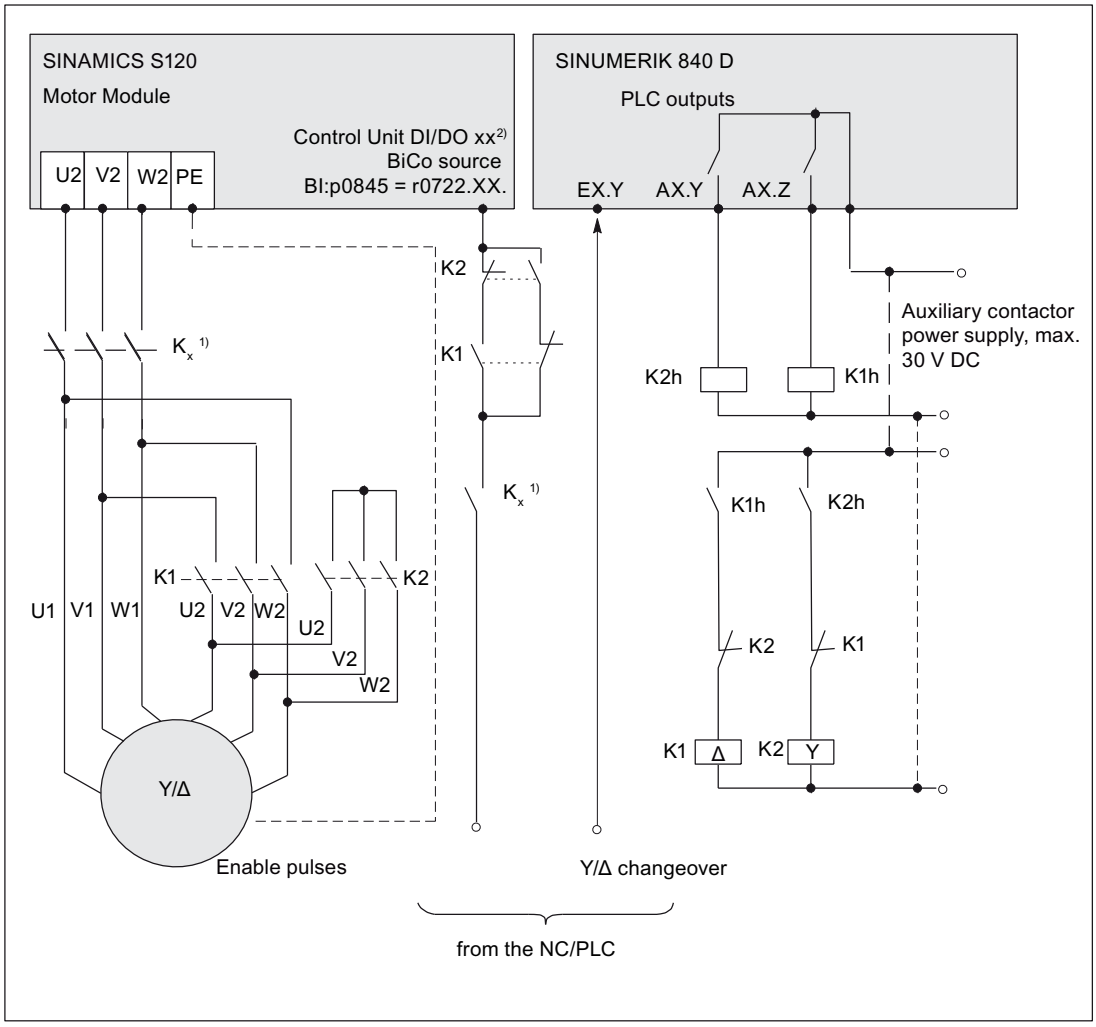


Figure 5-2 Connection diagram for Y/D changeover with SINAMICS

1) Safe operating stop cannot be guaranteed by simply opening K1 and K2. Therefore, for safety reasons there should be electrical isolation provided by contactor K_x. This contactor may only be switched-in the no-current condition, i.e. the pulse enable must be withdrawn 40 ms before the contactor is opened (de-energized).

2) Terminal X3 of the voltage limiting module VPM should be wired to a digital input of the Control Unit on which the assigned ECS motor spindle 2SP1 is also controlled. For the case that several VPMs are used, each terminal must be wired to a separate digital input of the relevant Control Unit.
For an armature short-circuit occurs (terminal X3 has opened), the pulses of the relevant axis must be inhibited. To achieve this, the digital input used is interconnected to the control bit OFF2 (pulse inhibit) via p0845 = r0722.xx.
Further information can be found in the SINAMICS S120 Function Manual.

5.2.7 System overview and engineering information/instructions

System overview

The SINAMICS drive system is controlled from the SINUMERIK 840D sl via DRIVE-CLiQ.

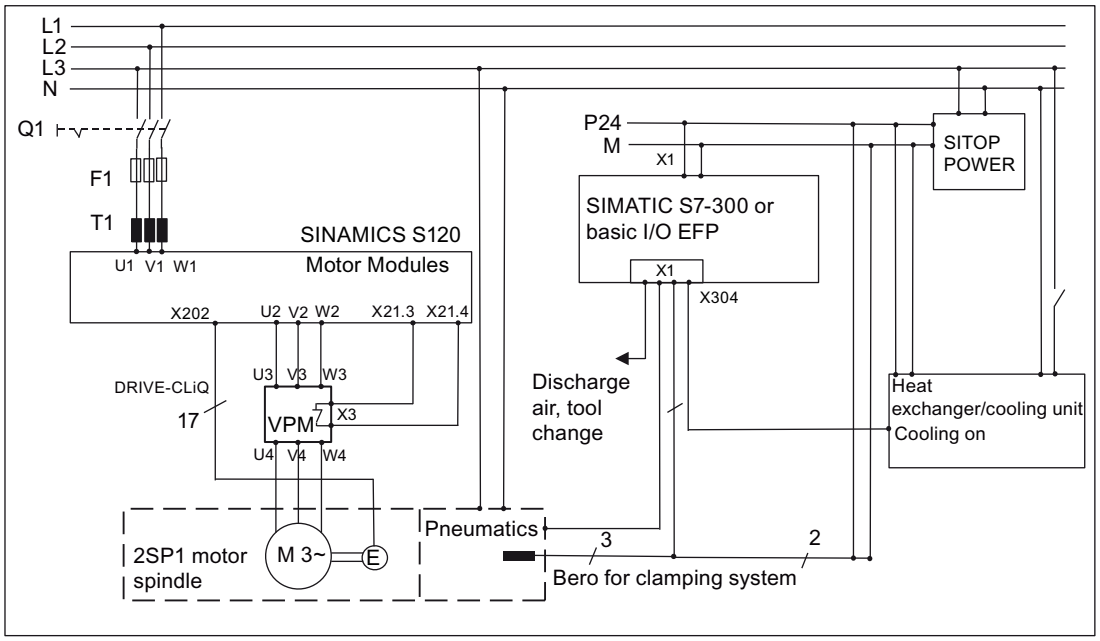


Figure 5-3 System example with SINUMERIK 840 D sl, 828D and SINAMICS S120

Dimensioning the Motor Module

The Motor Modules are selected and engineered according to the rated current I_N of the spindle, refer to Table and Chapter Technical data and characteristics (Page 139).

Table 5- 5 Assignment motor spindle - Motor Module

Order designation 2SP1 motor spindle	Maximum speed n_{max} [rpm]	Rated current I_N [A]	Rated torque M_N [Nm]	Motor type	Motor Module I_N [A] for S1	Order designation Motor Module 6SL3120- ...
2SP1202-1xAxx1	15000	30	42	Synch.	30	1TE23-0AA3
2SP1202-1xBxx2	18000	42	42	Synch.	45	1TE24-5AA3
2SP1204-1xAxx1	15000	60	84	Synch.	60	1TE26-0AA3
2SP1204-1xBxx2	18000	79	78	Synch.	85	1TE28-5AA3
2SP1253-8xAxx0	10000 1)	28 1)	70 1)	Induct.	30	1TE23-0AA3
2SP1253-8xAxx1	15000 1)	28 1)	70 1)	Induct.	30	1TE23-0AA3
2SP1255-8xAxx0	10000 1)	30 1)	140 1)	Induct.	30	1TE23-0AA3
2SP1255-8xAxx1	15000 1)	30 1)	140 1)	Induct.	30	1TE23-0AA3
2SP1253-1xAxx0	10000	53 (45)	100 (80)	Synch.	60	1TE26-0AA3
2SP1253-1xBxx1	15000	68 (60)	100 (80)	Synch.	85	1TE28-5AA3
2SP1255-1xAxx0	10000	95 (85)	170 (150)	Synch.	132	1TE31-3AA3
2SP1255-1xBxx1	15000	120 (105)	170 (150)	Synch.	132	1TE31-3AA3

Values in brackets apply for operation with the next smaller Motor Module.

1) Overview of the spindle values for star connection , drive converter selection applies for star and delta connection

Spindle power data

Spindle power data, see Chapter Technical data and characteristics (Page 139).

Note

Synchronous motor

When using smaller Motor Modules, then the complete speed range cannot be fully utilized; this applies even at low motor utilization levels. An additional field-weakening current is impressed from the rated speed onwards

Also refer to the appropriate characteristics (refer to Chapter Technical data and characteristics (Page 139)) or contact your local Siemens office.

A minimum current is required for the pole position identification. This means that the following must apply when selecting the Motor Module and the 2SP1 motor spindle:

Rated current (S1 current), power unit ≥ 50 % of the rated motor current.

Drive converter pulse frequencies

In order to achieve optimum control characteristics, a minimum drive converter pulse frequency must be maintained which is a function of the maximum motor speed.

Minimum drive converter pulse frequency up to 18000 rpm = 4.0 kHz

Derating of the converter rated current

For the drive converter, the rated current can depend on the pulse frequency and the rotating frequency of the output current. For the configuration of the 2SP1 motor spindles, a 4.0 kHz clock frequency is sufficient. It is not necessary to derate the converter as a function of the rotational frequency.

Spindle rating plate

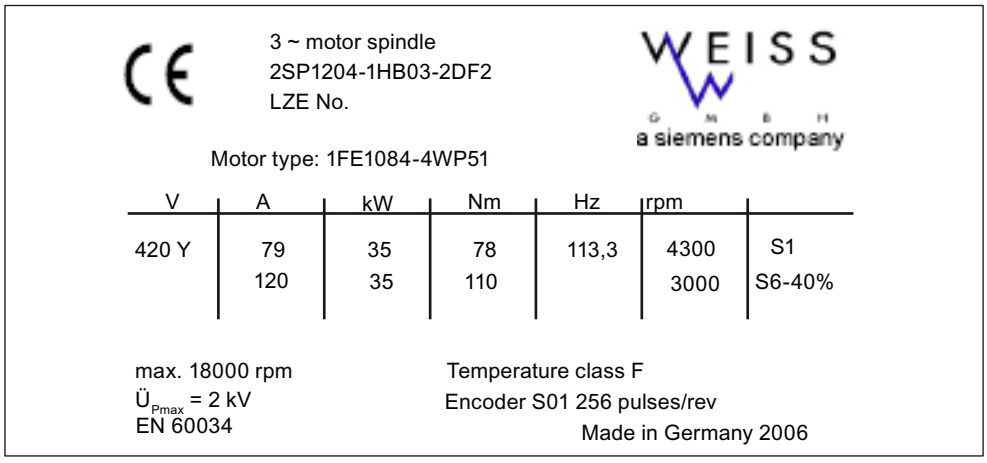


Figure 5-4 Spindle rating plate

5.3 Connecting cables / connector assignments

5.3.1 Power connection

2SP1 motor spindles are connected to the power source through cables. The connecting cables are 1.5 m long.

Table 5- 6 Cable properties

Properties	Characteristic values	Comments
Cable type	1-wire or 4-wire, see the following table	
Draggable	yes; carefully observe the minimum bending radius	
Minimum bending radius	Cable ∅ x 10 mm Cable ∅ x 15 mm	permanently routed Draggable
Material	1-wire cable: 4-wire cable: PUR	e.g. PUR ... e.g. PUR ...

Table 5- 7 Power connection

Order designation, motor spindle	Motor type	Circuit	Rated current I_N	Maximum speed n_{max}	Connecting cable cross-section	Connecting cable	Max. outer diameter	Shield
			[A]	[rpm]	[mm²]		[mm]	
2SP1202-1xAxx-1	Synch.	Y	30	15000	10	4 x 1-wire	10	Individual[2)]
2SP1202-1xBxx-2		Y	42	18000	10	4 x 1-wire	10	Individual[2)]
2SP1204-1xAxx-1		Y	60	15000	25	4 x 1-wire	14	Individual[2)]
2SP1204-1xBxx-2		Y	79	18000	25	4 x 1-wire	14	Individual[2)]
2SP1253-8xAxx-0	Induct.	Y	28	10000 [1)]	6	2 x 4-wire	16	Common[1)]
		Δ	29					
2SP1253-8xAxx-1		Y	28	10000 [1)]	6	2 x 4-wire	16	Common[1)]
		Δ	29					
2SP1255-8xAxx-0		Y	30	10000 [1)]	6	2 x 4-wire	16	Common[1)]
		Δ	29					
2SP1255-8xAxx-1		Y	30	10000 [1)]	6	2 x 4-wire	16	Common[1)]
		Δ	29					
2SP1253-1xAxx-0	Synch.	Y	45	10000	10	4 x 1-wire	10	Individual[2)]
2SP1253-1xBxx-0		Y	60	15000	16	4 x 1-wire	12	Individual[2)]
2SP1255-1xAxx-0		Y	85	10000	25	4 x 1-wire	14	Individual[2)]
2SP1255-1xBxx-1		Y	105	15000	35	4 x 1-wire	16	Individual[2)]

1) 4-wire cable with common shield

2) PE cable without shield

5.3.2 Direction of rotation

The direction of rotation of the motor spindle is defined when the power cables are connected to the drive system.

Table 5- 8 Connecting the cables for a clockwise direction of rotation

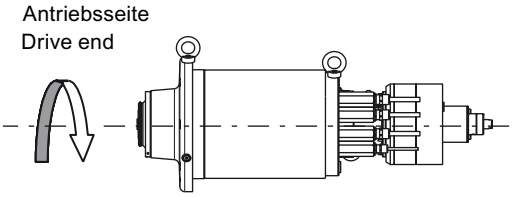
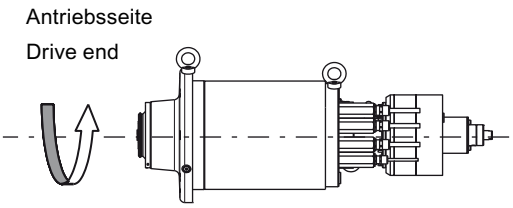
Cable designation, motor spindle	Terminal designations, SINAMICS S120	Direction of rotation of the spindle when viewing the drive side
U1 or wire designation 1	U2	
V1 or wire designation 2	V2	
W1 or wire designation 3	W2	
		

Table 5- 9 Connecting the cables for a counter-clockwise direction of rotation

Cable designation, motor spindle	Terminal designations, SINAMICS S120	Direction of rotation of the spindle when viewing the drive side
U1 or wire designation 1	V2	
V1 or wire designation 2	U2	
W1 or wire designation 3	W2	
		

⚠WARNING

The drive system rotating field must match the direction in which the encoder system counts. When connecting-up as specified in the previous table, the count direction of the encoder system must be adjusted using parameters, please refer to the List Manual.

If the rotating field of the drive system and counting direction of the encoder system do not match, then this can result in uncontrollable motion and destruction of the motor spindle.

Supplying the various media

6

6.1 Overview, supplying the various media

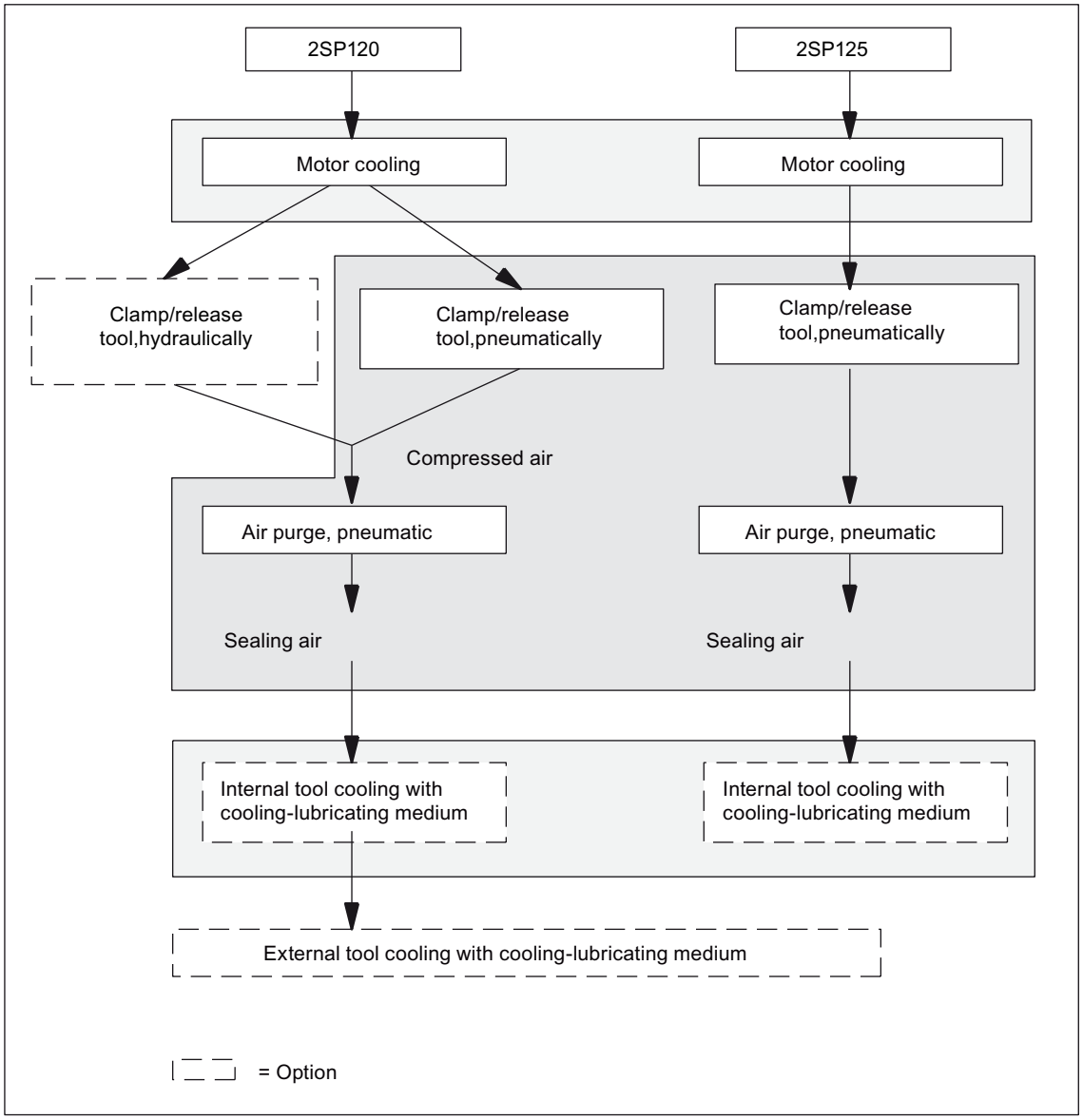


Figure 6-1 Overview, supplying the various media

6.2 Cooling medium

The spindle is designed for water cooling. The spindle housing is equipped with cooling ducts, which transfer the stator power loss (heat) into the cooling water. The temperature of the cooling water increases when it flows through the spindle corresponding to the flow rate and the thermal power that it absorbs.

$$\Delta T = \frac{1}{\dot{V} \cdot \rho \cdot c_p} \cdot P_V$$

ΔT = temperature difference between cooling water inlet and outlet
$\dot{V}$ = flow rate of the cooling water
P = density of the cooling water
c_p = spec. thermal capacity of the cooling water
P_V = power loss absorbed

NOTICE
In order to guarantee the necessary thermal transition in the cooling ducts, the minimum cooling water flow, specified in Chapter Order designation (Page 137), should be maintained.

Note

Higher cooling water flow rates are permissible as long as the permissible hydrostatic pressure in the system is not exceeded.

6.2.1 Cooling water connections

Table 6- 1 Cooling water connections

	2SP120	2SP125	Comments
Connection fitting	Connector for hose ∅ 12/10 mm	G1/2" (inner thread) for hoses ∅ 9 mm	On the spindle side
Connection code	I = motor cooling inlet II = motor cooling outlet	I = motor cooling inlet II = motor cooling outlet	On the spindle side
Permitted tightening torque [Nm]	--	100 Nm max.	

NOTICE
The feeder lines and hoses to the connections must be flexible and strain relieved. Rigid pipe connections are not permissible. Only use PU/PA connecting hose quality for the connectors of the 2SP120x spindle!

6.2.2 Cooling water conditioning

The cooling water must be conditioned in order to maintain the correct functioning of the cooling system on the spindle side (refer to the following table).

Table 6- 2 Conditioning the cooling water

	Value
Min. inlet temperature	No moisture condensation
Max. inlet temperature	Without de-rating 25 °C With derating, see the table below: 40 °C
Max. hydrostatic pressure	5 bar
Max. particle size	100 µm
Recommended anti-corrosion agents	max. 25 % Clariant, Antifrogen or Tyfocor

CAUTION
It is not permissible to cool using flowing water from drinking or process water supplies or with cooling-lubricating medium. The cooling water temperature must be set corresponding to the ambient temperature so that moisture condensation does not occur.

The S1 power (continuous duty) of the spindle depends on the inlet temperature of the cooling water. For inlet temperatures of up to 25 °C, the S1 power specified in the data sheet is reached. Above a cooling water inlet temperature of 25 °C, the S1 power is reduced (see table below).

Table 6- 3 Reduced S1 power as a function of the cooling-water temperature

Inlet temperature [°C]	Reduction factor
25	1
35	0.95
40	0.90

Cooling water additives

Additives must be added to the cooling water to protect against corrosion and living organisms. These additives must be compatible with the materials used for the cooling water feed system on the spindle side. Further, they must also be compatible with the materials used in the cooling water feed system on the machine side. Electro-chemical incompatibility between the materials of the cooling water feed and the spindle side and on the machine side is not permissible. The machine-side cooling water feed system must be appropriately designed.

List of materials for the cooling water feed on the spindle side:

- Steel, grey cast iron
- Brass
- Stainless steel
- Viton
- GFP

Cooling water requirements

Refer to Chapter Technical data and characteristics (Page 139) for the flow quantity and pressure drop.

6.2.3 Cooling systems

The cooling water that is taken from the spindle must be cooled using an external cooling system. The external cooling system is not included with the spindle.

The thermal load of the cooling water at the rated spindle power is described in Chapter Technical data and characteristics (Page 139).

Table 6- 4 External cooling system versions

Version	Characteristics
The existing cooling system is used	• The existing cooling system must be increased by the spindle power loss • The compatibility of the materials must be carefully checked • The pump must be able to provide the additional flow at the required pressure
Air-to-water heat exchanger cooling system	• Favorable investment and operating costs as a compressor does not have to be used • The heat exchanger must be dimensioned so that the inlet temperature for the spindle is a max. 5K above the ambient temperature • Higher space requirement of the heat exchanger than for the cooling unit
Stand-alone cooling system	• The inlet temperature for the spindle is independent of the ambient temperature

Cooling system manufacturers

Table 6- 5 Cooling system manufacturers

BKW Kälte-Wärme-Versorgungstechnik GmbH
Benzstraße 2 D-72649 Wolfschlungen Phone: +49 (0) 70 22 - 50 03 - 0 Fax: +49 (0) 70 22 - 50 03 - 30 mailto:info@bkw-kuema.de http://www.bkw.kuema.de
DELTATHERM Hirmer GmbH
Gewerbegebiet Bövingen 122 D-53804 Much Phone: +49 (0) 22 45 - 61 07 - 0 Fax: +49 (0) 22 45 - 61 07 - 10 mailto:info@deltatherm.de http://www.deltatherm.de
Glen Dimplex Deutschland GmbH, Geschäftsbereich RIEDEL Kältetechnik
Am Goldenen Feld 18 D-95326 Kulmbach Phone: +49 (0) 92 21 - 709 -555 Fax: +49 (0) 92 21 - 709 -549 mailto:info@riedel-cooling.de http://www.riedel-cooling.de
Hydac System GmbH
Postfach 1251 D-66273 Sulzbach/Saar Phone: +49 (0) 68 97 - 509 - 708 Fax: +49 (0) 68 97 - 509 - 454 http://www.hydac.com
Helmut Schimpke Industriekühlanlagen GmbH & Co. KG
Ginsterweg 25 - 27 D-42781 Haan Phone: +49 (0) 21 29 - 94 38 - 0 Fax: +49 (0) 21 29 - 94 38 - 99 mailto:info@schimpke.de http://www.schimpke.de
Hyfra Industriekühlanlagen GmbH
Industriepark 54 D-56593 Krunkel Phone: +49 (0) 26 87 - 898 - 0 Fax: +49 (0) 26 87 - 898 - 25 mailto:infohyfra@hyfra.com http://www.hyfra.de

KKT Kraus Kälte- und Klimatechnik
Mühllach 11 D-90552 Röthenbach a. d. Pegnitz Phone: +49 (0) 911 - 953 33 - 40 Fax: +49 (0) 911 - 953 33 - 33 http://www.kkt-kraus.de
Pfannenberg GmbH
Werner-Witt-Straße 1 D-21035 Hamburg Phone: +49 (0) 40 734 12 - 127 Fax: +49 (0) 40 734 12 - 101 http://www.pfannenberg.de

6.3 Compressed air

6.3.1 Using compressed air

The functions listed in the following table use compressed air.

Table 6- 6 Using compressed air

Functions using compressed air	Description
Actuating the pneumatic cylinder	• The tool is clamped in and released from the tool adapter using the pneumatic cylinder • The minimum pressure must be maintained • Compressed air is only used when clamping and releasing the tool • Particles in the compressed air are relatively non-critical
Bearing sealing air	• A high degree of purity is required (refer to Chapter Conditioning the compressed air (Page 89)) • A continuous airflow is required
Air purge	• Protects the tool adapter from becoming dirty - between ejecting the old tool and inserting the new tool • Purge air is only used while the tool is being changed • An average degree of purity is required

It is the responsibility of the machinery construction company/operating company to provide the compressed air in the required quality and quantity. The machinery construction company is responsible in controlling the individual compressed air flows.

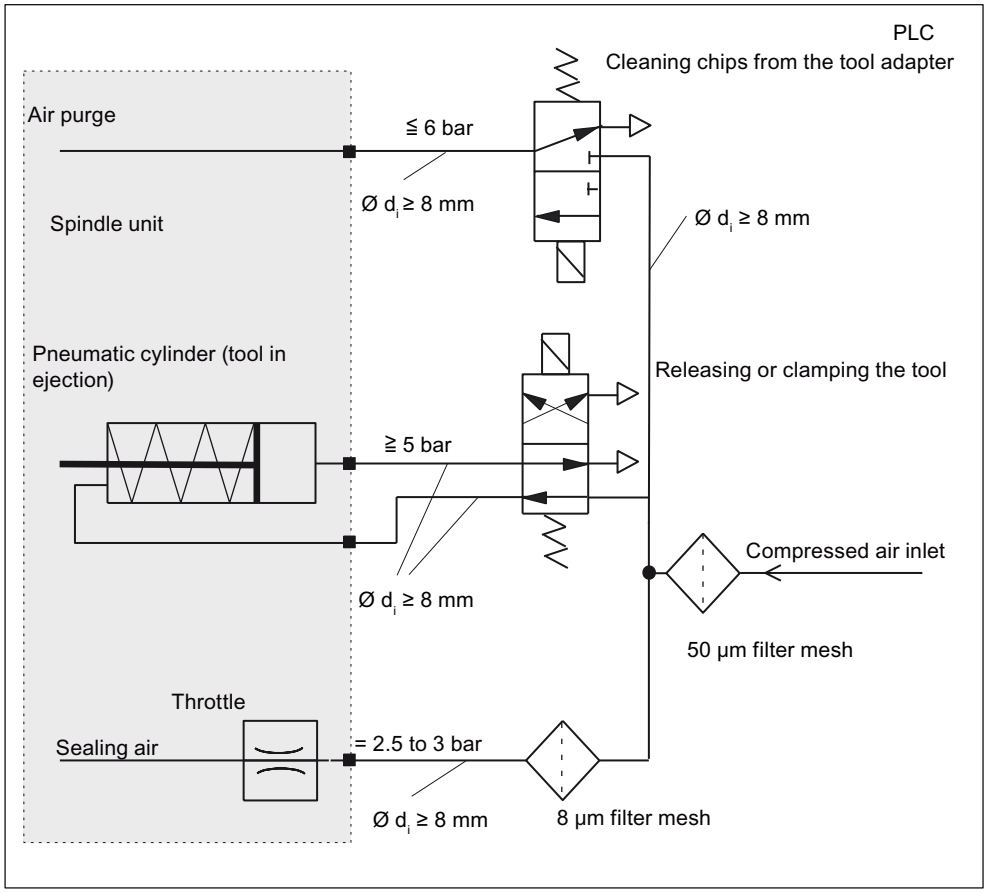


Figure 6-2 Recommended pneumatic system

6.3.2 Compressed air connections

All of the connections are compressed air feed connections (inlet). The compressed air which has been used is discharged to the environment.

Table 6- 7 Compressed air connections for 2SP120

	Pneumatic cylinder		Sealing air	Air purge
Function	Release tool, air inlet	Clamp tool, air inlet	Air inlet	Air purge inlet
Connection fitting (on the spindle side)	1 x G3/8" (inner thread) for hose ∅ ≥ 8 mm	1 x G1/8" (inner thread) for hose ∅ ≥ 8 mm	Radial: G1/8" (inner thread) Axial: ∅ 5.0 mm (provide a 6 x 2mm O ring) for hose ∅ ≥ 8 mm	G1/4" (inner thread) for hose ∅ ≥ 8 mm
Connection code (on the spindle side) 1)	VIIa	VIIIa	V	IX
Perm. tightening torque	30 Nm	20 Nm	20 Nm	40 Nm

1) Connection code refer also to chapter, dimension drawings

Table 6- 8 Compressed air connections for 2SP125

	Pneumatic cylinder		Sealing air	Air purge
Function	Release tool, air inlet	Clamp tool, air inlet	Air inlet	Air purge inlet
Connection fitting (on the spindle side)	M16 x 1.5 (inner thread) for hose ∅ ≥ 8 mm	G1/8" (inner thread) for hose ∅ ≥ 8 mm	Radial: G1/8" (inner thread) for hose ∅ ≥ 8 mm	G1/4" (inner thread) for hose ∅ ≥ 8 mm
Connection code (on the spindle side) 1)	X	XI	V	IXa
Perm. tightening torque	30 Nm	20 Nm	20 Nm	40 Nm

1) Connection code refer also to chapter, dimension drawings

NOTICE
The feeder lines and hoses to the connections must be flexible and strain relieved. Rigid pipe connections are not permissible.

6.3.3 Conditioning the compressed air

In addition to the different minimum requirements placed on the supply of the compressed air functions, the conditions, listed in Table "Conditioning" must be maintained.

Table 6- 9 General compressed air conditioning

Min. air inlet temperature [°C]	Ambient temperature
Max. air inlet temperature	35 °C
Max. residual water content	0.12 g/m^3
Max. residual oil content	0.01 mg/m^3
Max. residual dust	0.1 mg/m^3

Table 6- 10 Conditioning

	Minimum pressure [pa]	Maximum pressure [pa]	Max. particle size [µm]
Pneumatic cylinder	$5 \cdot 10^5$ (5 bar)	$10 \cdot 10^5$ (10 bar)	50
Sealing air	$2.5 \cdot 10^5$ (2.5 bar)	$3 \cdot 10^5$ (3 bar)	8
Air purge	$5 \cdot 10^5$ (5 bar)	$6 \cdot 10^5$ (6 bar)	50

6.3.4 Hydraulic fluid flow data and controlling the hydraulic fluid flow requirement

The compressed air functions should only be switched-in when actually required in order to minimize the air requirement.

NOTICE
The sealing air must be permanently active to protect the bearings as long as the motor spindle is operational.

Table 6- 11 Air requirement

Compressed air function	Air flow requirement [Nl]	Controlling the air flow requirement
Pneumatic cylinder	Air usage per tool change 2SP120: 800 cm^3/cycle 2SP125: 846 cm^3/cycle	Air only flows when changing a tool (releasing and clamping)
Air purge	2.1 Nm^3/h for five tool changes per minute.	Compressed air only has to be switched-in when the old tool is ejected up to when the new tool is drawn-in
Sealing air	1-1.5 Nm^3/h [1)]	The compressed air must be switched-in when the machine is powered-up

1) 1 Nm^3 = standard cubic meters

6.3.5 Standalone units to generate compressed air

An external compressor must be used to provide the compressed air and appropriately condition it. The compressor equipment is not included with the spindle.

If the machine construction company uses a separate compressor, storage device and pressure controller for the compressed air generating system, then the structure, as shown in the following diagram is recommended.

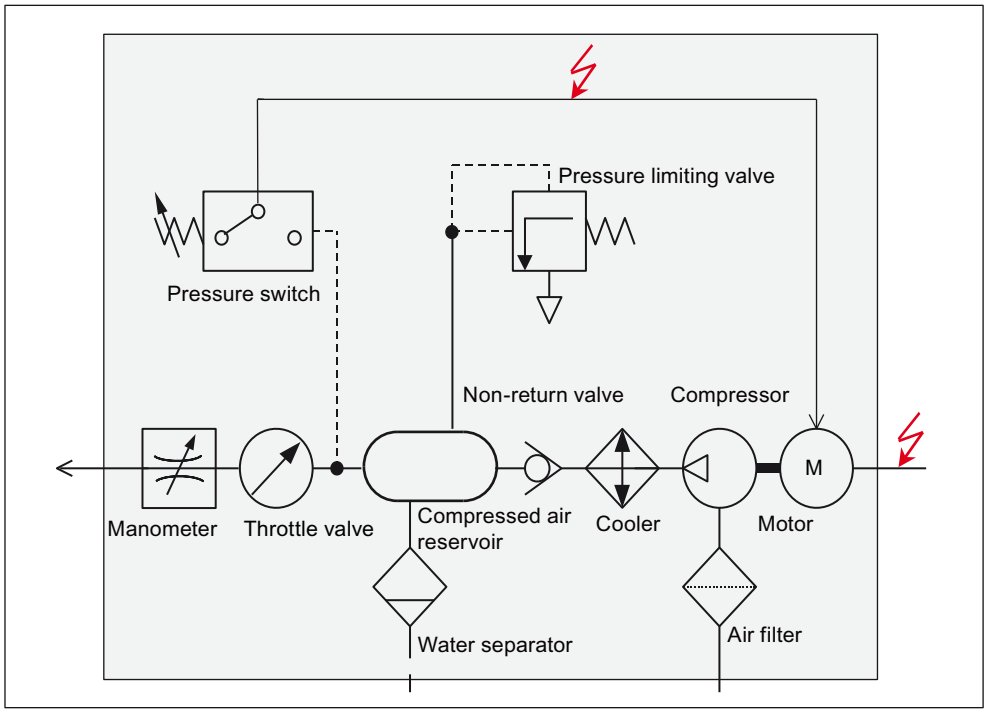


Figure 6-3 Recommended circuit-diagram of a compressed air system

6.4 Hydraulic (option, only for 2SP120)

6.4.1 Using hydraulics

Hydraulics is used to clamp and release the tool adapter.

Table 6- 12 Using hydraulics

Hydraulic functions	Description
Actuating the hydraulic cylinder	• The tool is clamped in the tool adapter and released from it using the hydraulic cylinder • The minimum pressure must be maintained • Hydraulics are only required when clamping and releasing the tool • Particles in the compressed air are relatively non-critical

The machinery construction OEM is responsible for:

- Providing the required quality and quantity of hydraulic fluid
- Controlling the individual hydraulic fluid flows

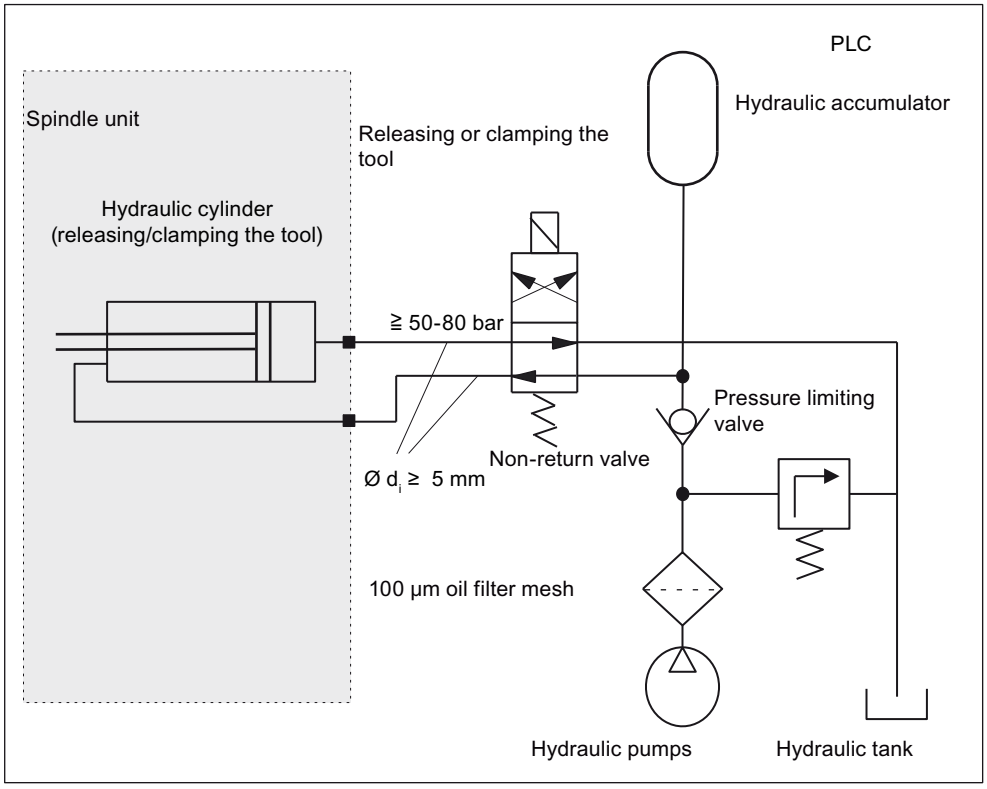


Figure 6-4 Recommended hydraulic system layout

6.4.2 Hydraulic connections

All of the connections only comprise a hydraulic fluid feed.

Table 6- 13 Technical data for the hydraulic control of the hydraulic cylinder

	Hydraulic cylinder	
Function	Release tool	Clamp tool
Connection fitting (on the spindle side)	G1/4"	G1/4"
Connection code (on the spindle side) 1)	VII	VIII
Perm. tightening torque	40 Nm	40 Nm
Release/clamping pressure	50 to 80 bar	
Max. particle size	100 µm	

1) Connection code refer also to chapter, dimension drawings

NOTICE
The feeder lines and hoses to the connections must be flexible and strain relieved. Rigid pipe connections are not permissible.

6.4.3 Hydraulic fluid flow data and controlling the hydraulic fluid flow requirement

The hydraulic functions should only be switched-in when actually required in order to minimize oil usage.

6.5 Internal tool cooling using the cooling-lubricating medium (option)

The 2SP1 motor spindle is optionally available with the inner tool cooling function. In this case, cooling-lubricating medium is fed through a rotary gland from the rear of the shaft through the spindle shaft to the tool. The user must appropriately condition and provide this cooling-lubricating medium in order to guarantee the service lifetime of the rotary gland.

The "internal tool cooling with cooling-lubricating medium" can only be retrofitted with the spindle removed and only by an authorized repair workshop.

Table 6- 14 Connecting the internal tool cooling

	Cooling-lubricating medium inlet	**Leakage drain**
Connection fitting (on the spindle side)	G1/4" (inner thread)	G1/8" (inner thread)
Connection code (on the spindle side)	For 2SP120: X For 2SP125: IXb	IV
Permissible tightening torque [Nm]	40	20

CAUTION

It is not permissible to use a rigid pipe connections.

The piping must be free of any tension and pressure as well as bending torque and torsion. The piping may not be subject to tensile stress - neither when pressurized nor under a no-pressure condition.

The piping may not exert any torsion on the connection fitting of the cooling-lubricating medium feed. Flexible hoses with the appropriate loop must be used to make the connection.

NOTICE

Small cooling-lubricating medium leaks will occur in operation, especially when tools are being changed. The leaked cooling-medium fluid is collected in the cooling-lubricating medium gland from where it can drain.

The fluid must be able to freely drain from the pipes.

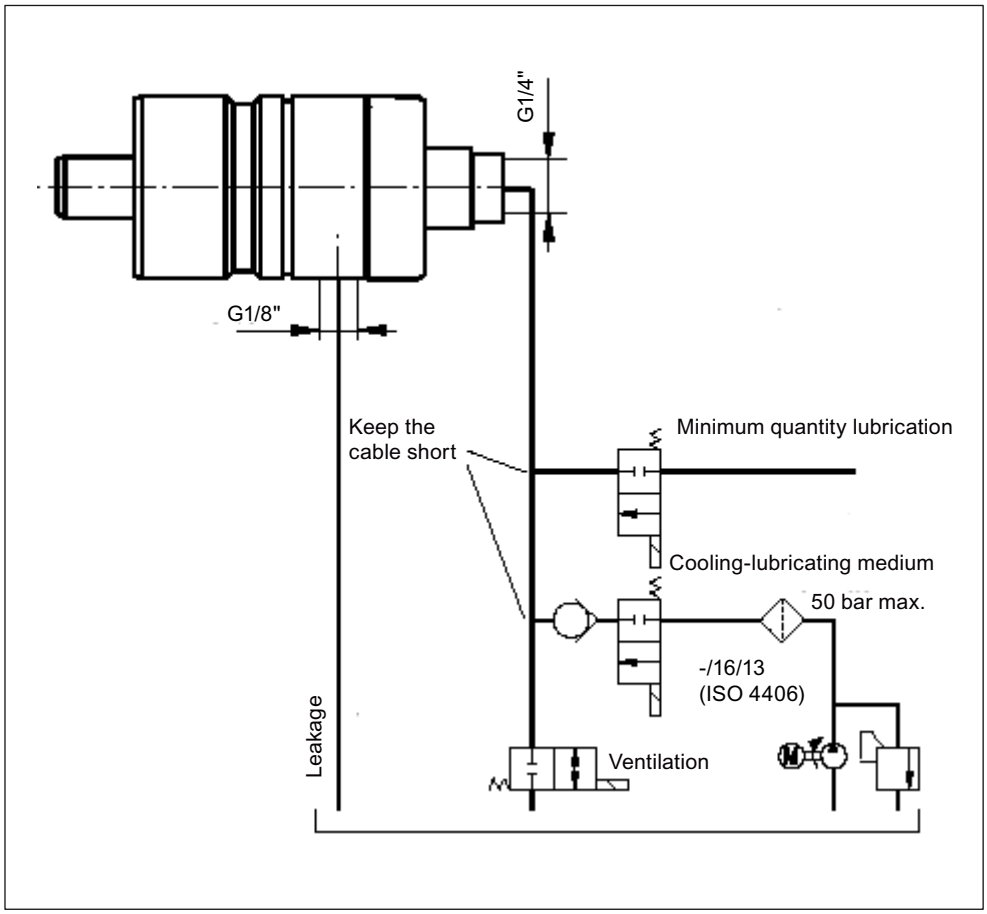


Figure 6-5 Connections for various media

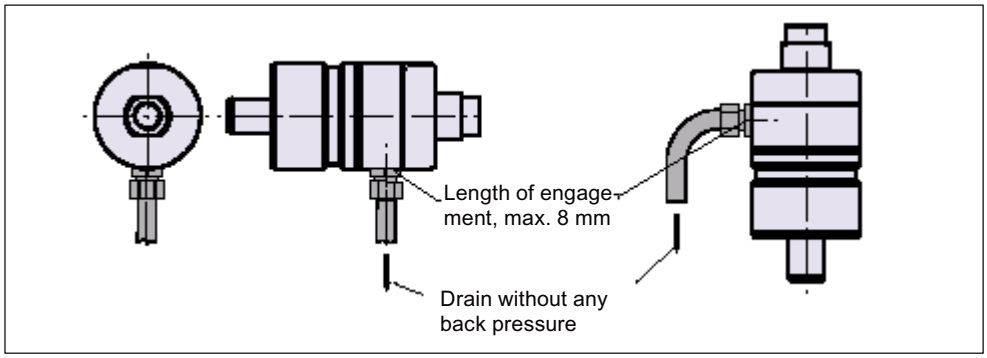


Figure 6-6 Drain connection

6.5.1 Operating conditions

The data in the following table apply for the cooling-lubricating medium flow when the spindle is being operated.

Table 6- 15 Data of the cooling-lubricating medium gland

	Value	Comments
Max. pressure	50 10^5 Pa (50 bar)	
Max. speed	18000 rpm	Also under no pressure conditions
Max. particle size	50 µm	Cooling-lubricating medium acc. to ISO 4406 (-/16/13)
Max. cooling-lubricating medium temperature	40 °C	
Max. flow rate	54 l/min	Dependent on the pressure
Pressure loss	2.7 10^5 Pa (2.7 bar)	
Frictional torque	0.3 Nm	

The frictional torque of the cooling-lubricating medium gland means that its temperature increases and reduces the available maximum torque.

Table 6- 16 Permissible media for the internal tool cooling

Operation with cooling-lubricating medium	The flow must be guaranteed
Operation with a minimum quantity of cooling-lubricating medium	Mixture, maximum 5 bar
	Lubricating medium percentage, minimum 10 ml/h
	Lubrication must be guaranteed
	2/2 way valve must permit unrestricted flow (due to possible separation) (e.g. ball-type valve)
	Cooling-lubricating medium and compressed air may never be simultaneously applied to the MQL system
Dry machining without compressed air	The line must be vented; there may be no residual pressure

When changing a tool, to clean the tool cone/nose at standstill, compressed air can be fed-in through the integrated cooling-lubricating medium gland.

CAUTION
The cooling-lubricating medium must be conditioned so that pressure peaks in the feeder line are avoided. The maximum permissible pressure may never be exceeded - even during pressure peaks. The integrated cooling-lubricating medium gland is not suitable to feed-in hydraulic fluids and compressed air while the spindle is rotating. Only suitable tools with a through hole which allows the cooling-lubricating medium to be discharged may be used when feeding-in cooling-lubricating medium for internal tool cooling; there must always be a transfer pipe to connect the tool to the clamping system so that no fluid is lost. If unsuitable tools are used, then the grease is flushed-out of the tool gripper and, depending on the pressure, can cause failure of the spindle or the rotary gland.

6.6 External tool cooling with the cooling-lubricating medium (option only for 2SP120x)

The 2SP120x motor spindle is optionally available with the "external tool cooling" function. The "external tool cooling with cooling-lubricating medium" function can also be retrofitted on spindles that have already been supplied.

The "external tool cooling" function is implemented using a ring that is mounted at the motor spindle flange. The ring is available with adjustable spray nozzles or with threaded holes so that customer-specific spray nozzles can be used.

The cooling-lubricating medium is fed-in either through an axial or radial connection at the stationary mounting flange of the spindle. The connection that is not used must be sealed.

The cooling-lubricating medium jet can be aligned using the manually adjustable spray nozzles so that the cooling-lubricating medium cools the tool and the workpiece from the outside. In order to guarantee the function of the spray nozzles, the user must appropriately condition the cooling-lubricating medium (refer to Chapter Operating conditions (Page 98)).

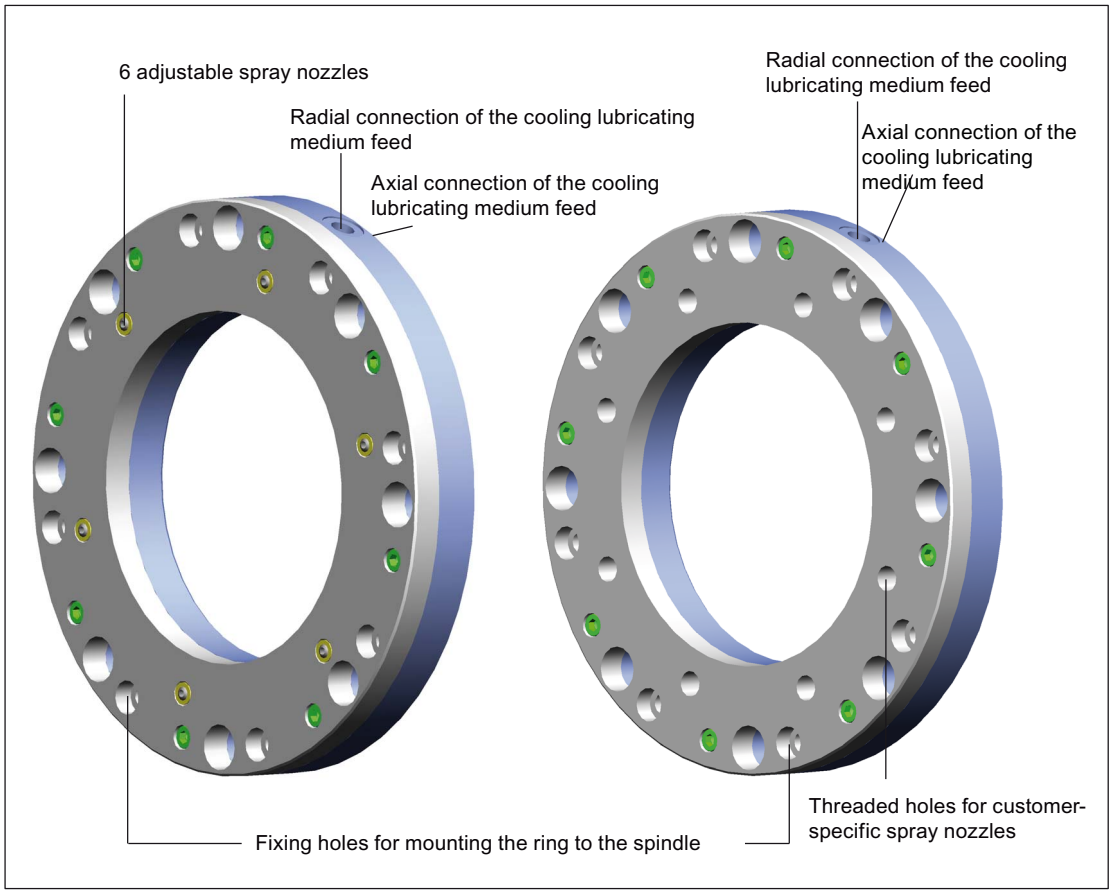


Figure 6-7 Left-hand side: Ring with the adjustable spray nozzles for the external tool cooling; Righthand side: Ring with threaded holes to screw-in spray nozzles or link chains for external tool cooling

Table 6- 17 Connection for the external tool cooling (for 2SP120)

	Connection, cooling-lubricating inlet	
	Axial	**Radial**
Connection fitting (on the spindle side)	Hole Ø 8.8 mm prepared for O-ring 11 x 2 mm	G1/4" (inner thread)
Connection code (on the spindle side) 1)	XI	XI
Perm. tightening torque	-	40 Nm
Cooling-lubricating medium outlet via adjustable spray nozzles (standard)	6 spray nozzles, adjustable from 0-30 °	
Cooling-lubricating medium outlet through threaded holes for customer-specific spray nozzles (option)	Threaded holes 8 x G1/4"	

1) Connection code refer also to chapter, dimension drawings

CAUTION
It is not permissible to use a rigid pipe connections. The piping must be free of any tension and pressure as well as bending torque and torsion. The piping may not be subject to tensile stress - neither when pressurized nor under no-pressure conditions. The piping may not exert any torsion on the connection fitting of the cooling-lubricating medium feed. Flexible hoses with the appropriate loop must be used to make the connection.

6.6.1 Operating conditions

The data in the following table apply for the cooling-lubricating medium flow when the spindle is being operated.

Table 6- 18 Data of the external tool cooling with cooling-lubricating medium

	Value	Comments
Max. pressure	$5 \cdot 10^5$ Pa (5 bar)	
Max. particle size	50 µm	Cooling-lubricating medium acc. to ISO 4406 (-/16/13)
Max. cooling-lubricating medium temperature	40 °C	
Max. flow rate	Dependent on the pressure	

CAUTION
The cooling-lubricating medium must be conditioned so that pressure peaks are avoided. The maximum permissible pressure may not be exceeded.

6.7 Media connections and coding

6.7.1 Media connections for 2SP120x

Table 6- 19 Media connections for 2SP120x (on the spindle side)

Description	Coding 1)	Connection fitting
Motor cooling inlet	I	Connector for hose ∅ 12/10 mm
Motor cooling outlet	II	Connector for hose ∅ 12/10 mm
Sealing air inlet	V	G1/8" radial or axial above the ∅ 5 mm hole for sealing 6 x 2 mm
Release tool, air inlet	VIIa	1 x G3/8"
Clamp tool, air inlet	VIIIa	1 x G1/8"
Release tool, hydraulic inlet	**VII**	**G1/4"**
Clamp tool, hydraulic inlet	**VIII**	**G1/4"**
Air purge inlet	IX	G1/4"
Internal tool cooling with cooling-lubricating medium		
Cooling-lubricating medium inlet	**X**	**G1/4"**
Leakage drain	**IV**	**G1/8"**
External tool cooling with cooling-lubricating medium		
Cooling-lubricating medium inlet	**XI**	**G1/4" radial or axial above the ∅ 8.8 mm hole for sealing 11 x 2 mm**
Leakage drain	**IV**	**G1/8"**

In bold = option

1) Connection code refer also to chapter, dimension drawings

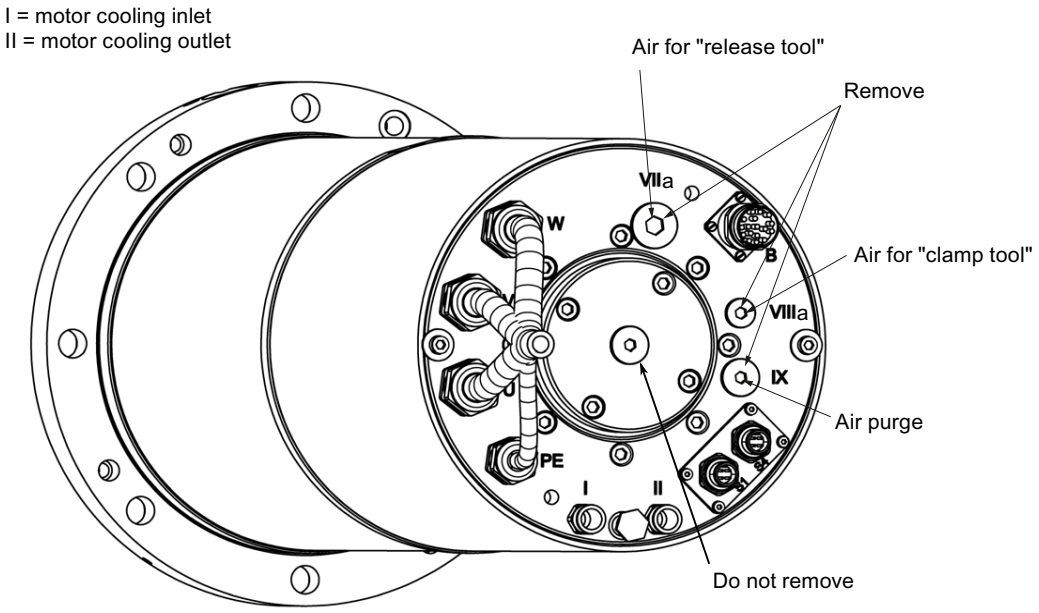


Figure 6-8 ECS-M pneumatic 2SP120x-1Hx2x-xxxx without rotary gland

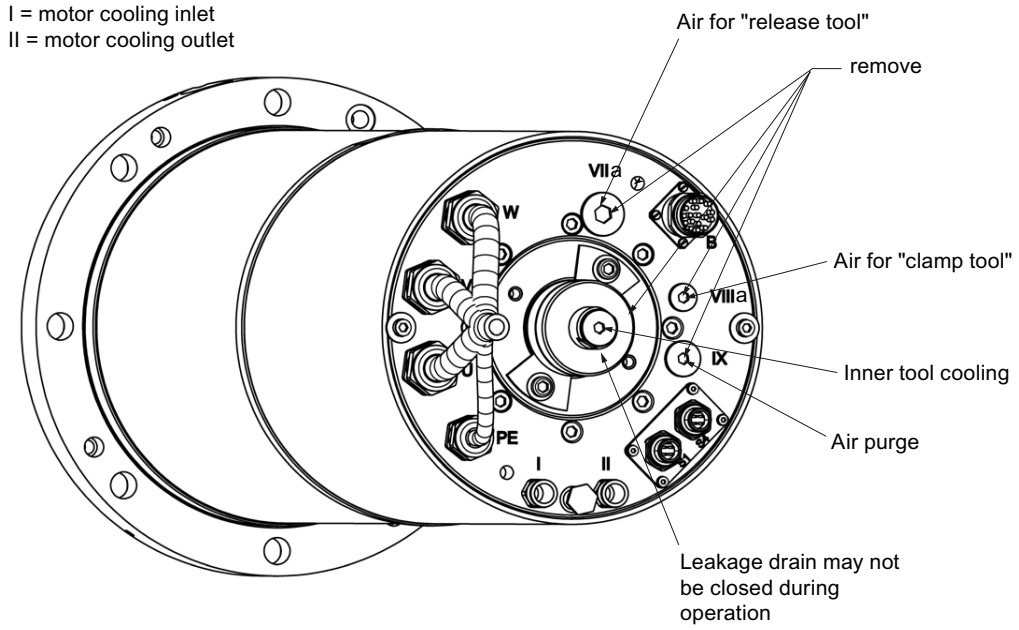


Figure 6-9 ECS-M pneumatic 2SP120x-1Hx2x-xxxx with rotary gland

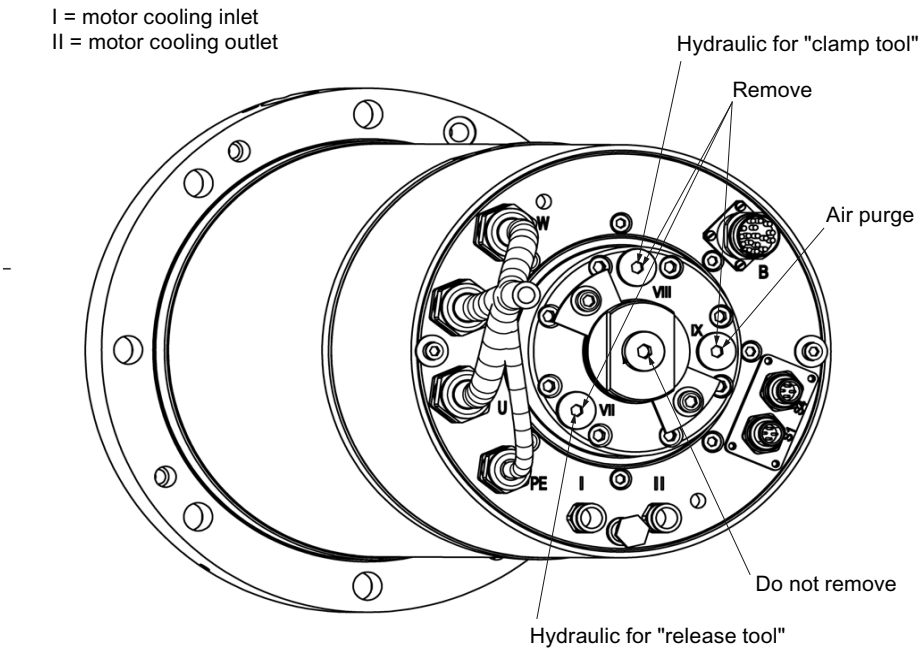


Figure 6-10 ECS-M hydraulic 2SP120x-1Hx3x-xxxx without rotary gland

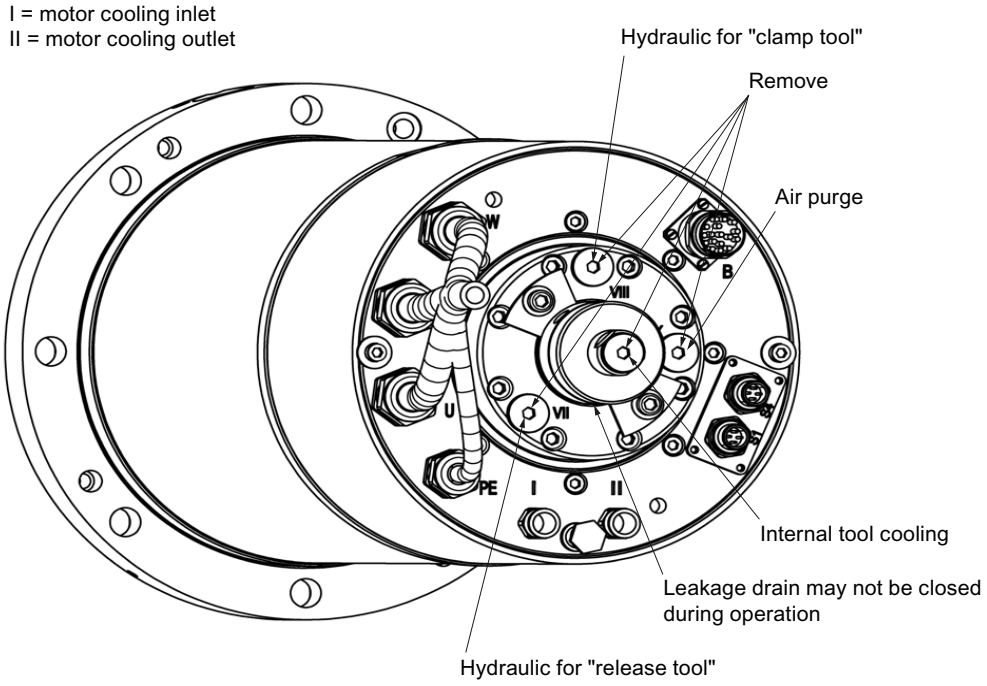


Figure 6-11 ECS-M hydraulic 2SP120x-1Hx3x-xxxx with rotary gland

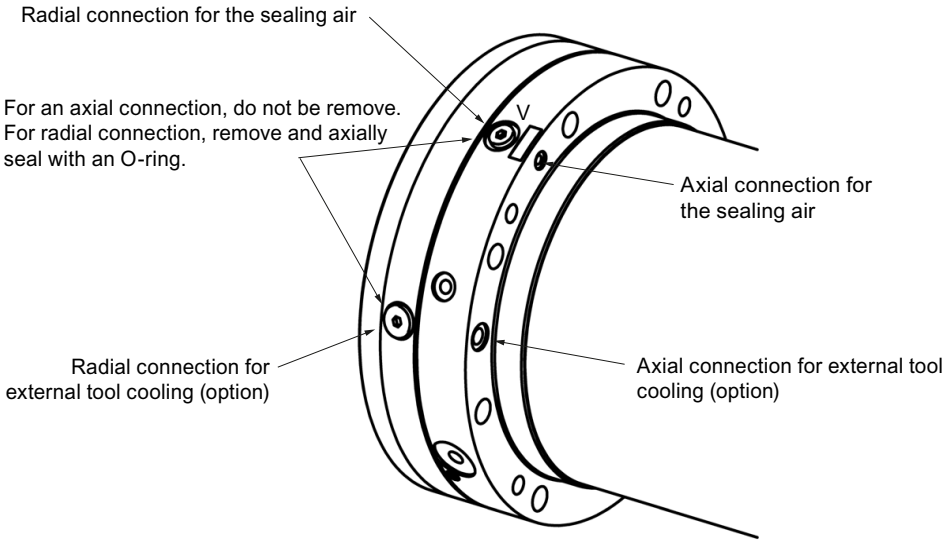


Figure 6-12 ECS-M 2SP120x optional external cooling-lubricating medium

6.7.2 Media connections for 2SP125x

Table 6- 20 Media connections for 2SP125x (on the spindle side)

Description	Coding 1)	Connection fitting
Motor cooling inlet	I	G1/2"
Motor cooling outlet	II	G1/2"
Sealing air inlet	V	G1/8"
Release tool, air inlet	X	M16 x 1.5
Clamp tool, air inlet	XI	G1/8"
Air purge inlet	IXa	G1/4"
Internal tool cooling with cooling-lubricating medium		
Cooling-lubricating medium inlet	**IXb**	**G1/4"**
Leakage drain	**IV**	**G1/8"**

In bold = option

1) Connection code refer also to chapter, dimension drawings

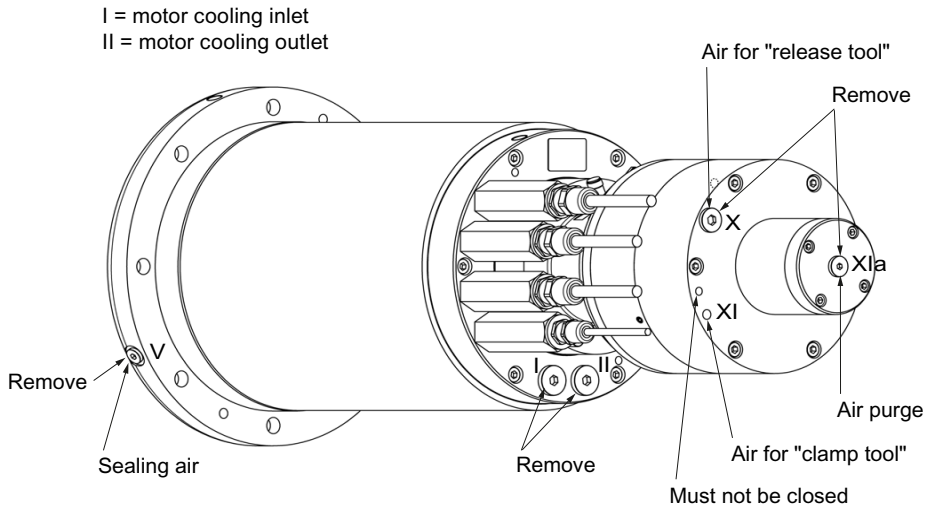


Figure 6-13 ECS-L 2SP125x without rotary gland

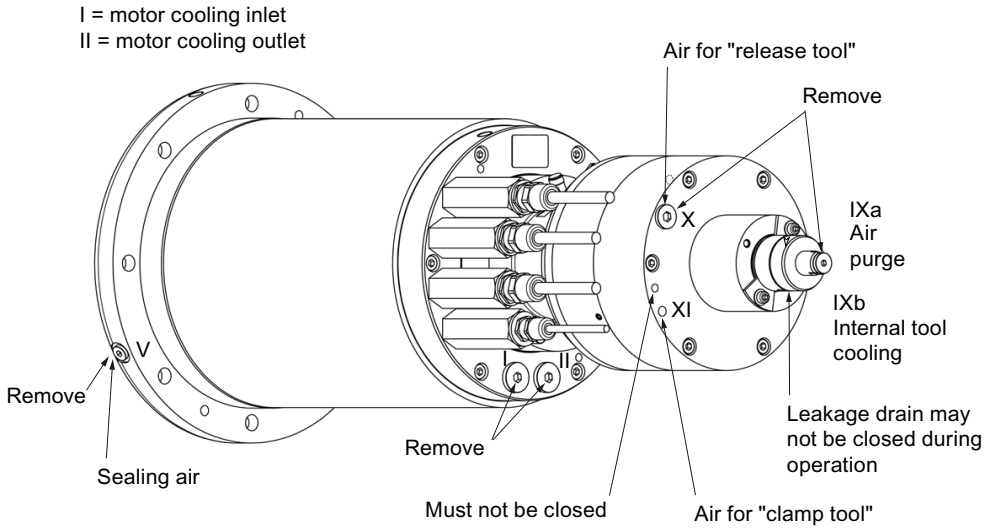


Figure 6-14 ECS-L 2SP125x with rotary gland

Sensors

7

7.1 Encoder/angular encoder

7.1.1 Electrical signals

2SP1 motor spindles are equipped with a hollow-shaft incremental encoder with 256 pulses. It is rugged and is insensitive to shock stressing and accumulated dirt.

The encoder works on a magnetic principle. The encoder has

- one sinusoidal signal
- one cosinusoidal signal
- one reference signal

The sine-cosine signal is suitable for fine interpolation.

The reference signal supplies one pulse at each shaft revolution and allows the shaft angle to be referenced.

For a synchronous motor, the reference pulse indicates the positive zero crossover of phase U (with a clockwise rotating field). The encoder interface is electrically and functionally compatible to the encoders used for SIEMENS main spindle motors.

Table 7- 1 Designation of the encoder signals

Signal	Designation for a non-inverted electrical signal	Designation for an inverted electrical signal	Designation for a differential signal
Sinusoidal	A	A*	A
Cosine	B	B*	B
Reference	R	R*	R

Electrical signals

The signal data comprises, electrically, two individual signals - an inverted and a non-inverted signal. The individual signals have a DC voltage component with a magnitude of half of the encoder power supply voltage. The differential signal of 1 V_{pp} is obtained in the encoder interface of the drive converter by subtracting the individual signals (refer to the following diagram). As a result of this subtraction, the DC voltage component of the signal track disappears and the signal amplitude doubles with respect to the individual signal.

This differential signal is relevant for the subsequent encoder evaluation. The features and properties of the differential signal are described in the following.

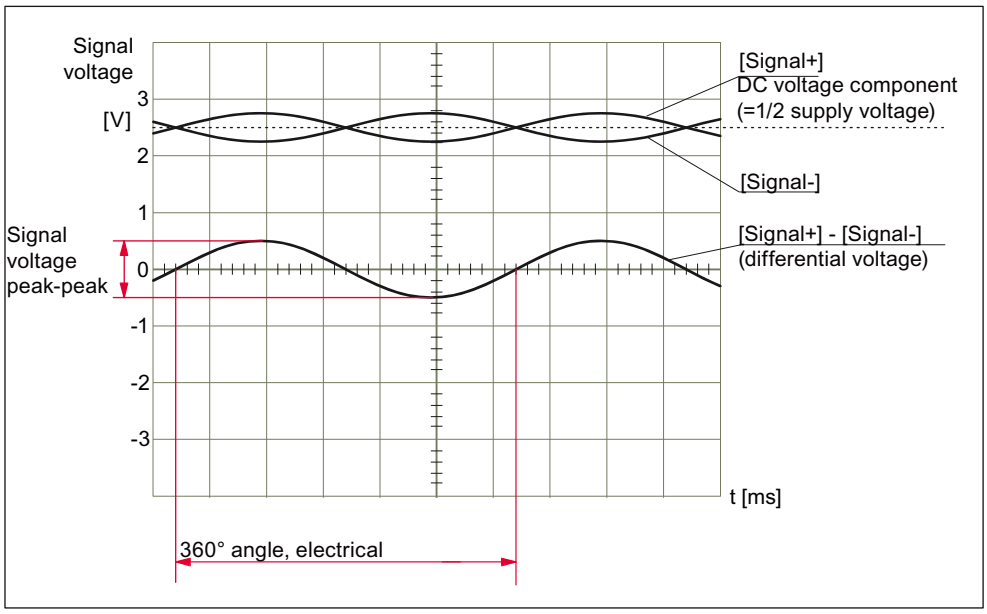


Figure 7-1 Electrical signal level

Phase position of the reference signal

The phase position of the maximum of the reference signal is centered between the sinusoidal and cosinusoidal signals. The maximum deviation from the theoretical value is designated in the encoder data table as clear signal range α (see the diagram below).

Phase position of the sine/cosine signals

The phase offset between the sinusoidal and cosinusoidal signal is 90 °. The maximum deviation from the theoretical value is designated in the encoder data table as β (see the diagram below).

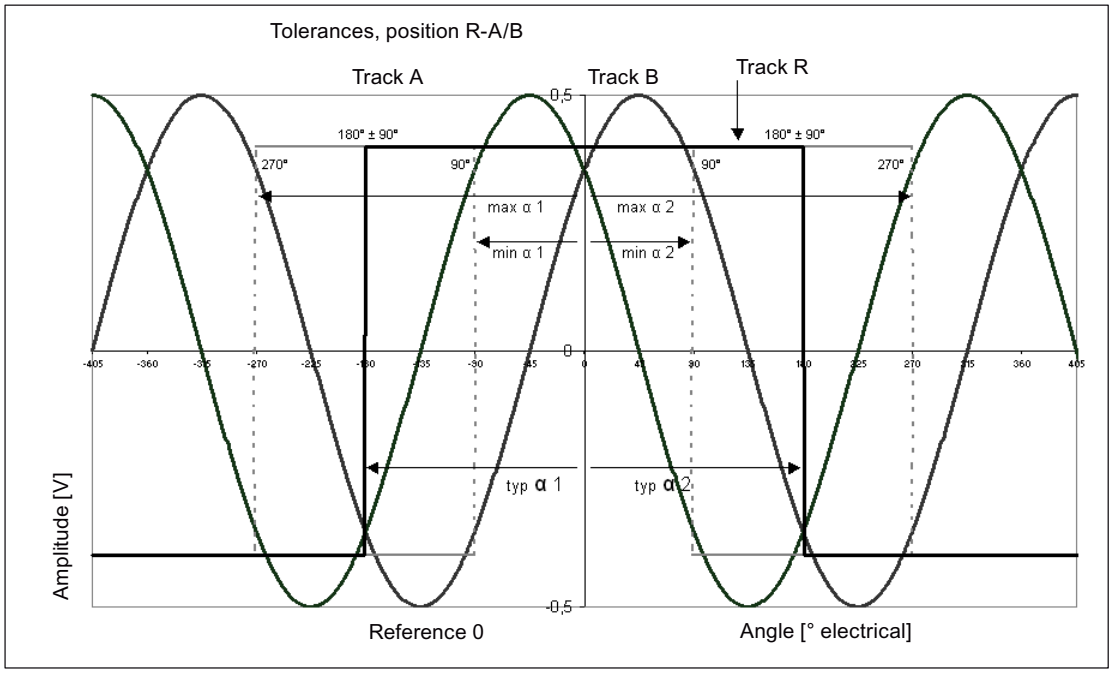


Figure 7-2 Clear signal range of the reference track; phase relationship between the sinusoidal and cosinusoidal signal

DC voltage offset

The signals can have a DC voltage offset (refer to the following diagram). The maximum offset voltages of the two incremental signals (sine, cosine) and the reference signal are specified in the encoder data table.

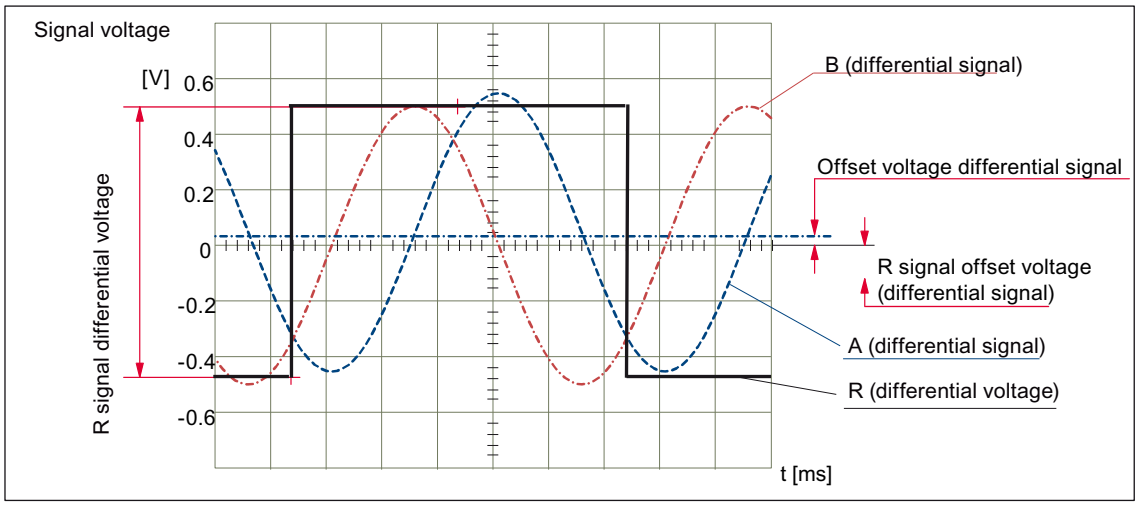


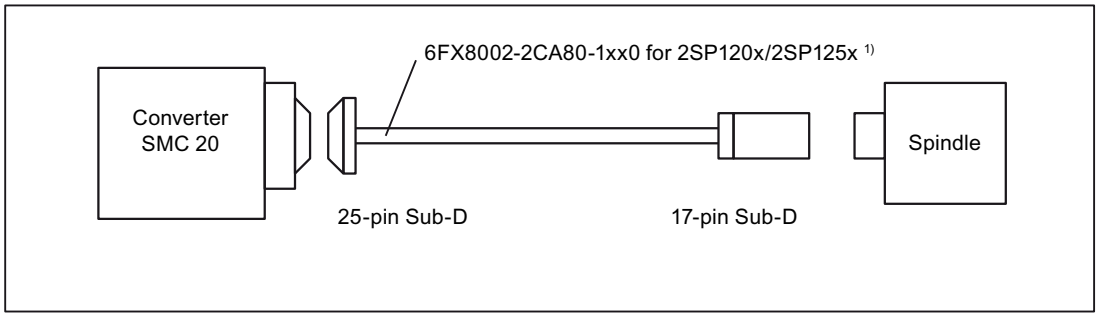
Figure 7-3 Offset voltages of the encoder signals

Table 7- 2 Electrical data of the incremental encoder

	Comments	Unit	Characteristic values		
Supply voltage		V	5 ±5 %		
Supply current		mA	40 (typical)		
			min.	typical	Maximum
Signal amplitude (A ; B)	Differential signal	V_{pp}	0.75	1.00 ... 1.10	1.20
Signal ratio (A ; B)			0.9	0.95 ... 1.05	1.1
Phase shift β	between A and B	° el.	-5	-2 ... +2	+5
Signal offset	Differential signal	mV	-60	-15 ... +15	+60
Signal voltage R	Differential signal	V	0.4	1.0	1.2
Offset R signal		mV	-400	-450	-500
Clear signal range α		° el.	-200	-160... +160	+200

7.1.2 Connecting the signal lines

The signal cable is connected through a 17-pin flange-mounted socket. Pre-assembled (MOTION-CONNECT) cables should be used to connect the encoder to the drive converter.



1) This avoids signals from the additional temperature sensors for third-party systems from being coupled-into the closed-loop control

Figure 7-4 Signal cable without the temperature sensor brought out

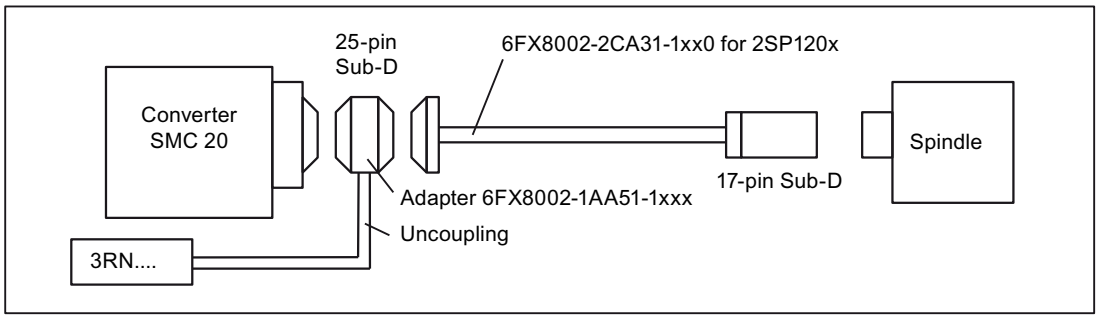
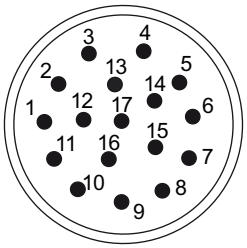


Figure 7-5 Signal cable with the temperature sensors, PTC, NTC brought out

Pin assignment

Table 7- 3 Pin assignment for the encoder connection (17-pin flange-mounted socket)

Pin No.	Conductor color	Signal	View of the connector side
1	Blue	A	
2	Red	A*	
3	Green	R	
4	Brown	PTC, NTC K227 2)	
5	White/brown	NTC K227, NTC PT3-51F 2)	
6	White	NTC PT3-51F 2)	
7	Black	M encoder	
8	Black	+ KTY 84 1)	
9	White	- KTY 84 1)	
10	White	P encoder	
11	Gray	B	
12	Yellow	B*	
13	Brown	R*	
14	White	PTC 2)	
15	Violet	M sense	
16	Orange	P sense	
17		not connected	

1) 2-conductor temperature sensor lead

2) Connections of additional temperature sensors for spindle 2SP120x

For additional information on the signal cables, refer to Catalog NC 61, Chapter "Connection system".

7.1.3 Commutation angle

NOTICE
With synchronous spindles, the angle must be determined or entered when the spindle is first commissioned or when the spindle is replaced!

The "installed" permanent magnetic field of the rotor must be synchronized with the electrically generated magnetic field of the stator. This enables the two magnetic fields of the stator and rotor to be optimally superimposed on one another.

This "synchronization angle" relative to the zero mark of the encoder system can be measured and saved in the drive system (commutation angle offset).

Pole position identification / determining the commutation angle for SINAMICS

1. Select a Motor Module and select the (closed-loop) control type "Speed control with encoder".
2. Select the motor spindle from the motor selection list; then press the "Continue" key.
3. Select a speed encoder (hollow-shaft incremental encoder, 1 V_{pp}); then press the "Enter data" key.
4. The pole position identification routine provides coarse synchronization. The encoder has a zero mark, therefore, after the zero mark has been crossed, the pole position can be automatically adjusted to the zero mark position (fine synchronization). The zero mark position must be electrically adjusted (p0431). Fine synchronization is recommended (p0404.15 = 1), as it avoids measurement spread and allows the determined pole position to be automatically checked.
5. "Pole position identification" must be selected in the encoder data screen under coarse synchronization. "Zero marks" should be selected for fine synchronization. The other fields are already pre-assigned. The "Saturation-based 1st + 2nd harmonic" is selected and acknowledged using "Pole position ID parameter".
6. The configuration has been completed once the Wizards have been completed and data has been downloaded into the drive. The correct pole position identification technique (p1980) is pre-assigned with the motor-specific identification currents (p0325, p0329) and their selection (p1982).
7. Before determining the commutation angle offset, the control sense of the drive should be checked, i.e. for motor clockwise rotation, the encoder must supply positive speed actual values in r0061.
8. The correct commutation angle offset (p0431) should be determined by selecting p1990 = 1. In the expert list, switch-on the drive using the commissioning tool (control panel) (PLI is performed) p1990 = 1. Then enter a low speed setpoint. After the zero mark has been crossed for the first time, the determined commutation angle offset is automatically entered into p0431. Alarm A07971 is output during the determination routine. p1990 is automatically set to the value of 0 at the end of the measurement.
9. The automatically determined value in p0431 should be subject to a plausibility check. Several techniques are recommended in the parameter description for p1990 (see SINAMICS S120/S150 List Manual LH1).

If the angle is already known (e.g. final acceptance report), then this value should be used to check the value that has been determined.

Note

Deviations > 5°

For deviations > 5°, the authorized technical personnel of the manufacturer must be contacted.

7.2 Clamping state sensors

For a function description, see Chapter Clamping system and tool change (Page 59).

Integration into the control, refer to Chapter Analog and digital sensors of the 2SP120 spindle (Page 112) .

7.2.1 Analog and digital sensors of the 2SP120 spindle

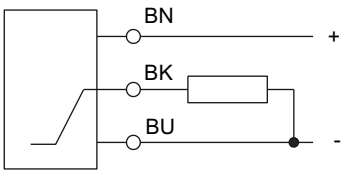
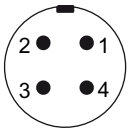
Information on the sensor systems to monitor the tool clamped status (analog sensor S1) and to monitor the position of the piston of the release unit (digital sensor S4).

Connection

Connectors are used to connect-up the sensors (refer to drawings, Chapter Technical data and characteristics (Page 139)).

The cables that are used to connect-up the sensors are not included with the spindle. These cables are commercially available as standard products.

Table 7- 4 Electrical data and mechanical design of the connector for the clamping state sensor (analog)

Sensor S1 to display the clamped state (analog)	
Type	Analog sensor
	1 = +24 V 2 = not assigned 3 = 0 V 4 = analog signal 
Output signal	0 ... 10 V
Operating voltage	15 ... 30 V DC
Rated operating voltage	24 V DC
Nominal clearance	3 mm
Residual ripple	≤15 % of Ue
Max. linearity error	±3% of Ua
Max. operating point offset	± 0.3 mm
Linearity range	1 ... 5 mm
Connection	Connector
Short-circuit protection	Yes
Reverse polarity protection	Yes

Sensor S1 to display the clamped state (analog)	
Connector (plug) at the cable end (on the spindle side)	Binder series 763, 4 pins, 763-09-3431-116-04
Connector (socket) at the sensor cable	• Type, Siemens: – Axial: 3RX1535 – Radial: 3RX1548 (with LED) • Type, Balluff: – Axial: BKS-S19-4 – Radial: BKS-S20-4 (with LED)

The precise voltage values for the clamped states "draw bar in the release position", "tool clamped" and "clamped without tool" are specified in the acceptance report of the particular spindle.

Table 7- 5 Electrical data and mechanical design of the connector for the clamping state sensor (digital)

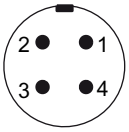
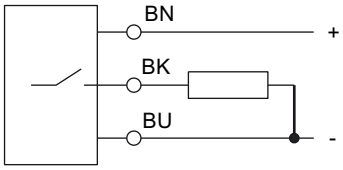
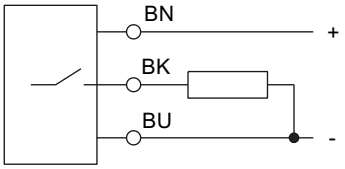
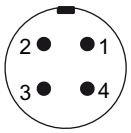
Sensors S1, S2, S3 to display the clamped state (digital)		
Pin arrangement at the sensor	**Connector at the sensor**	**Socket at the cable**
1: +U 2: not assigned 3: -U 4: Switching contact  		• Type, Siemens with connector outlet – Axial: 3RX1535 – Radial: 3RX1548 (with LED) • Type, Balluff with connector outlet – Axial: BKS-S19-4 – Radial: BKS-S20-4 (with LED)
	Plug contacts	Socket contacts
	M12 x 1	M12 x 1

Table 7- 6 Electrical data and mechanical design of the connector for the position sensor of the release unit

Sensor S4 to display the piston position of the release unit	
Type	Digital sensor
	1 = +24 V 2 = not assigned 3 = 0 V 4 = switching contact 
Output signal	PNP
Operating voltage	12 ... 30 V DC
Rated operating voltage	24 V DC
Rated operating current	100 mA
Repeat accuracy	≤5 % of Ue
Switching frequency	600 Hz
No-load current	≤ 12 mA
Connection	Connector
Short-circuit protection	Yes
Reverse polarity protection	Yes
Connector (plug) at the cable end (on the spindle side)	Binder series 763, 4 pins, 763-09-3431-116-04
Connector (socket) at the sensor cable	• Type, Siemens: – Axial: 3RX1535 – Radial: 3RX1548 (with LED) • Type, Balluff: – Axial: BKS-S19-4 – Radial: BKS-S20-4 (with LED)

7.2.2 Digital sensors of 2SP125 spindles

Information on the sensor system to monitor the tool clamped status (digital sensors S1, S2 and S3).

Table 7- 7 Electrical implementation of the clamping status sensors

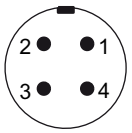
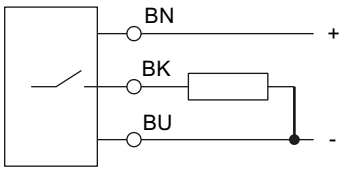
Supply	0 V		PIN 3
	+ 24 V	Max. tolerance ±20% Current requirement < 40 mA plus the load current	PIN 1
Switching contact	Switches to the pos. supply voltage	Active (H)	PIN 4
	Switches to the high-ohmic state	Inactive (L)	
Load capacity of the switching contact		200 mA max. **The following voltages are not permissible:** Greater than 5 V below the voltage at PIN 3 and greater than 5 V above the voltage at PIN 1 When an inductive load is connected to PIN 4, an appropriate measure must be provided to limit the voltage.	(PIN 4)

Connection

The clamping state sensors are contact-free transistor switches with a 3-wire connection. Connectors are used to connect-up the sensors (refer to drawings, Chapter Technical data and characteristics (Page 139)).

The cables that are used to connect-up the sensors are not included with the spindle. These cables are commercially available as standard products.

Table 7- 8 Mechanical implementation of the plug-in connection

Pin arrangement at the sensor	Connector at the sensor	Socket at the cable
1: +U 2: not assigned 3: -U 4: switching contact   		• Type, Siemens with connector outlet – Axial: 3RX1535 – Radial: 3RX1548 (with LED) • Type, Balluff with connector outlet – Axial: BKS-S19-4 – Radial: BKS-S20-4 (with LED)
	Plug contacts	Socket contacts
	M12 x 1	M12 x 1

7.3 Thermal sensors/motor protection

KTY 84 PTC thermistors are used to sense the motor temperature. These PTC thermistors are suitable to measure temperatures in an analog fashion.

Additional temperature sensors to sense the motor temperature using NTC thermistors are included in the 2SP120 spindle; they can be used together with third-party systems. Further, the 2SP120 spindle has additional temperature sensors that allow full motor protection to be implemented (e.g. for loads that are applied when the spindle is stationary or at low speeds).

Temperature evaluation using KTY 84

For SINAMICS S120, an external tripping device to evaluate the motor temperature is not required. The PTC thermistor function is monitored.

1. Pre-alarm temperature

   When the pre-alarm temperature is exceeded, the drive converter signals this using an appropriate fault signal.

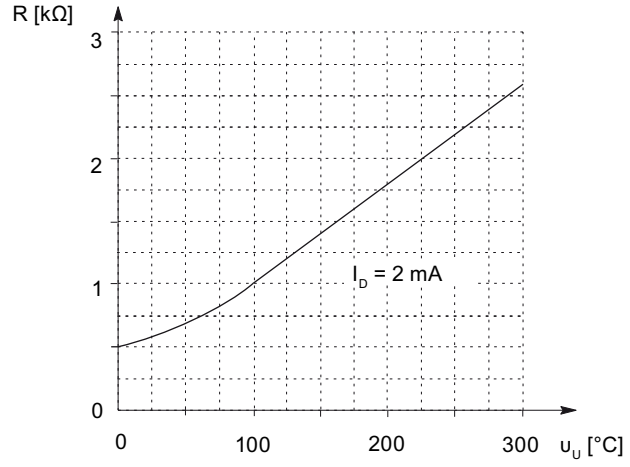
   This signal must be externally evaluated.

   The signal is withdrawn if the motor temperature < pre-alarm temperature.

2. Motor limit temperature

   When the motor limiting temperature is exceeded, the drive converter shuts down and signals this using an appropriate fault message.

Table 7- 9 Technical data of the KTY 84 PTC thermistor

Designation	Description
Type	KTY 84
Resistance when cold (20 °C)	Approx. 580 Ω
Resistance when hot (100 °C)	Approx. 1000 Ω
Connection	via signal cable (please observe the polarity!)
Temperature characteristic	

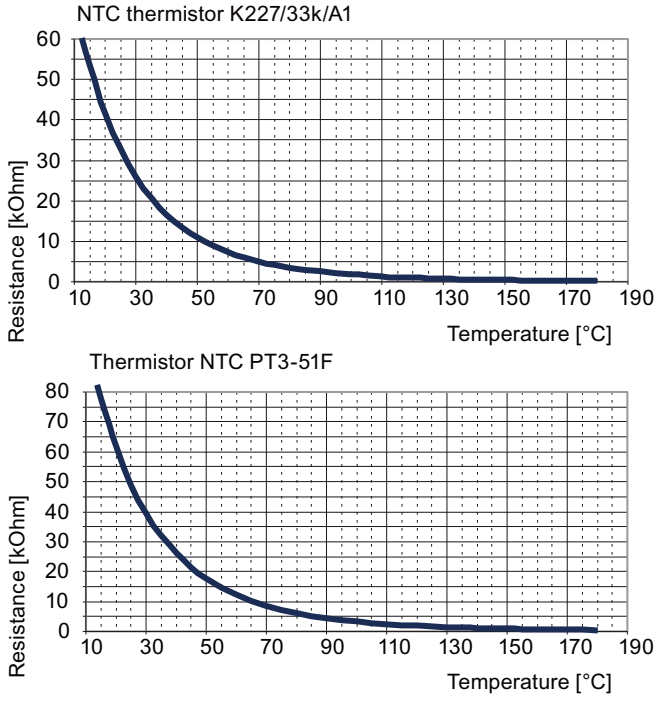
Temperature evaluation using NTC thermistors (spindle 2SP120)

Both NTC K227 and NTC PT3-51F thermistors are included as standard and are used if the drive converter cannot evaluate the KTY thermistor.

The drive converter senses and evaluates the motor temperature using the sensor signal (refer to the drive converter documentation).

Table 7- 10 Technical data, NTC K227 and NTC PT3-51

Designation	Technical data	
	NTC K227	**NTC PT3-51F**
PTC thermistor resistance (25 °C)	Approx. 32.8 kΩ	Approx. 49.1 kΩ
Resistance when hot (100 °C)	Approx. 1800 Ω	Approx. 3300 Ω
Connection	via signal cable	
Temperature characteristic		



Temperature evaluation using a PTC thermistor triplet (spindle 2SP120)

The PTC thermistor triplet must be evaluated using an external tripping/evaluation unit (this is not included in the scope of supply). This means that the sensor cable is monitored for wire breakage and short-circuit by this unit.

The PTC signals must be retrieved (refer to Chapter Connecting the signal lines (Page 109)) close to the spindle using an intermediate connector or a terminal box.

The motor must be switched into a no-torque condition when the response temperature is exceeded.

Table 7- 11 Technical data for the PTC thermistor triplet

Designation	Technical data
Type (acc. to DIN 44082-M180)	PTC thermistor triplet
PTC thermistor resistance (20 °C)	≤ 750 Ω
Resistance when hot (180 °C)	≥ 1710 Ω
Response temperature	180 °C
Connection	Using an external evaluation unit, e.g. 3RN1013-1GW10

Note

The PTC thermistors do not have a linear characteristic and are, therefore, not suitable to determine the instantaneous temperature.

Temperature monitoring machining-side bearings (spindle 2SP120)

The PT100 resistance sensor can be optionally ordered for the spindle 2SP120x.

The PT100 resistance sensor is used for

- Monitoring the bearing temperature
- Compensation for thermal-related length increase of the spindle

The appropriate PT100 signal evaluation units must be used for the evaluation.
The connection is made using the signal cable.

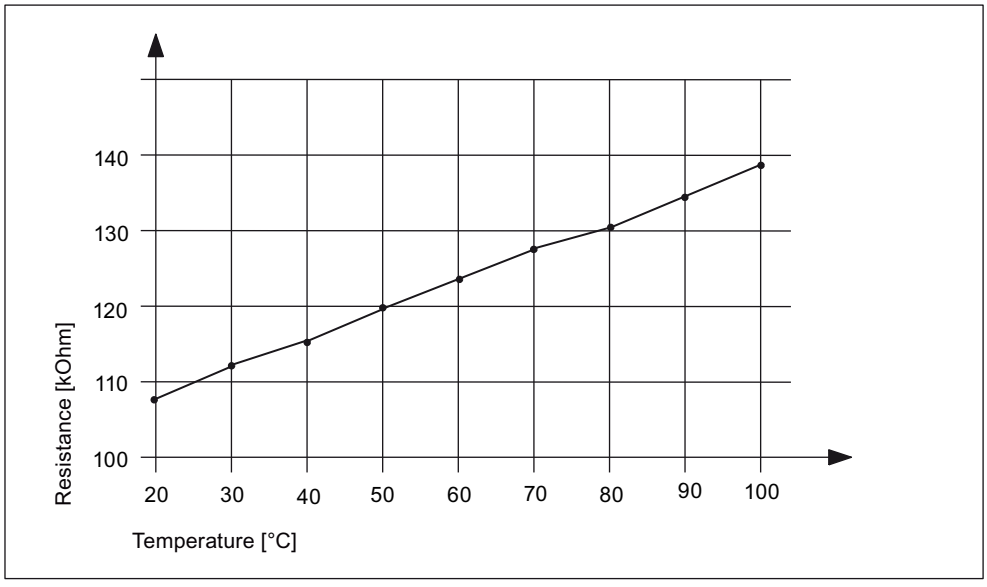


Figure 7-6 Temperature characteristic PT100

Control

8

The central machine control (PLC) controls the following:

- The spindle
- The tool change mechanism
- The supply equipment and devices

The power-on and operating conditions for correct spindle operation are listed in the following.

8.1 Conditions that enable the spindle to rotate

Table 8- 1 Enable signals for spindle rotation

Signal/sensor interrogation	Required status	Remarks
Motor temperature	T_{KTY84} < 150 °C	KTY 84 (integrated motor temperature sensor)
Spindle cooling	• Coolant temperature in the setpoint range • Coolant flow quantity in the setpoint range	See Chapter Cooling water conditioning (Page 83)
Pressure at the tool clamping and release unit	Pressure to clamp the tool is in the reference range 1) The release cylinder piston is not in contact with the spindle shaft 2)	See Chapter Clamping system and tool change (Page 59)
Sealing air	Input pressure in the reference range	See Chapter Conditioning the compressed air (Page 89)
Clamping state sensors	Tool is clamped	See Chapter Clamping system and tool change (Page 59)

1) The reference pressure depends on whether the motor spindle is equipped with a pneumatic or a hydraulic release unit.

2) For 2SP120 motor spindles, the position of the piston in the clamped state is additionally monitored using a sensor. This must display the following state: Tool clamping and release unit in the "clamped" end position.

⚠WARNING

The machinery construction OEM must evaluate the sensor signals that can then be used to check the required states in order to permit the spindle to rotate (e.g. permissive signal). The spindle should be stopped if one of the enable conditions is no longer present.

8.2 Clamping state sensors

The tool is clamped or ejected using the pulling or pushing force of the draw bar. When clamping or ejecting the tool, the draw bar always assumes an appropriate position in the axial direction. The clamping state is linked with the axial position of the draw bar and is interrogated using this (refer to Fig. "Signal assignment of sensors S1 and S4 for 2SP120", Chapter Clamping state sensors 2SP120x (Page 120)).

8.2.1 Clamping state sensors 2SP120x

Basic version with analog sensors

Sensor S1: Analog sensor to detect the tool clamped state

Sensor S4 Digital sensor to sense the position of the release cylinder

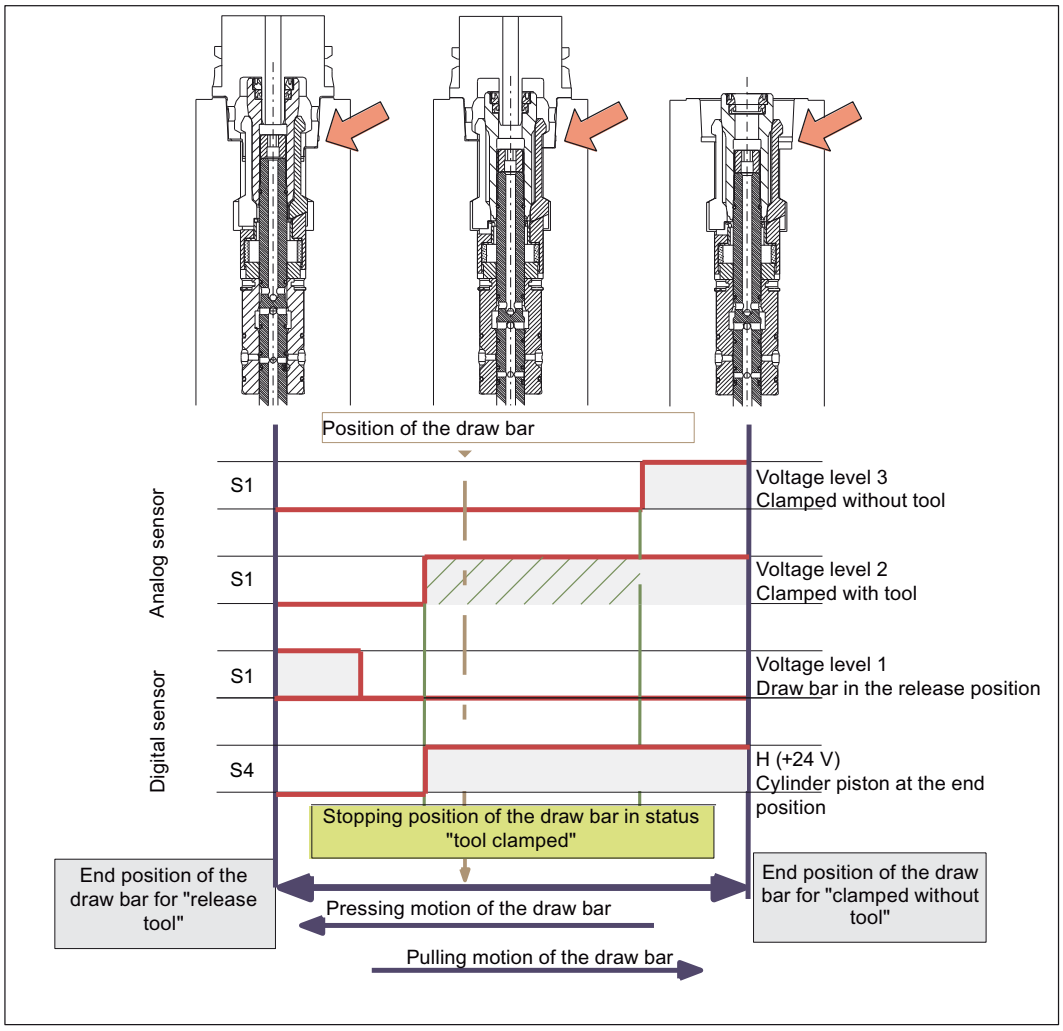


Figure 8-1 Signal assignment of sensors S1 and S4 for 2SP120

NOTICE
Under extreme machining conditions signal faults and disturbances can occur in operation.

Nominal states of S1 and S4

Table 8- 2 Nominal states of S1 (for precise values, refer to the acceptance report for the particular spindle)

State	Voltage [V]
Draw bar in the release position	≥ 8.5 V
Tool clamped	1.5 to 4.5 V
Clamped without tool	1 ±0.2 V

Table 8- 3 Nominal states of S4

State	Signal level: High, Low
Release piston at the back (status, tool clamped)	H
Release piston at the front (status, tool released)	L

Signals from S1 and S4

Table 8- 4 Signals from the analog sensor regarding the tool clamping state and the digital sensor for the position of the release piston

State	S1analog	S4 digital	PLC action	Possible error causes
Draw bar in the release position, release piston at the front [1]	Highest voltage level ≥ 8.5 V [2]	L	• Enable signal to allow a tool to be changed after a defined wait time	
Draw bar in the release position, release piston at the back [1]	Highest voltage level ≥ 8.5 V [2]	H	• The spindle is not enabled for rotation • No enable signal to change the tool	• The clamping system is jammed • Defective sensors
Tool clamped, the correct clamping position has not been reached	Average voltage level > 4.5 to 8.5 V [2]	L	• The spindle is not enabled for rotation • No enable signal to change the tool Normal case at the transition from clamping/releasing	In case of fault: • The release piston jams • Incorrect function of the switching valve

State	S1analog	S4 digital	PLC action	Possible error causes
Tool clamped, the correct clamping position has not been reached	Average voltage level > 4.5 to 8.5 V [2]	H	• The spindle is not enabled for rotation • No enable signal to change the tool Normal case at the transition from releasing/clamping	In case of fault: • Foreign body in the tool adapter • Tool that is not in compliance with the standard • Tool does not match the tool interface of the spindle
Tool clamped, correct clamping position reached, release piston still at the shaft	Low voltage level 1.5 to 4.5 V [2]	L	• The spindle is not enabled for rotation • No enable signal to change the tool Normal case at the transition from releasing/clamping	In case of fault: • The release piston jams
Tool clamped, the correct clamping position has been reached, release piston at the back	Low voltage level 1.5 to 4.5 V [2]	H	• The spindle is enabled for rotation after a defined waiting time • No enable signal to change the tool	
Draw bar is tensioned, but the clamping position was exceeded	Lowest voltage level < 1.5 V [2]	L	• The spindle is not enabled for rotation • No enable signal to change the tool	• No tool clamped • Tool that is not in compliance with the standard • Release piston still not at the end position
Draw bar is tensioned, but the clamping position was exceeded	Lowest voltage level < 1.5 V [2]	H	• The spindle is not enabled for rotation • No enable signal to change the tool	• No tool clamped • Tool that is not in compliance with the standard • Release piston at its end stop

1) **Caution:** Jammed tools cannot be detected with sensor S1

2) The specified values are nominal values. The exact values are specified in the acceptance report of the particular spindle

Basic version with digital sensors

Sensor S1: Digital sensor to sense "draw bar in the release position"

Sensor S2: Digital sensor to sense "tool clamped"

Sensor S3: Digital sensor to sense "clamped without tool"

Sensor S4 Digital sensor to sense the position of the release cylinder

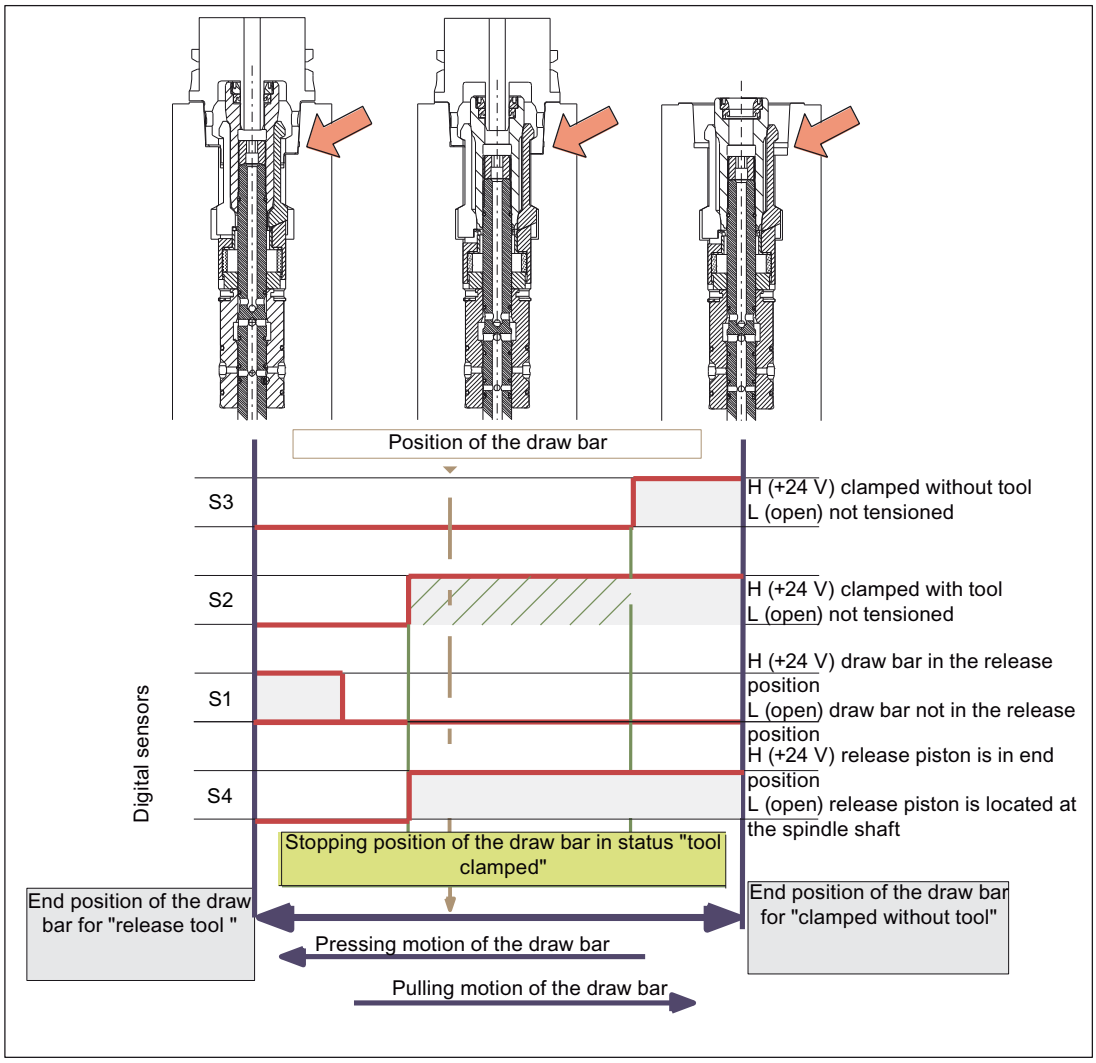


Figure 8-2 Signal assignment of sensors S1, S2, S3 and S4 for 2SP120

Depending on the position of the draw bar, the clamping state sensors respond and allow the clamping state to be detected (refer to the following table).

NOTICE
Under extreme machining conditions signal faults and disturbances can occur in operation.

Signals from S1, S2, S3 and S4

Table 8- 5 Signals of the digital sensors for the tool clamped state

State	S1	S2	S3	S4	PLC action	Possible error causes
Draw bar in the release position, release piston at the front [1)]	H	L	L	L	Enable signal to allow a tool to be changed after a defined waiting time	
Tool clamped, the correct clamping position has not been reached	L	L	L	L	• The spindle is not enabled for rotation • No enable signal to change the tool	• Foreign bodies (e.g. chips) in the tool adapter • Tool, which is not in compliance with the standard, clamping head too short
Tool clamped, the correct clamping position has been reached, release piston still in contact with the shaft	L	H	L	L	• The spindle is not enabled for rotation • No enable signal to change the tool Transition, releasing/clamping	• The release piston jams
Tool clamped, the correct clamping position has been reached, release piston at the back Tool is clamped	L	H	L	H	Spindle is enabled for rotation after a defined waiting time	
Draw bar is tensioned, but the clamping position was exceeded, release piston at the back	L	H	H	H	• The spindle is not enabled for rotation • No enable signal to change the tool	• No tool clamped • Tool which is not in compliance with the standard, clamping head too long
Draw bar is tensioned, but the clamping position was exceeded, release piston at the back	L	L	H	H	• The spindle is not enabled for rotation • No enable signal to change the tool	• No tool clamped • Tool which is not in compliance with the standard, clamping head too long • Incorrect function of either the sensors or evaluation unit
Draw bar in the release position, tool clamped, correct clamping position was reached, release piston at the back	H	H	L	H	• The spindle is not enabled for rotation • No enable signal to change the tool	• The clamping system is jammed • Incorrect function of either the sensors or evaluation unit
Draw bar is in the release position, draw bar is clamped, but the clamping position was exceeded, release piston at the back	H	H	H	H	• The spindle is not enabled for rotation • No enable signal to change the tool	• Incorrect function of either the sensors or evaluation unit

1) **Caution:** Jammed tools cannot be detected with sensor S1

8.2.2 Clamping state sensors 2SP125x

Basic version with digital sensors

Table 8- 6 Basic equipping and option of the digital sensors

Sensor	Status detection	Automatic tool change		Manual tool change	
		Basic equipment	Option	Basic equipment	Option
S1	"Draw bar in the release position"	X	---	---	X
S2	"Tool clamped"	X	---	X	---
S3	"Clamped without tool"	X	---	---	X

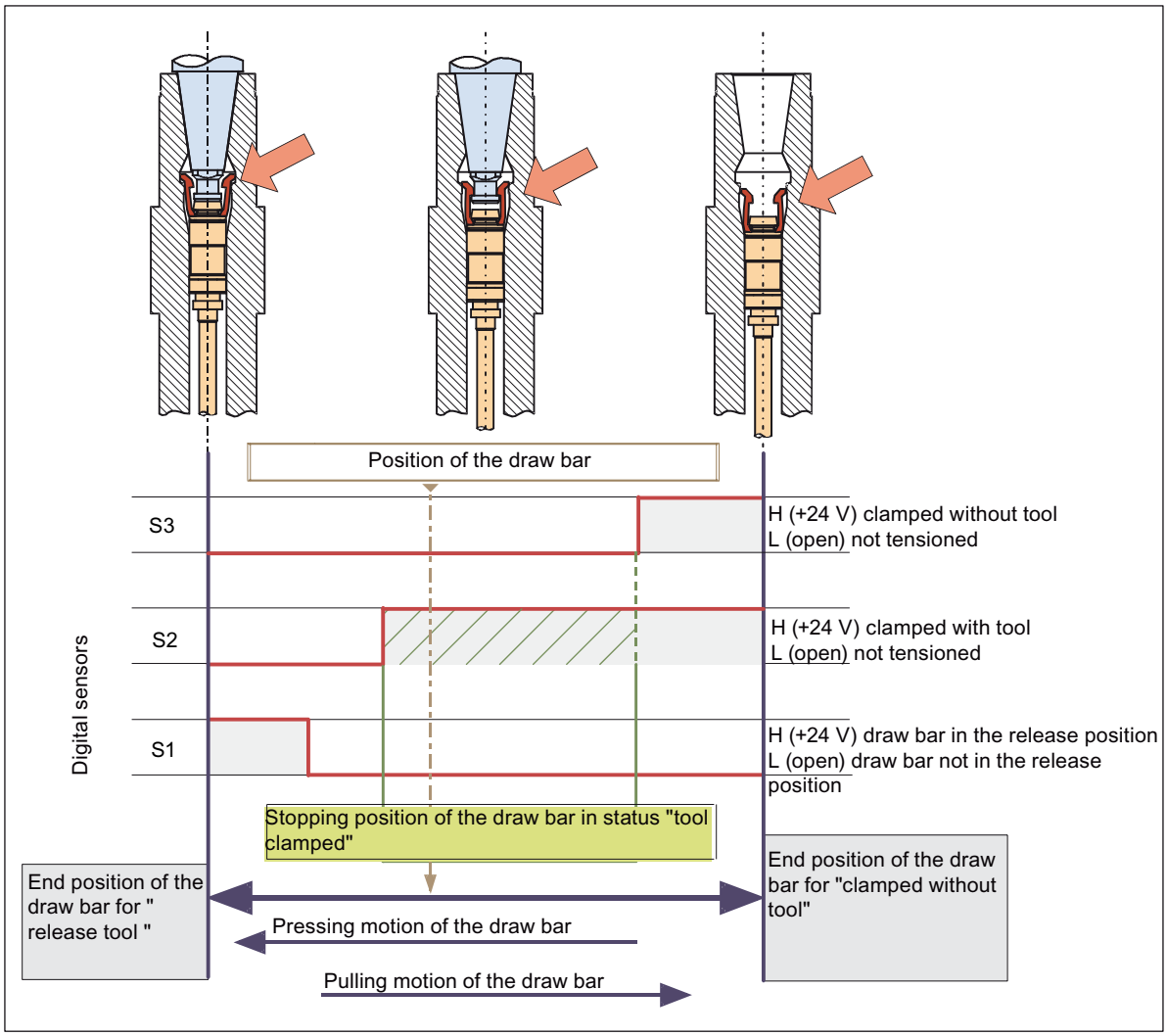


Figure 8-3 Signal assignment of the digital sensors S1, S2 and S3 for 2SP125

⚠CAUTION
Using the spindles without sensors S1 and S3: If the spindle is used without sensors S1 or S3, then other measures must be applied to ensure that the correct clamping state is reached before the spindle is enabled for rotation or a tool can be changed. These measures include, for example, tool monitoring or specific operator actions.

Depending on the position of the draw bar, the clamped state sensors respond and allow the clamped state to be detected (see table "Signals of the digital sensors for the tool clamped state", Chapter Clamping state sensors 2SP120x (Page 120)).

NOTICE
Under extreme machining conditions signal faults and disturbances can occur in operation.

Signals from S1, S2 and S3

Table 8- 7 Signals of the digital sensors for the tool clamped state

State	S1	S2	S3	PLC action	Possible error causes
Draw bar in the release position[1)]	H	L	L	Enable signal to allow a tool to be changed after a defined delay time	
Tool clamped, the correct clamping position has not been reached	L	L	L	• The spindle is not enabled for rotation • No enable signal to change the tool	• Foreign bodies (e.g. chips) in the tool adapter • Tool, which is not in compliance with the standard, clamping head too short
Tool clamped, the correct clamping position has been reached! Tool is clamped	L	H	L	Spindle is enabled for rotation after a defined delay time	
Draw bar is tensioned, but the clamping position was exceeded	L	H	H	• The spindle is not enabled for rotation • No enable signal to change the tool	• No tool clamped • Tool which is not in compliance with the standard, clamping head too long
Draw bar is tensioned, but the clamping position was exceeded	L	L	H	• The spindle is not enabled for rotation • No enable signal to change the tool	• No tool clamped • Tool which is not in compliance with the standard, clamping head too long • Incorrect function of either the sensors or evaluation unit
Draw bar in the release position, tool clamped,correct clamping position was reached	H	H	L	• The spindle is not enabled for rotation • No enable signal to change the tool	• The clamping system is jammed • Incorrect function of either the sensors or evaluation unit
Draw bar is in the release position, draw bar is clamped, but the clamping position was exceeded	H	H	H	• The spindle is not enabled for rotation • No enable signal to change the tool	• Incorrect function of either the sensors or evaluation unit

1) **Caution:** Jammed tools cannot be detected with sensor S1

8.3 Tool change

A tool may only be changed when the spindle is at a complete standstill. The correct, specified pressure must be available at the pneumatic or hydraulic cylinder while removing and inserting the tool, refer to Chapter Conditioning the compressed air (Page 89) and Hydraulic (option, only for 2SP120) (Page 91).

CAUTION
The clamping system could be damaged if tool change operations are carried-out without the pneumatic or hydraulic cylinder having the correct pressure.

8.3.1 Automatic tool change for 2SP120x

The tool change and spindle enable can be controlled using sensors S1 and S4.

Table 8- 8 Sensors S1 and S4

Sensor	Display/comments (minimum wait times)
S1 analog	Dependent on the tool clamped status, different voltage levels are displayed, 1 to 3: • Level 1: "Draw bar in the release position" (≥ 8.5 V) • Level 2: "Tool clamped" (1.5 to 4.5 V) • Level 3: "Clamped without tool" (1 ±0.2 V) The precise voltage values are specified in the acceptance report of the motor spindle. Minimum wait times $t_{wait\ until\ removal}$ and $t_{wait\ until\ enable}$ The following minimum wait time must be maintained between the "draw bar in the release position" signal (Level 1) being output and actually removing the tool: $t_{wait\ up\ until\ removal}$ = 100 ms **Caution:** Jammed tools cannot be reliably detected with sensor S1. The following minimum wait time must be maintained after the "tool clamped" signal (Level 2) is output: $t_{wait\ up\ until\ enable}$ = 100 ms
S4 digital	Displays the state if the hydraulically or pneumatically actuated release piston is in a safe end position without being in contact with the rotating spindle shaft. Release piston at the back (tool clamped state): H Release piston at the front (status, tool released) L

Condition that enables the spindle to rotate

Spindle rotation can be enabled if the following prerequisites are fulfilled:

- S1 is after $t_{wait\ until\ enable}$ at level 2 (it is not permissible that level 3 is reached)
- S4 has responded

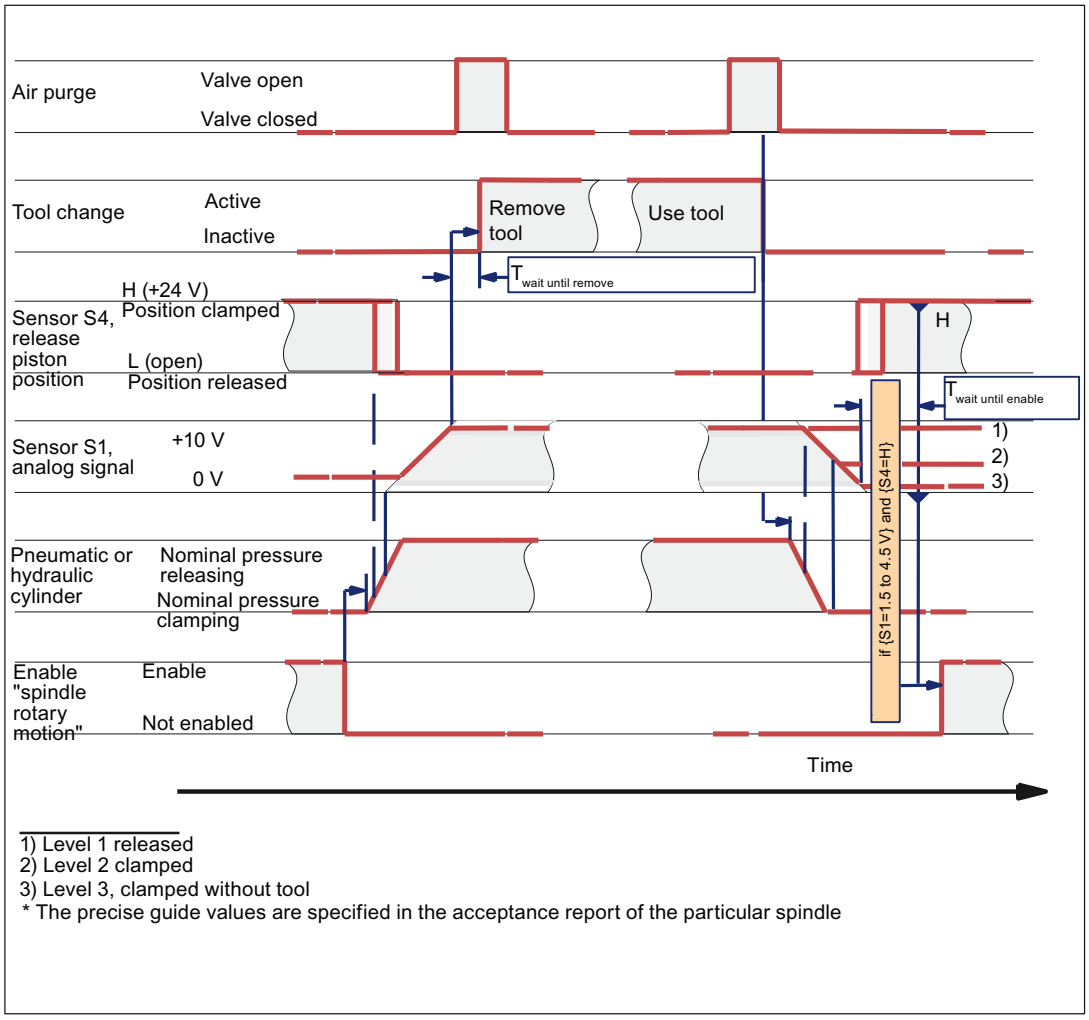


Figure 8-4 Control diagram for an automatic tool change with S1 and S4

8.3.2 Tool change sequence with standard clamping system and tool change gripper

Table 8- 9 Recommended sequence for a tool change with standard clamping system and tool change gripper

Step	Description
1.	Stop the spindle (0 speed) in the orientated tool change position
2.	Shut down the internal tool cooling, open the bleed valve
3.	Open the door of the automatic tool change system
4.	Move the machine axes into the tool change position
5.	Prepare the tool magazine for the tool change
6.	Start the automatic tool change mechanism - tool change gripper takes the tool in the tool magazine and inserts the tool into the spindle.
7.	Stop the automatic tool change mechanism
8.	Activate the air purge
9.	Release the tool by controlling the valve "release tool" Check sensor signal S1 [1)] for state "draw bar in release position"
10.	Continuation of the automatic tool change mechanism - tool removal, 180 °-rotation of the tool change gripper and insertion of the new tool into the spindle. Place the previously used tool into the tool magazine. The tool change gripper still holds the tool into the spindle.
11.	Shut off the air purge and close the bleed valve
12.	Clamp tool Check sensor signal S1 for "tool clamped" state Check that sensor S4 has a "high" signal (release piston at the back)
13.	Move the tool change gripper into the park position. Exit the automatic tool changing mechanism.
14.	Start spindle. Close the door of the automatic tool change system.
15.	Move the axes into the machining position

1) Precise test values, refer to the acceptance report of the particular motor spindle

8.3.3 Tool change sequence with holding clamping system and tool change gripper

Table 8- 10 Recommended sequence for a tool change with holding clamping system and tool change gripper

Step	Description
1.	Stop the spindle (0 speed) in the orientated tool change position
2.	Shut down the internal tool cooling, open the bleed valve
3.	Release the tool in the spindle by controlling the valve "release tool". Check sensor signal S1 1) for state "draw bar in release position" The tool is still held by the collet. **Caution: The tool weight should not exceed the permissible limits, otherwise the tool can fall out of the tool adapter.**
4.	Activate the air purge
5.	Open the door of the automatic tool change system
6.	Move the machine axes into the tool change position **Caution: If the acceleration or deceleration is too high then the tool can drop out of the tool adapter.**
7.	Prepare the tool magazine for the tool change
8.	Start the automatic tool change mechanism - tool change gripper takes the tool in the tool magazine and inserts the tool into the spindle. Tool removal (holding force of 270 N must be overcome). 180° rotation of the tool change gripper and insertion of the new tool into the spindle. Place the previously used tool into the tool magazine.
9.	Move the tool change gripper into the park position. Exit the automatic tool changing mechanism.
10.	Shut off the air purge and close the bleed valve
11.	Clamp tool Check sensor signal S1 for "tool clamped" state Check that sensor S4 has a "high" signal (release piston at the back)
12.	Start spindle. Close the door of the automatic tool change system.
13.	Move the axes into the machining position

1) Precise test values, refer to the acceptance report of the particular motor spindle

8.3.4 Manual tool change for 2SP125x

With the basic equipping (with sensor S2 - without S1 and S3), this version can be used for a manual tool change.

NOTICE
The appropriate operator actions must be applied to ensure that the appropriate clamping state has been reached before the spindle is allowed to rotate and before a tool may be changed.

CAUTION
Jammed tools cannot be reliably detected using sensor S1. If the spindle is operated without the optional sensor S1, then it is the responsibility of the machinery construction company to detect the "tool released" state. If the spindle is operated without the optional sensor S3, then it is the responsibility of the machinery construction company to detect the "clamped without tool" state.

Note

It is advantageous if additional information is incorporated in the tool change control sequence by using additional sensors.

The machinery construction company must provide any additional sensors.

The pressure at the release piston can also be incorporated in the tool change control system.

Enable condition

Enable condition to initiate a tool change:

- The required pressure - to release the tool - must be available

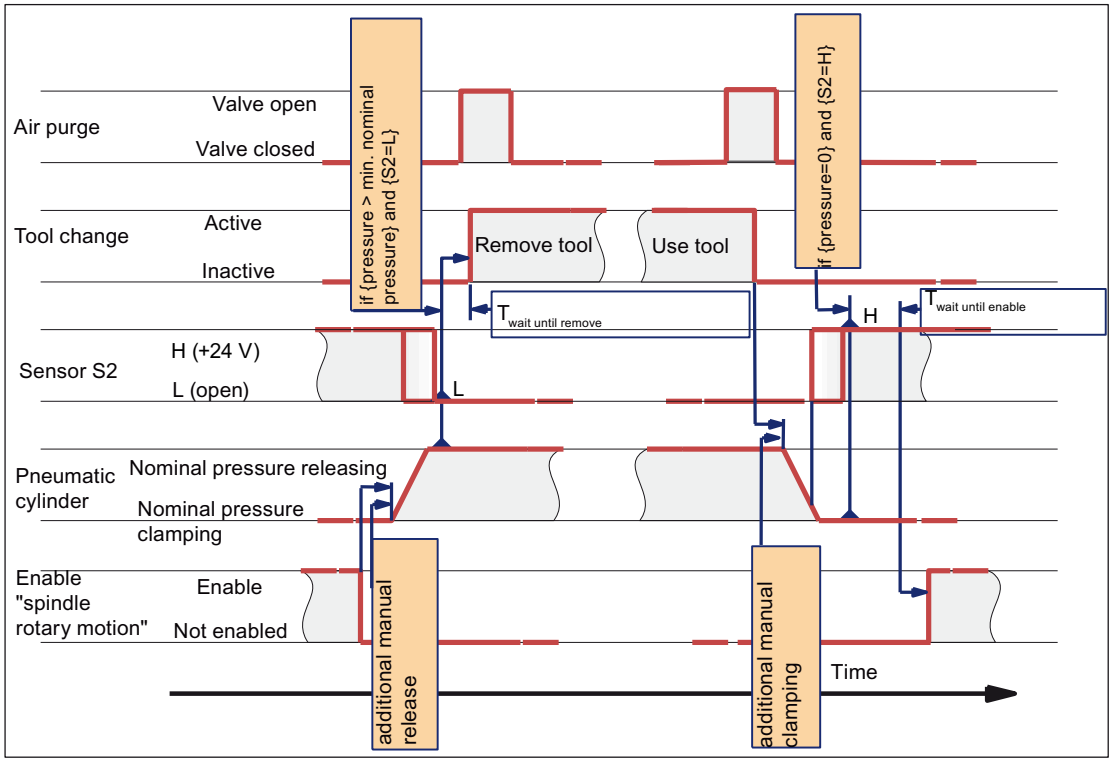


Figure 8-5 Control diagram for a manual tool change with S2

8.3.5 Automatic tool change for 2SP125x

If the spindle is operated with the digital sensors S1, S2 and S3, then this version can be used for an automatic tool change.

Table 8- 11 Sensors S1, S2 and S3

Sensor	Display/comments (minimum wait times)
S1 digital	State display "draw bar in the release position" Minimum wait time The following minimum wait time must be maintained between the "draw bar in the release position" (H) signal being output and actually removing the tool: $t_{wait\ up\ until\ removal}$ = 100 ms **Caution:** Jammed tools cannot be reliably detected with sensor S1.
S2 digital	State display, "tool clamped" Minimum wait time The following minimum delay time must be maintained after the "tool clamped" (H) signal is output: $t_{wait\ up\ until\ enable}$ = 100 ms
S3 digital	Display state, "clamped, without tool"

CAUTION
For spindles with internal tool cooling, sufficient time must be provided to blow-out the cooling lubricating medium from the tool clamp. Only then may a new tool be clamped.

Condition which enables the spindle to rotate

The spindle can be allowed to rotate if the following prerequisite is fulfilled:

- After the minimum wait time $t_{wait\ up\ to\ enable}$, S3 must be at L

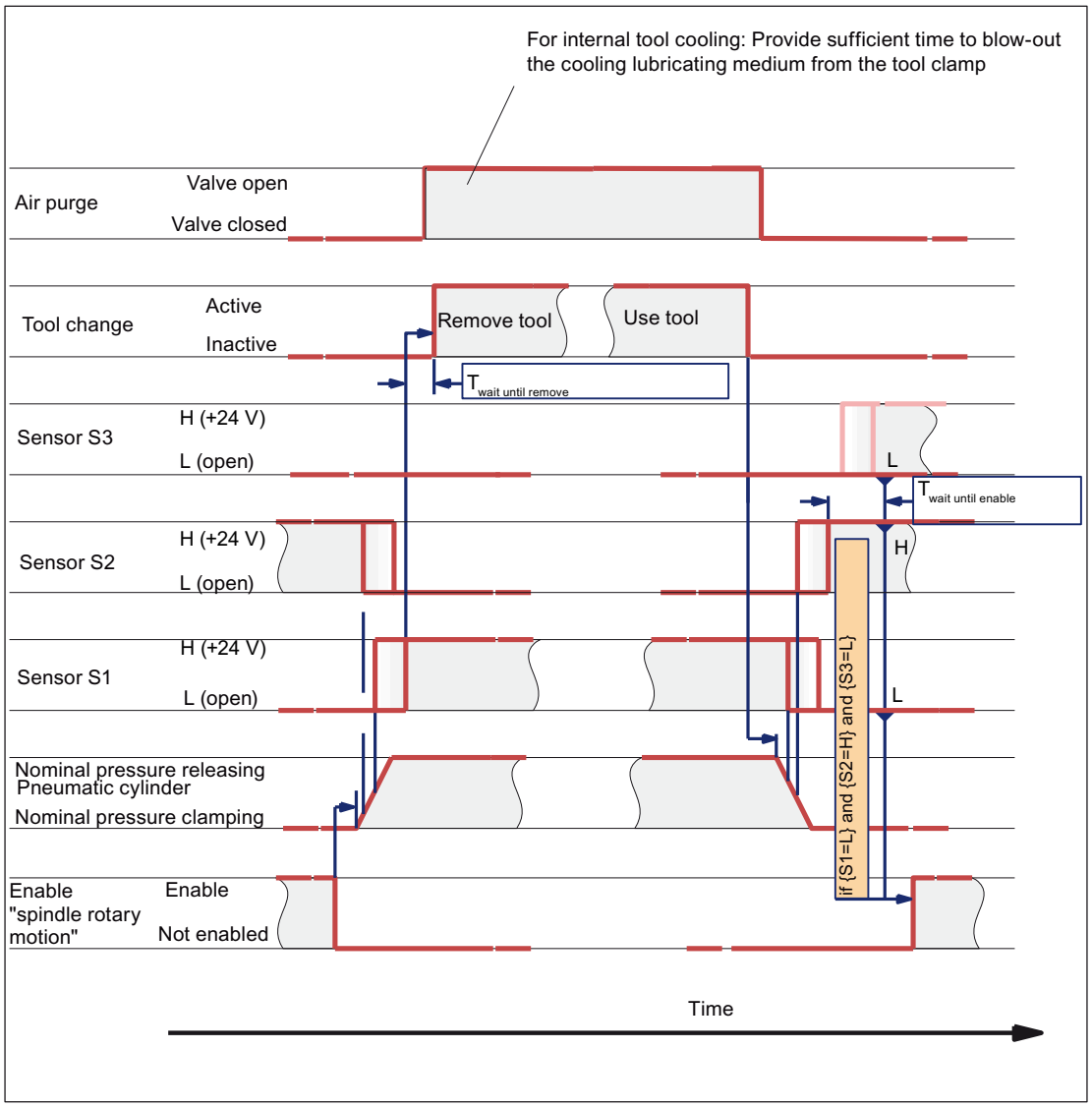


Figure 8-6 Control diagram for an automatic tool change with S1, S2 and S3

Order designation

Order designation for 2SP12□□

The order designation comprises a combination of digits and letters.

Spindle diameter	Rated power Star/delta for duty type		Rated torque Star/delta for duty type		Rated speed Star/delta	Maximum speed	2SP1 motor spindles Standard type
	P_{rated}		M_{rated}		n_{rated}	n_{max}	
	S1	S6-40 %	S1	S6-40 %			
mm (in)	kW (HP)	kW (HP)	Nm (lb_f-in)	Nm (lb_f-in)	rpm	rpm	Order No.
Synchronous – Water cooling							
200	12.0/– (16.1/–)	12.0/– (16.1/–)	42/– (372/–)	55/– (487/–)	2700/–	15000	2SP1202-1HA ■■-1D ■■
	15.5/– (20.8/–)	15.5/– (20.8/–)	42/– (372/–)	55/– (487/–)	3500/–	18000	2SP1202-1HB ■■-2D ■■
	26.4/– (35.4/–)	26.4/– (35.4/–)	84/– (744/–)	110/– (974/–)	3000/–	15000	2SP1204-1HA ■■-1D ■■
	35.0/– (46.9/–)	35.0/– (46.9/–)	78/– (690/–)	110/– (974/–)	4300/–	18000	2SP1204-1HB ■■-2D ■■
Asynchronous – Water cooling							
250	13.2/13.2 (17.7/17.7)	18.9/18.9 (25.3/25.3)	70/32 (620/283)	100/45 (885/398)	1800/4000	10000	2SP1253-8HA 0 ■-0 ■ 2
	13.2/13.2 (17.7/17.7)	18.9/18.9 (25.3/25.3)	70/32 (620/283)	100/45 (885/398)	1800/4000	15000	2SP1253-8HA 0 ■-1D ■ 2
	11.7/11.7 (15.7/15.7)	16.7/16.7 (22.4/22.4)	140/62 (1239/549)	200/89 (1170/788)	800/1800	10000	2SP1255-8HA 0 ■-0 ■ 2
	11.7/11.7 (15.7/15.7)	16.7/16.7 (22.4/22.4)	140/62 (1239/549)	200/89 (1170/788)	800/1800	15000	2SP1255-8HA 0 ■-1D ■ 2
Synchronous – Water cooling							
250	26.0/– (34.9/–)	29.0/– (38.9/–)	100/– (885/–)	130/– (1151/–)	2500/–	10000	2SP1253-1HA 0 ■-0 ■ 2
	35.0/– (46.9/–)	38.0/– (50.9/–)	100/– (885/–)	130/– (1151/–)	3300/–	15000	2SP1253-1HB 0 ■-1D ■ 2
	46.3/– (62.1/–)	55.0/– (73.7/–)	170/– (1505/–)	236/– (2089/–)	2600/–	10000	2SP1255-1HA 0 ■-0 ■ 2
	53.4/– (71.6/–)	64.0/– (85.8/–)	170/– (1505/–)	236/– (2089/–)	3000/–	15000	2SP1255-1HB 0 ■-1D ■ 2

Tool clamping and release mechanism:	
Pneumatic (Only for 2SP125)	0
Pneumatic (Only for 2SP120)	2
Hydraulic (Only for 2SP120)	3
Cooling:	
Closed cooling jacket	1
Closed cooling jacket and internal tool cooling	3
Closed cooling jacket and ring for external tool cooling (Only for 2SP120)	4
Closed cooling jacket, internal tool cooling and ring for external tool cooling (Only for 2SP120)	5
Tool interfaces:	
Tool interface SK 40	A
Tool interface BT 40 45°	B
Tool interface CAT 40	C
Tool interface HSK A63	D
Tool interface BT 40 30°	E
Tool interface HSK A63, latching (Only for 2SP120)	R
Sensors:	
Sensor: Tool clamped/Draw-bar in the release position/Clamped without tool	D
As with D + Sensor: Position of release piston (Only for 2SP120)	F
Type of connection:	
(Permanently connected cable, sensor cable with signal connector, length: 1.5 m (4.92 ft))	
Power cable with exposed core ends	2
Power cable with connector (2SP1202: Connector size 1.5/2SP1204: Connector size 3)	6

Motor type (repeated)	Moment of inertia	Weight,[1] approx.	Rated current Star/delta for duty type		Voltage Protection Module [2]	SINAMICS S120 Motor Module	
						Required rated current for S1 duty	Booksize format For additional versions and components, see SINAMICS S120 drive system
	J	m	I_{rated}			I_{rated}	
			S1	S6-40 %			
	kgm^2 (lb_f-in-s^2)	kg (lb)	A	A		A	Order No.
Synchronous – Water cooling							
2SP1202-1HA...	0.015 (0.1327)	83 (183)	30/–	43/–	VPM 120	30	6SL312 ■ - 1TE23-0AA3
2SP1202-1HB...	0.015 (0.1327)	83 (183)	42/–	60/–	VPM 120	45	6SL312 ■ - 1TE24-5AA3
2SP1204-1HA...	0.023 (0.2035)	101 (223)	60/–	85/–	VPM 120	60	6SL312 ■ - 1TE26-0AA3
2SP1204-1HB...	0.023 (0.2035)	101 (223)	79/–	120/–	VPM 120	85	6SL312 ■ - 1TE28-5AA3
Asynchronous– Water cooling							
2SP1253-8HA0.-0...	0.037 (0.3274)	130 (287)	28/29	39/39	–	30	6SL312 ■ - 1TE23-0AA3
2SP1253-8HA0.-1...	0.037 (0.3274)	130 (287)	28/29	39/39	–	30	6SL312 ■ - 1TE23-0AA3
2SP1255-8HA0.-0...	0.055 (0.4867)	165 (364)	30/29	40/37	–	30	6SL312 ■ - 1TE23-0AA3
2SP1255-8HA0.-1...	0.055 (0.4867)	165 (364)	30/29	40/37	–	30	6SL312 ■ - 1TE23-0AA3
Synchronous – Water cooling							
2SP1253-1HA...	0.037 (0.3274)	130 (287)	53/–	75/–	VPM 120	60	6SL312 ■ - 1TE26-0AA3
2SP1253-1HB...	0.037 (0.3274)	130 (287)	68/–	98/–	VPM 120	85	6SL312 ■ - 1TE28-5AA3
2SP1255-1HA...	0.055 (0.4867)	165 (364)	95/–	135/–	VPM 120	132	6SL312 ■ - 1TE31-3AA3
2SP1255-1HB...	0.055 (0.4867)	165 (364)	120/–	180/–	VPM 200	132	6SL312 ■ - 1TE31-3AA3

Cooling:	
Internal air cooling	0
External air cooling	1
Motor Module:	
Single Motor Module	1

[1] No options included.
Internal tool cooling: + 1 kg (2.21 lb)
External tool cooling: + 8 kg (17.6 lb).

[2] IVP Internal Voltage Protection as integrated SINAMICS function for SINAMICS S120 Motor Modules in booksize format, see SINAMICS S120 Function Manual.

Technical data and characteristics

10

10.1 Technical characteristic data

Electrical power data

The values in the following table only apply in conjunction with the Siemens system components SINAMICS S120.

Table 10- 1 Electrical power data

Order designation	P_N S1 [kW]	M_N S1 [Nm]	n_N [rpm]	I_N S1 [A]	P_N S6-40% [kW]	M_N S6-40% [Nm]	P_N S1 [kW]	M_N S1 [Nm]	n_N [rpm]	I_N S1 [A]	I_{max} 1) [A]	n_{max} [rpm]
	Star operation						Delta operation					
Synchronous												
2SP1202-1HA□□-1D□□	12.0	42	2700	30	12.0	55	---	---	---	---	60	15000
2SP1202-1HB□□-2D□□	15.5	42	3500	42	15.5	55	---	---	---	---	84	18000
2SP1204-1HA□□-1D□□	26.4	84	3000	60	26.4	110	---	---	---	---	120	15000
2SP1204-1HB□□-2D□□	35.0	78	4300	79	35.0	110	---	---	---	---	160	18000
Induction												
2SP1253-8HA0□-0□□2	13.2	70	1800	28	18.9	100	13.2	32	4000	29	51	10000
2SP1253-8HA0□-1D□2	13.2	70	1800	28	18.9	100	13.2	32	4000	29	51	15000
2SP1255-8HA0□-0□□2	11.7	140	800	30	16.7	200	11.7	62	1800	29	51	10000
2SP1255-8HA0x-1D□2	11.7	140	800	30	16.7	200	11.7	62	1800	29	51	15000
Synchronous												
2SP1253-1HA0□-0□□2	26.0	100	2500	53	29.0	130	---	---	---	---	106	10000
Reduced motor data 2)	22.5	80	2700	45	---	---	---	---	---	---	---	---
2SP1253-1HB0□-1D□2	35.0	100	3300	68	38.0	130	---	---	---	---	136	15000
Reduced motor data 2)	30	80	3600	60	---	---	---	---	---	---	---	---
2SP1255-1HA0□-0□□2	46.3	170	2600	95	55.0	236	---	---	---	---	170	10000
Reduced motor data 2)	40	150	2560	85	---	---	---	---	---	---	---	---
2SP1255-1HB0□-1D□2	53.4	170	3000	120	64.0	236	---	---	---	---	240	15000
Reduced motor data 2)	40	150	3000	105	---	---	---	---	---	---	---	---

1) It is not permissible that the maximum current is exceeded due to danger of de-magnetization

2) The values apply for reduced motor data that match the next smaller SINAMICS Motor Module.

Supply data

Table 10- 2 Supply data

Order designation	Motor type	Max. speed n_{max} [rpm]	Required cooling power $Pcool_N$ [kW] at		Coolant flow quantity V [l/min]	Coolant pressure drop 1) Δp [hpa]	Max permissible coolant pressure p [bar]
			n_N	n_{max}			
2SP1202-1HA□□-1D□□	Synch.	15000	2.0	2.0	10	0.5	5.0
2SP1202-1HB□□-2D□□	Synch.	18000	2.0	2.6	10	0.5	5.0
2SP1204-1HA□□-1D□□	Synch.	15000	3.6	4.2	10	1.0	5.0
2SP1204-1HB□□-2D□□	Synch.	18000	3.6	5.0	10	1.0	5.0
2SP1253-8HA0□-0□□2	Induct.	10000	2.8	2.8	10	0.75	5.0
2SP1253-8HA0□-1D□2	Induct.	15000	2.8	2.8	10	0.75	5.0
2SP1255-8HA0□-0□□2	Induct.	10000	4.3	4.3	10	1.0	5.0
2SP1255-8HA0□-1D□2	Induct.	15000	4.3	4.3	10	1.0	5.0
2SP1253-1HA0□-0□□2	Synch.	10000	2.1	3.0	10	0.75	5.0
2SP1253-1HB0□-1D□2	Synch.	15000	2.1	4.5	10	0.75	5.0
2SP1255-1HA0□-0□□2	Synch.	10000	3.5	4.5	10	1.0	5.0
2SP1255-1HB0□-1D□2	Synch.	15000	3.5	6.0	10	1.0	5.0

1) At the specified flow quantity

Power data at the tool adapter

Table 10- 3 Power data at the tool adapter

Order designation of the motor spindle	Radial eccentricity 1) [µm]	Pull-in force2) [kN]	Typical time3) [ms] to the		Minimum acceleration time up to n_{max} 6) [sec]
			Clamp tool 4)	Release tool5)	
2SP1202-1HA0□-1	15	18	320	350	1.5
2SP1202-1HA1□-1	15	18	180	200	1.5
2SP1202-1HB0□-2	15	18	320	350	1.7
2SP1202-1HB1□-2	15	18	180	200	1.7
2SP1204-1HA0□-1	15	18	320	350	1.0
2SP1204-1HA1□-1	15	18	180	200	1.0
2SP1204-1HB0□-2	15	18	320	350	1.2
2SP1204-1HB1□-2	15	18	180	200	1.2
2SP1253-8HA0□-0	15	8	270	230	1.30
2SP1253-8HA0□-1	15	18	180	300	3.50
2SP1255-8HA0□-0	15	8	270	230	2.25
2SP1255-8HA0□-1	15	18	180	300	6.75
2SP1253-1HA0□-0	15	8	270	230	0.8
2SP1253-1HB0□-1	15	18	180	300	1.25
2SP1255-1HA0□-0	15	8	270	230	0.6
2SP1255-1HB0□-1	15	18	180	300	1.1

1) Radial eccentricity measured at the plug gauge 280 mm from the spindle nose.

2) Nominal value, dependent on the tool interface (SK40/HSK A63)

Tolerance values for SK40: +1.6 kN, -0.8 kN

Tolerance values for HSK A63: +5.4 kN, -1.9 kN

3) Characteristic values depend on the release pressure, flow rate and for the pneumatic release unit, on the number connections used:

Hydraulic release unit:

The specified values are reached for an 80 bar release pressure and a sufficient flow rate.

Pneumatic release unit:

The specified values are reached for a release pressure of 6 bar, sufficient flow rate and two connections.

4) Time between the valve switching up to the "tool clamped" sensor signal.

5) Time between the valve switching up to the "draw bar in release position" sensor signal.

6) For an adequately dimensioned power unit.

Geometrical data for 2SP120x

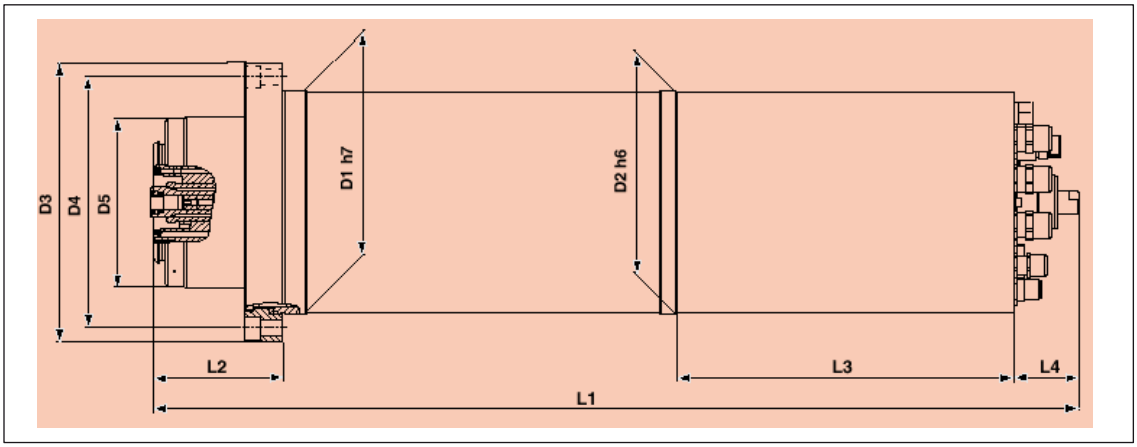


Figure 10-1 Length and diameter designations for 2SP120x

Table 10- 4 Geometrical data for 2SP120x

Order designation of the motor spindle	Length [1] [mm]	Diameter [mm] (fit for cartridge)		Flange diameter [mm]	Circle of holes diameter [2] [mm]	Weight [kg]	Support at NDE required [5]
	L1	D1 (DE)	D2 (NDE)	D3	D4		
2SP1202-1HA0x-0	684	200 h7	199 h6	250	225	83 [3] [4]	Yes
2SP1202-1HA1x-1	593	200 h7	199 h6	250	225	82 [3] [4]	Yes
2SP1202-1HB0x-2	684	200 h7	199 h6	250	225	83 [3] [4]	Yes
2SP1202-1HB1x-2	593	200 h7	199 h6	250	225	82 [3] [4]	Yes
2SP1204-1HA0x-1	784	200 h7	199 h6	250	225	101 [3] [4]	Yes
2SP1204-1HA1x-1	693	200 h7	199 h6	250	225	100 [3] [4]	Yes
2SP1204-1HB0x-2	784	200 h7	199 h6	250	225	101 [3] [4]	Yes
2SP1204-1HB1x-2	693	200 h7	199 h6	250	225	100 [3] [4]	Yes

1) When the internal tool cooling option is used, the spindle is 43 mm longer

2) For fixing, 8 x M12 screws with a minimum strength of 10.9 must be used. The spindle must be mounted so that the motor spindle is not subject to any compulsive forces.

3) With internal tool cooling weight +1 kg

4) With external tool cooling weight +8 kg

5) When supported, applicable for both horizontal or vertical working position

Geometrical data for 2SP125x

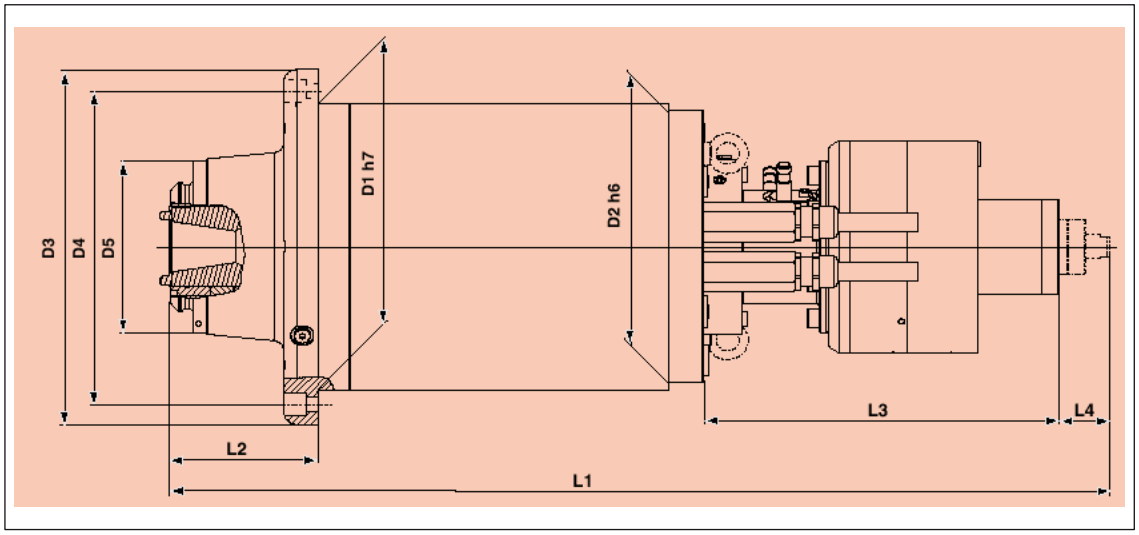


Figure 10-2 Length and diameter designations for 2SP125x

Table 10- 5 Geometrical data for 2SP125x

Order designation of the motor spindle	Length [1] [mm]	Diameter [mm] (fit for cartridge)		Flange diameter [mm]	Circle of holes diameter [2] [mm]	Weight [kg]	Support at NDE required [5]
	L1	D1 (DE)	D2 (NDE)	D3	D4		
2SP1253-8HAxx-0	776	250 h7	237 h6	310	275	130 [3]	No
2SP1253-8HAxx-1	770	250 h7	237 h6	310	275	130 [3]	No
2SP1255-8HAxx-0	876	250 h7	237 h6	310	275	165 [3]	No
2SP1255-8HAxx-1	870	250 h7	237 h6	310	275	165 [3]	Yes
2SP1253-1HAxx-0	776	250 h7	237 h6	310	275	130 [3]	No
2SP1253-1HBxx-0	770	250 h7	237 h6	310	275	130 [3]	No
2SP1255-1HAxx-0	876	250 h7	237 h6	310	275	165 [3]	No
2SP1255-1HBxx-1	870	250 h7	237 h6	310	275	165 [3]	Yes

1) When the internal tool cooling option is used, the spindle is 43 mm longer

2) For fixing, 8 x M12 screws with a minimum strength of 10.9 must be used. The spindle must be mounted so that the motor spindle is not subject to any compulsive forces.

3) With internal tool cooling weight +1 kg

5) When supported, applicable for both horizontal or vertical working position

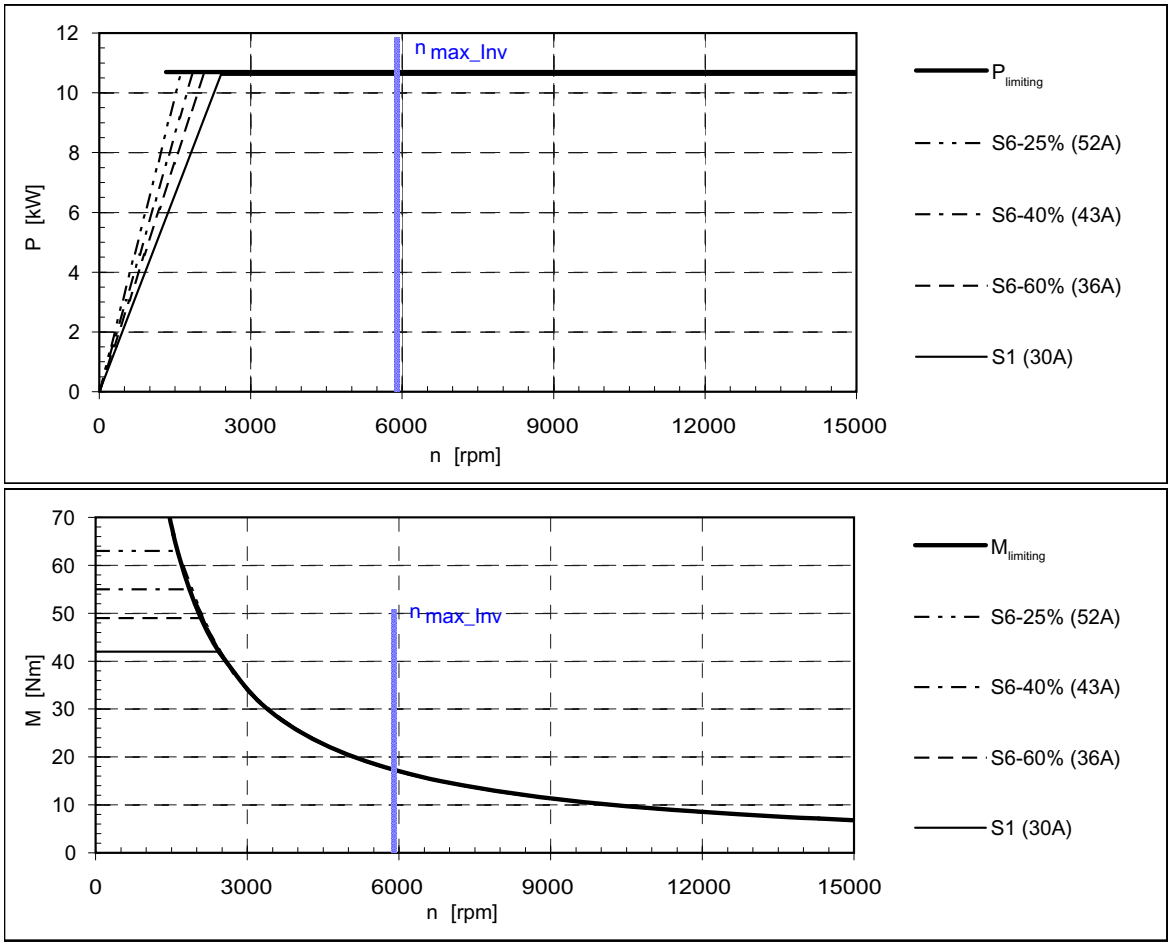
10.2 P/n and M/n diagrams

The diagrams apply for a 600 V DC link voltage

10.2.1 2SP120x synchronous motor

Table 10- 6 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1202-1HA□□-1D□□ (only star circuit configuration)

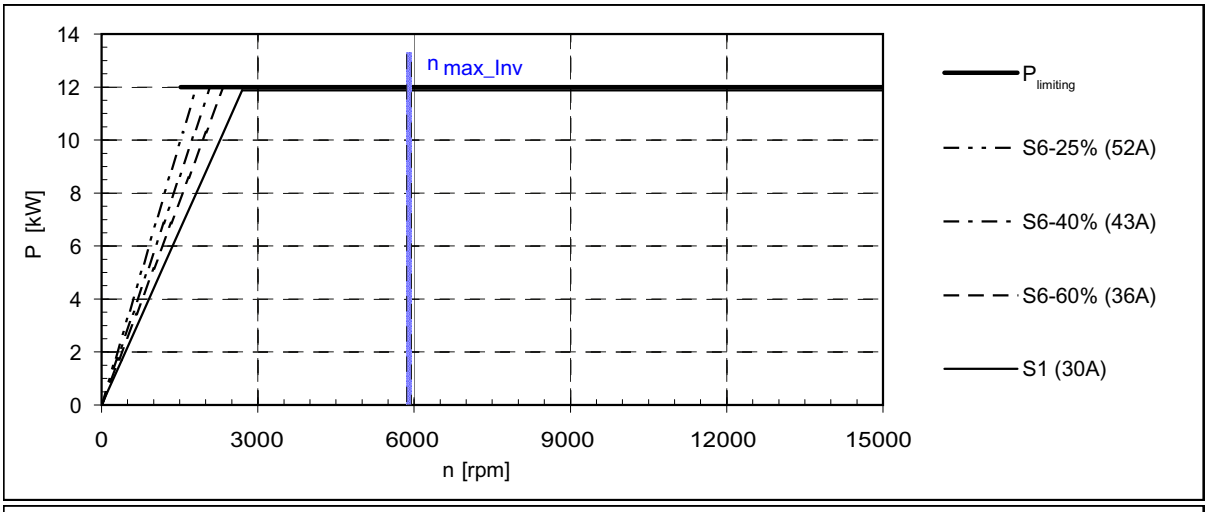
Rated power	P_N	kW	10.6
Rated speed	n_N	rpm	2410
Rated torque	M_N	Nm	42
Rated current	I_N	A	30
Maximum current	I_{max}	A	60
Maximum speed	n_{max}	rpm	15000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	5900
Maximum torque	M_{max}	Nm	68
Spindle moment of inertia	J	kg m^2	0.015
Voltage constant / EMF	k_E	V/1000 rpm	98
Thermal time constant	T_{therm}	min	3

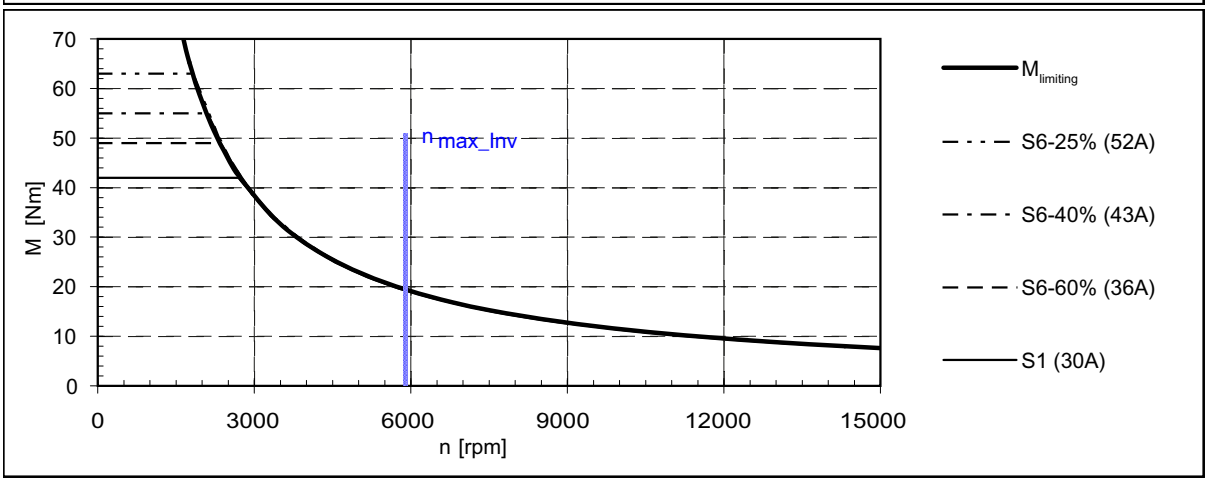


The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 7 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1202-1HA□□-1D□□ (only star circuit configuration)

Rated power	P_N	kW	12
Rated speed	n_N	rpm	2700
Rated torque	M_N	Nm	42
Rated current	I_N	A	30
Maximum current	I_{max}	A	60
Maximum speed	n_{max}	rpm	15000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	5900
Maximum torque	M_{max}	Nm	68
Spindle moment of inertia	J	kg m^2	0.015
Voltage constant / EMF	k_E	V/1000 rpm	98
Thermal time constant	T_{therm}	min	3

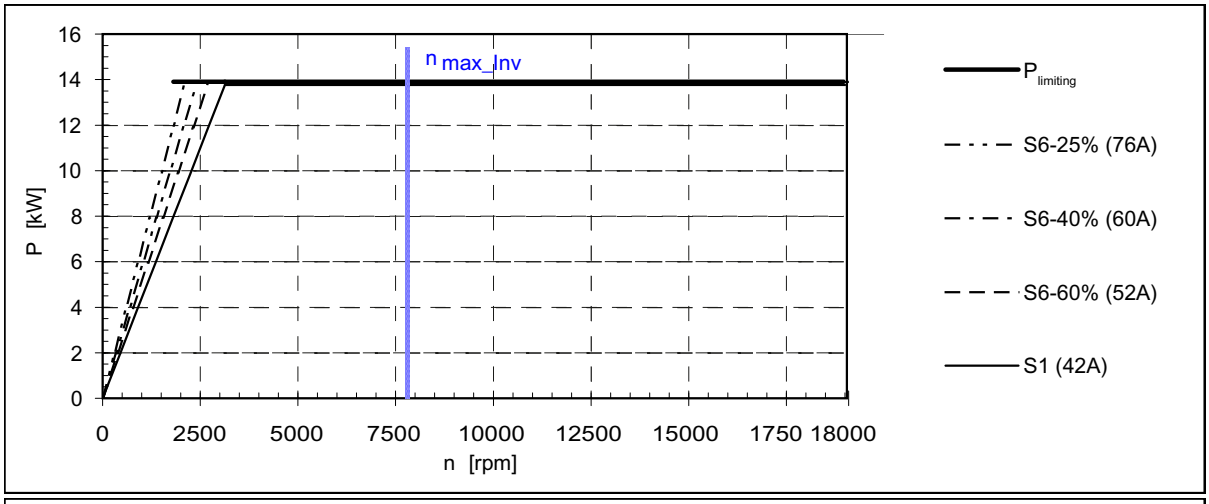


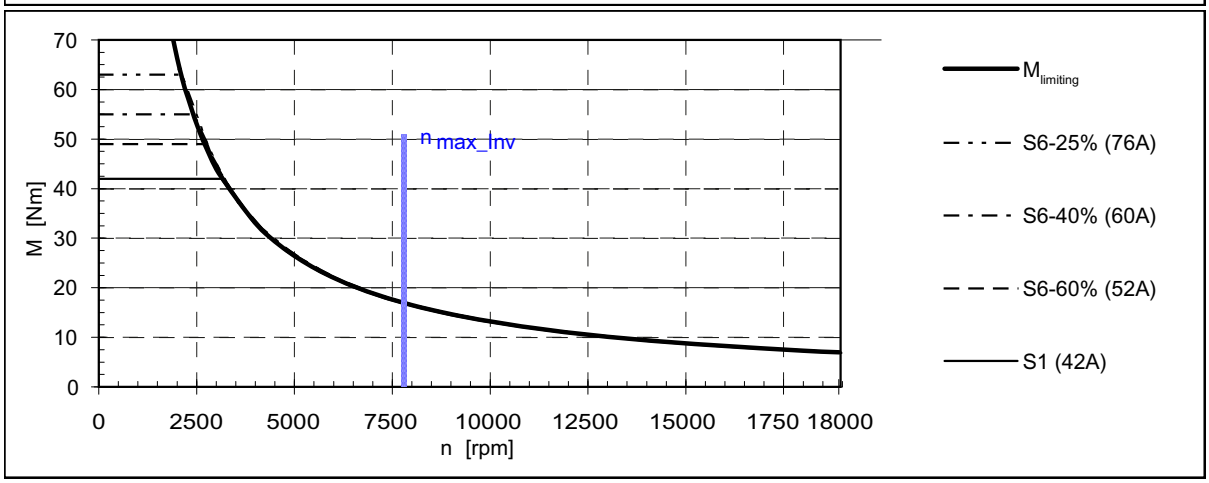


The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 8 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1202-1HB□□-2D□□ (only star circuit configuration)

Rated power	P_N	kW	13.8
Rated speed	n_N	rpm	3130
Rated torque	M_N	Nm	42
Rated current	I_N	A	42
Maximum current	I_{max}	A	84
Maximum speed	n_{max}	rpm	18000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	7800
Maximum torque	M_{max}	Nm	68
Spindle moment of inertia	J	kg m^2	0.015
Voltage constant / EMF	k_E	V/1000 rpm	74
Thermal time constant	T_{therm}	min	3

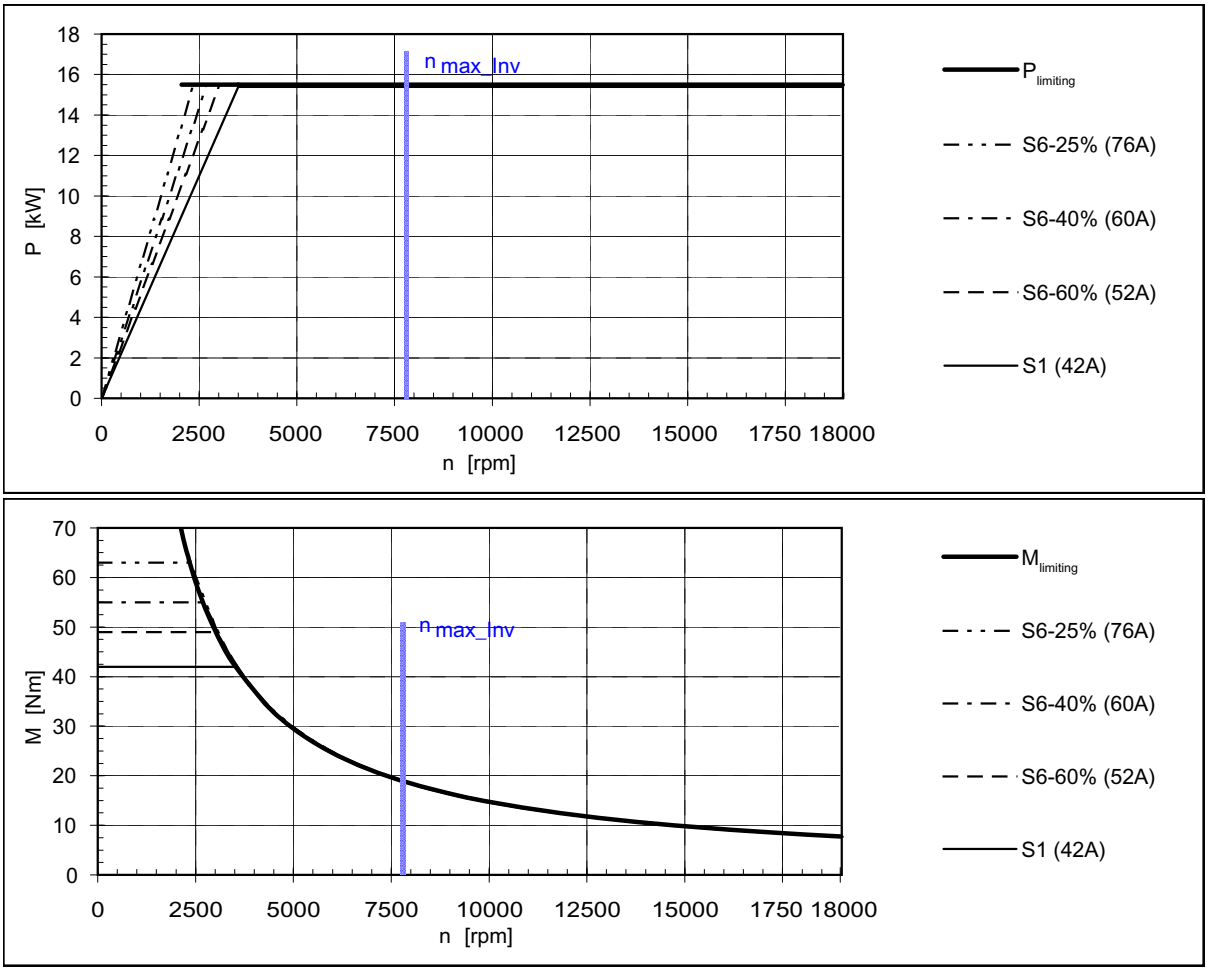




The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 9 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1202-1HB□□-2D□□ (only star circuit configuration)

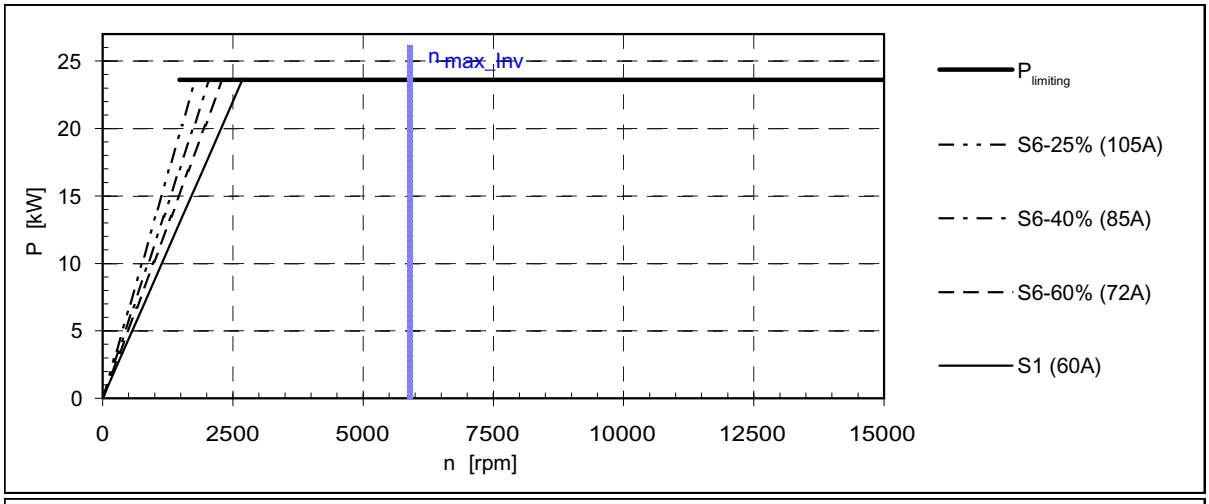
Rated power	P_N	kW	15.5
Rated speed	n_N	rpm	3500
Rated torque	M_N	Nm	42
Rated current	I_N	A	42
Maximum current	I_{max}	A	84
Maximum speed	n_{max}	rpm	18000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	7800
Maximum torque	M_{max}	Nm	68
Spindle moment of inertia	J	kg m^2	0.015
Voltage constant / EMF	k_E	V/1000 rpm	74
Thermal time constant	T_{therm}	min	3

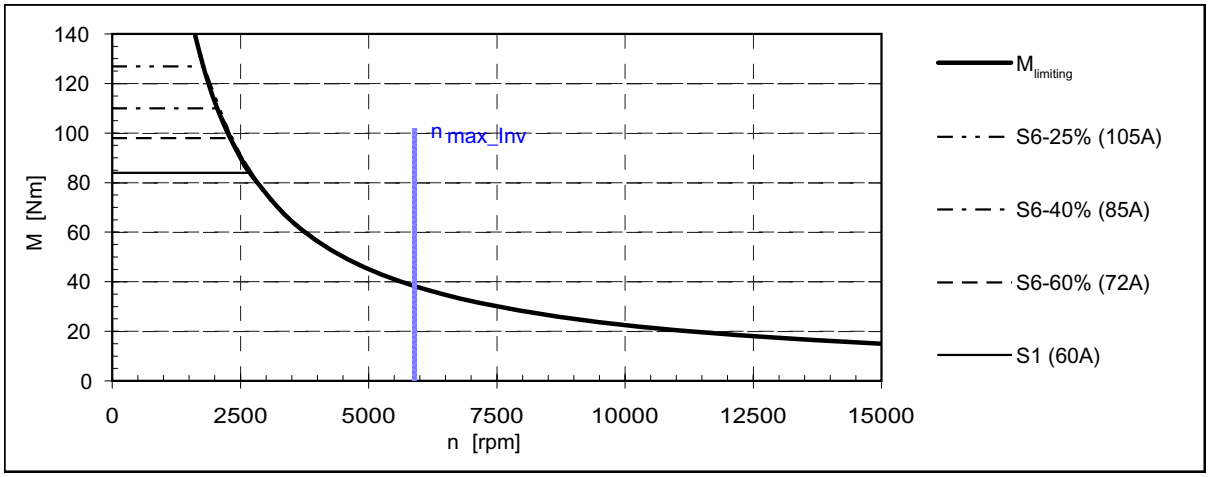


The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 10 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1204-1HA□□-2D□□ (only star circuit configuration)

Rated power	P_N	kW	23.6
Rated speed	n_N	rpm	2680
Rated torque	M_N	Nm	84
Rated current	I_N	A	60
Maximum current	I_{max}	A	120
Maximum speed	n_{max}	rpm	15000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	5900
Maximum torque	M_{max}	Nm	140
Spindle moment of inertia	J	kg m^2	0.023
Voltage constant / EMF	k_E	V/1000 rpm	97
Thermal time constant	T_{therm}	min	3

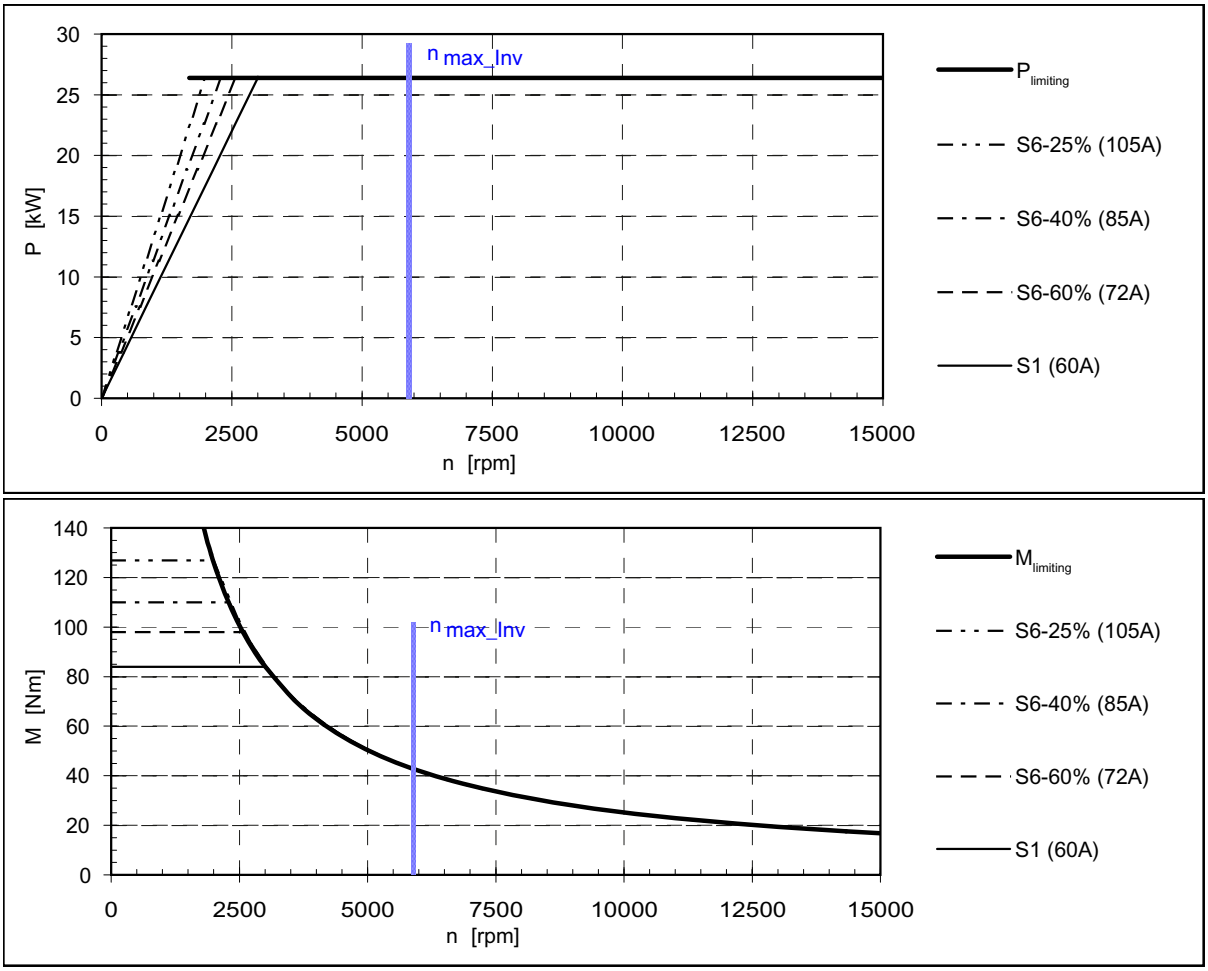




The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 11 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1204-1HA□□-1D□□ (only star circuit configuration)

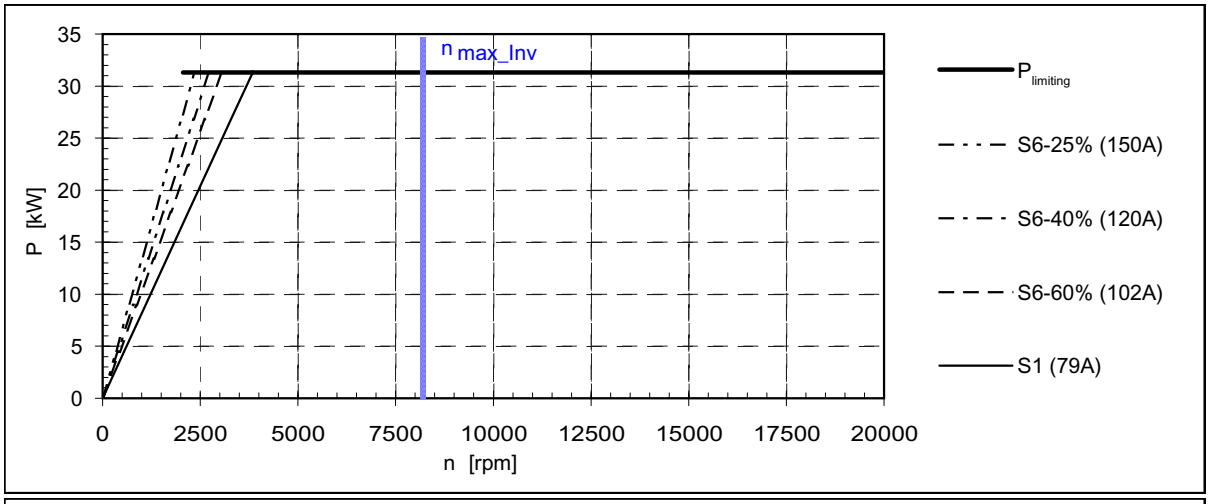
Rated power	P_N	kW	26.4
Rated speed	n_N	rpm	3000
Rated torque	M_N	Nm	84
Rated current	I_N	A	60
Maximum current	I_{max}	A	120
Maximum speed	n_{max}	rpm	15000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	5900
Maximum torque	M_{max}	Nm	140
Spindle moment of inertia	J	kg m^2	0.023
Voltage constant / EMF	k_E	V/1000 rpm	97
Thermal time constant	T_{therm}	min	3

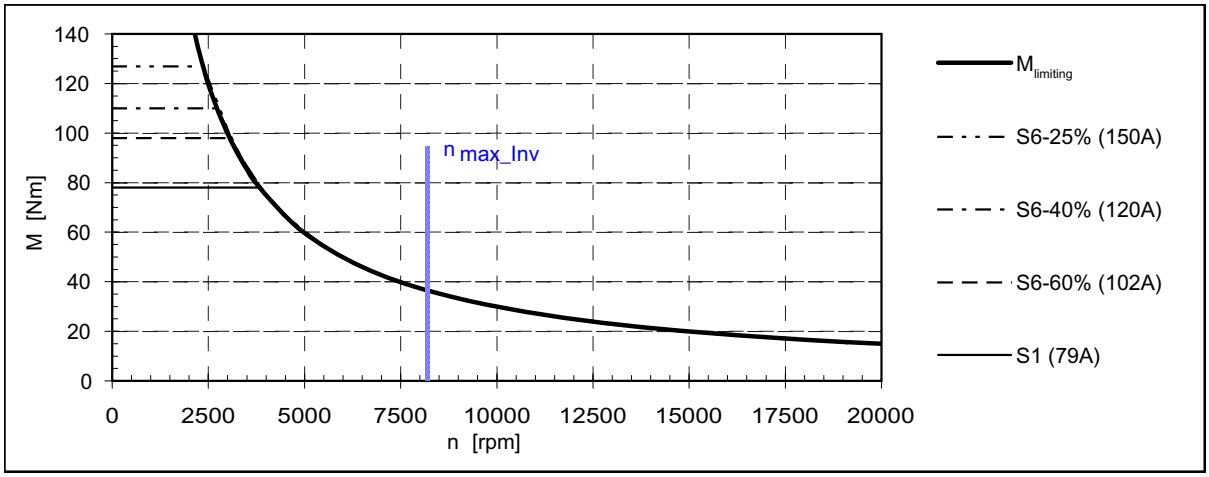


The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 12 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1204-1HB□□-2D□□ (only star circuit configuration)

Rated power	P_N	kW	31.4
Rated speed	n_N	rpm	3840
Rated torque	M_N	Nm	78
Rated current	I_N	A	79
Maximum current	I_{max}	A	160
Maximum speed	n_{max}	rpm	20000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	8200
Maximum torque	M_{max}	Nm	140
Spindle moment of inertia	J	kg m^2	0.023
Voltage constant / EMF	k_E	V/1000 rpm	70
Thermal time constant	T_{therm}	min	3

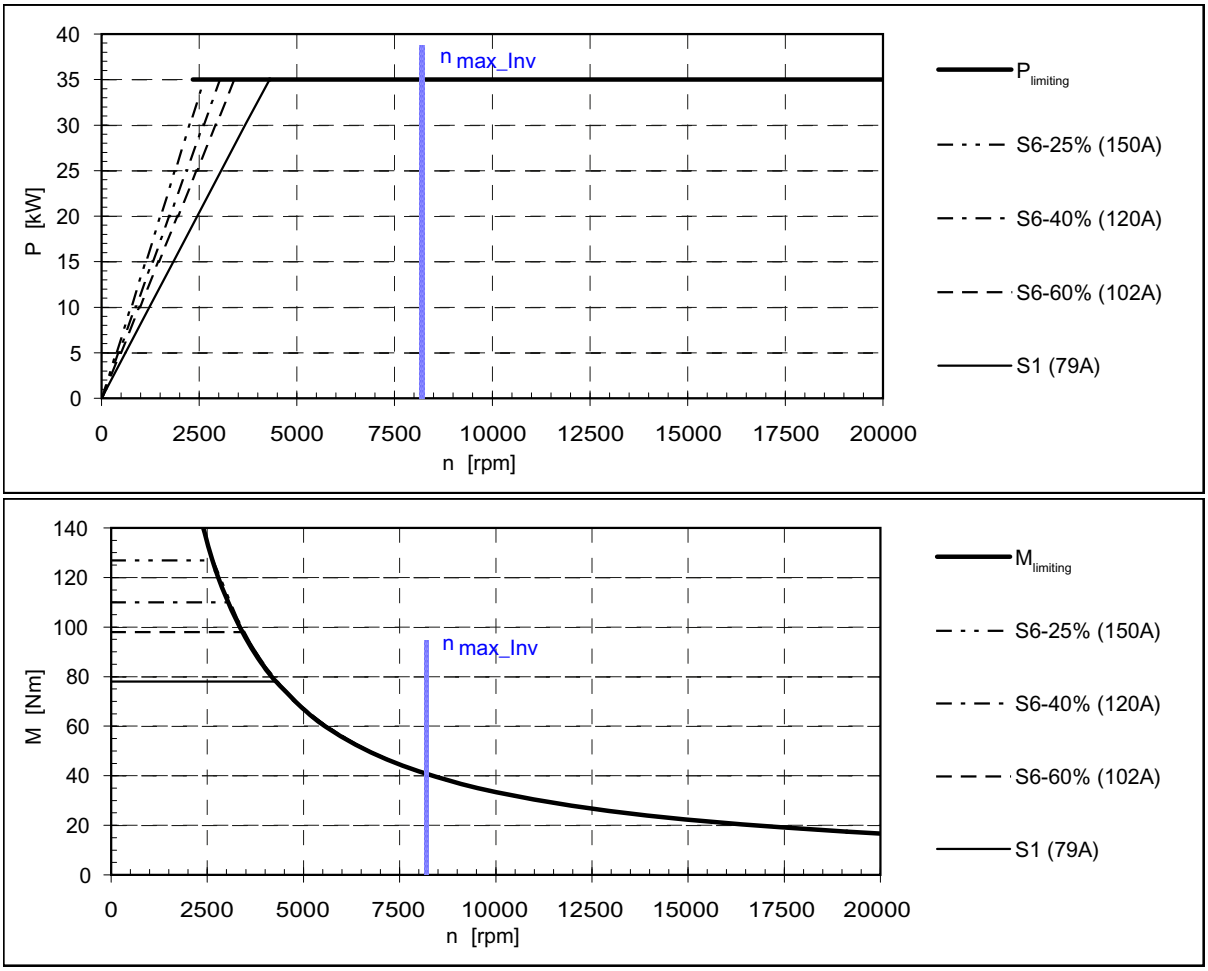




The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 13 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1204-1HB□□-2D□□ (only star circuit configuration)

Rated power	P_N	kW	35
Rated speed	n_N	rpm	4300
Rated torque	M_N	Nm	78
Rated current	I_N	A	79
Maximum current	I_{max}	A	160
Maximum speed	n_{max}	rpm	18000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	8200
Maximum torque	M_{max}	Nm	140
Spindle moment of inertia	J	kg m^2	0.023
Voltage constant / EMF	k_E	V/1000 rpm	70
Thermal time constant	T_{therm}	min	3

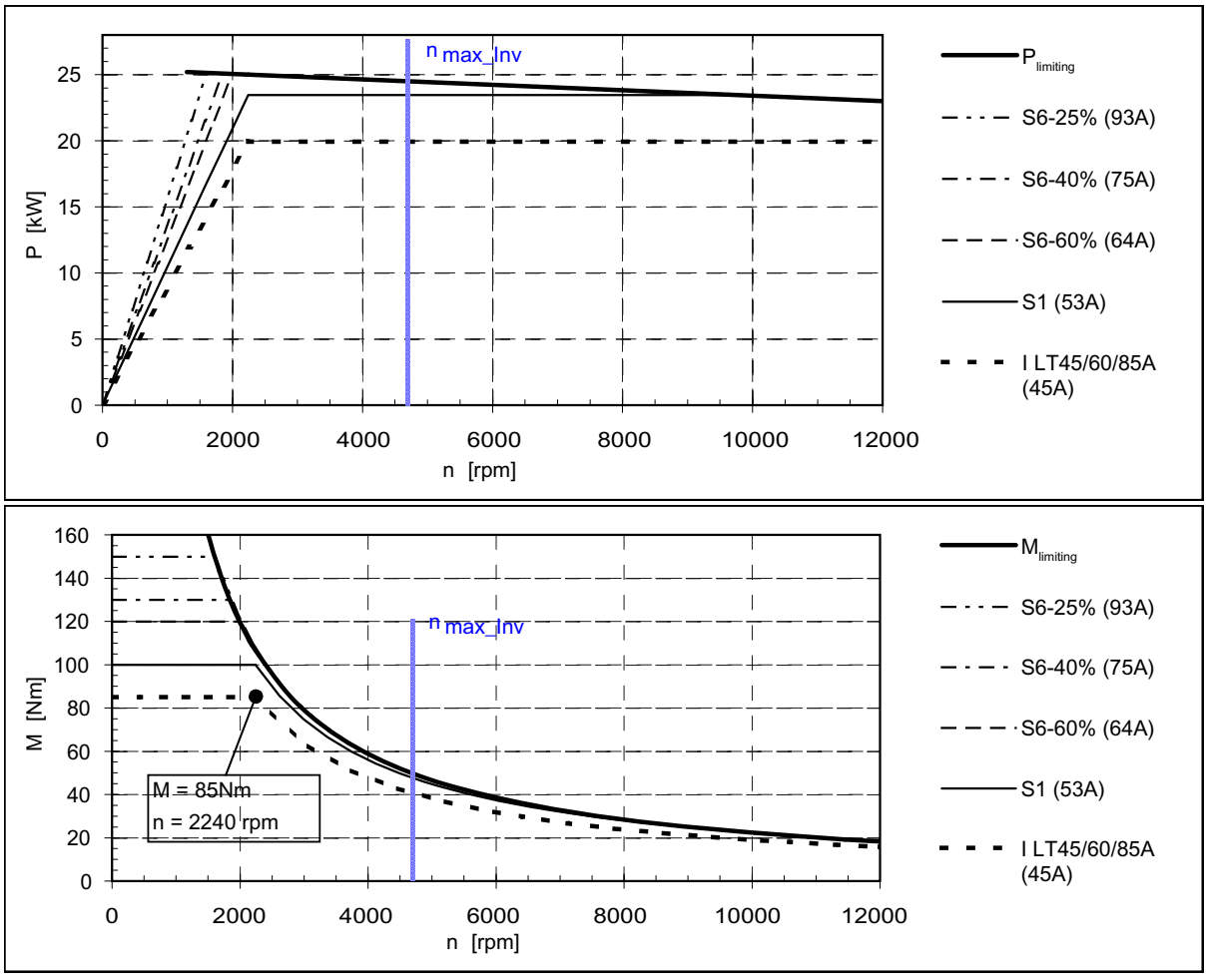


The data for duty type S6 are valid for a 2 min. duty cycle.

10.2.2 2SP125x synchronous motor

Table 10- 14 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1253-1HA□□-2□□2 (only star circuit configuration)

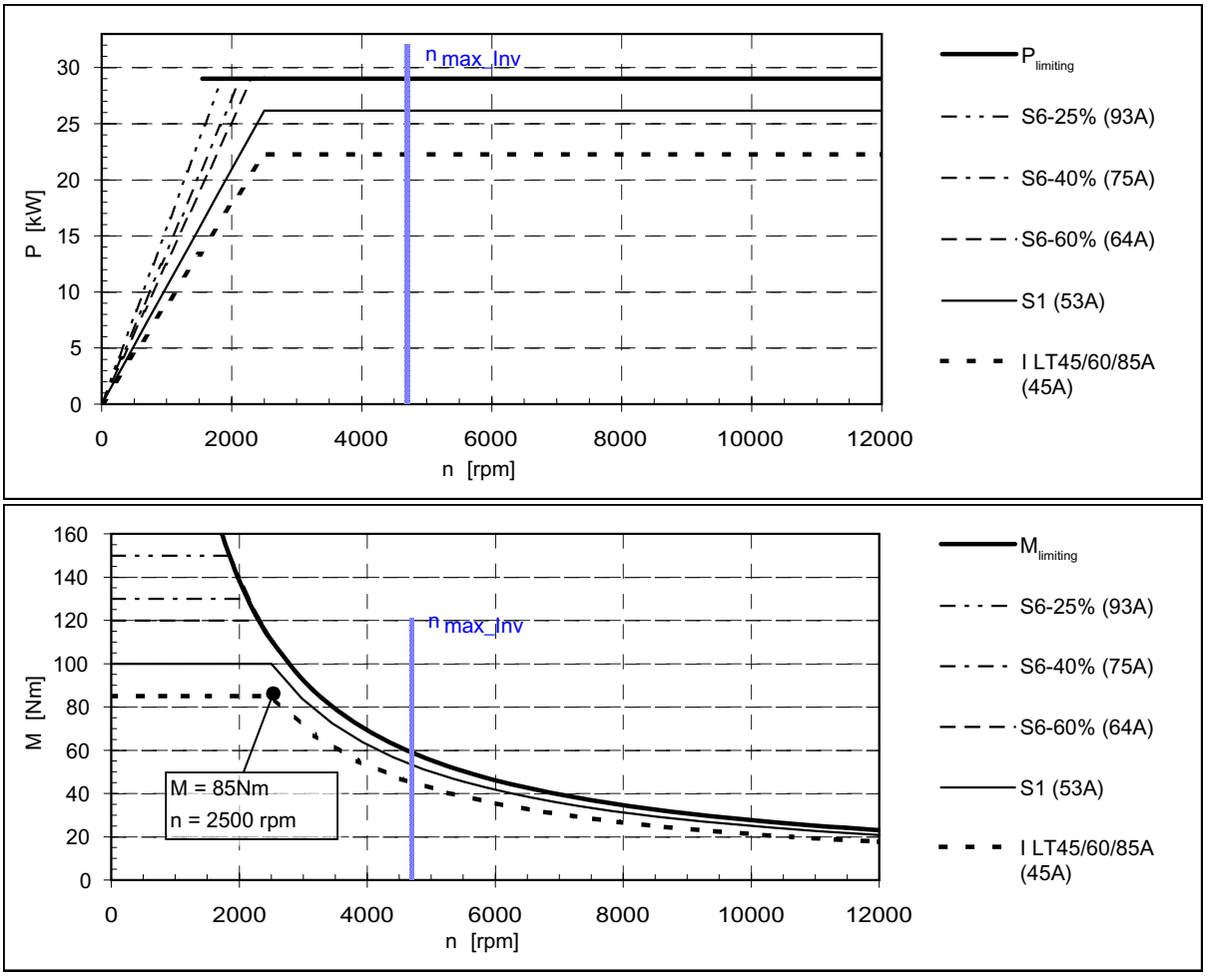
Rated power	P_N	kW	23.5
Rated speed	n_N	rpm	2240
Rated torque	M_N	Nm	100
Rated current	I_N	A	53
Maximum current	I_{max}	A	106
Maximum speed	n_{max}	rpm	12000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	4700
Maximum torque	M_{max}	Nm	158
Spindle moment of inertia	J	kg m^2	0.037
Voltage constant / EMF	k_E	V/1000 rpm	121
Thermal time constant	T_{therm}	min	3



The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 15 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1253-1HA□□-2□□2 (only star circuit configuration)

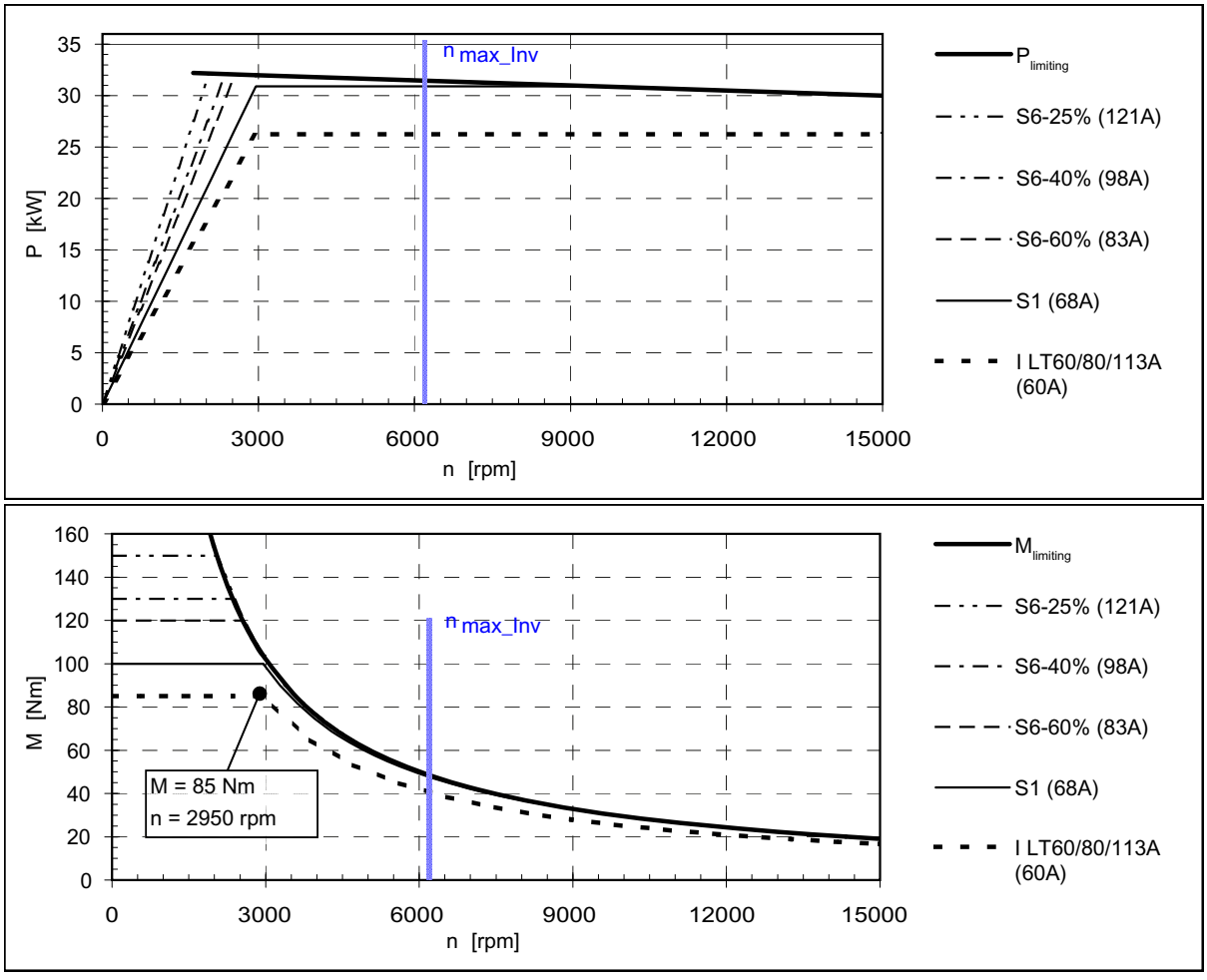
Rated power	P_N	kW	26
Rated speed	n_N	rpm	2500
Rated torque	M_N	Nm	100
Rated current	I_N	A	53
Maximum current	I_{max}	A	106
Maximum speed	n_{max}	rpm	12000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	4700
Maximum torque	M_{max}	Nm	158
Spindle moment of inertia	J	kg m^2	0.037
Voltage constant / EMF	k_E	V/1000 rpm	121
Thermal time constant	T_{therm}	min	3



The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 16 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1253-1HB□□-1D□2 (only star circuit configuration)

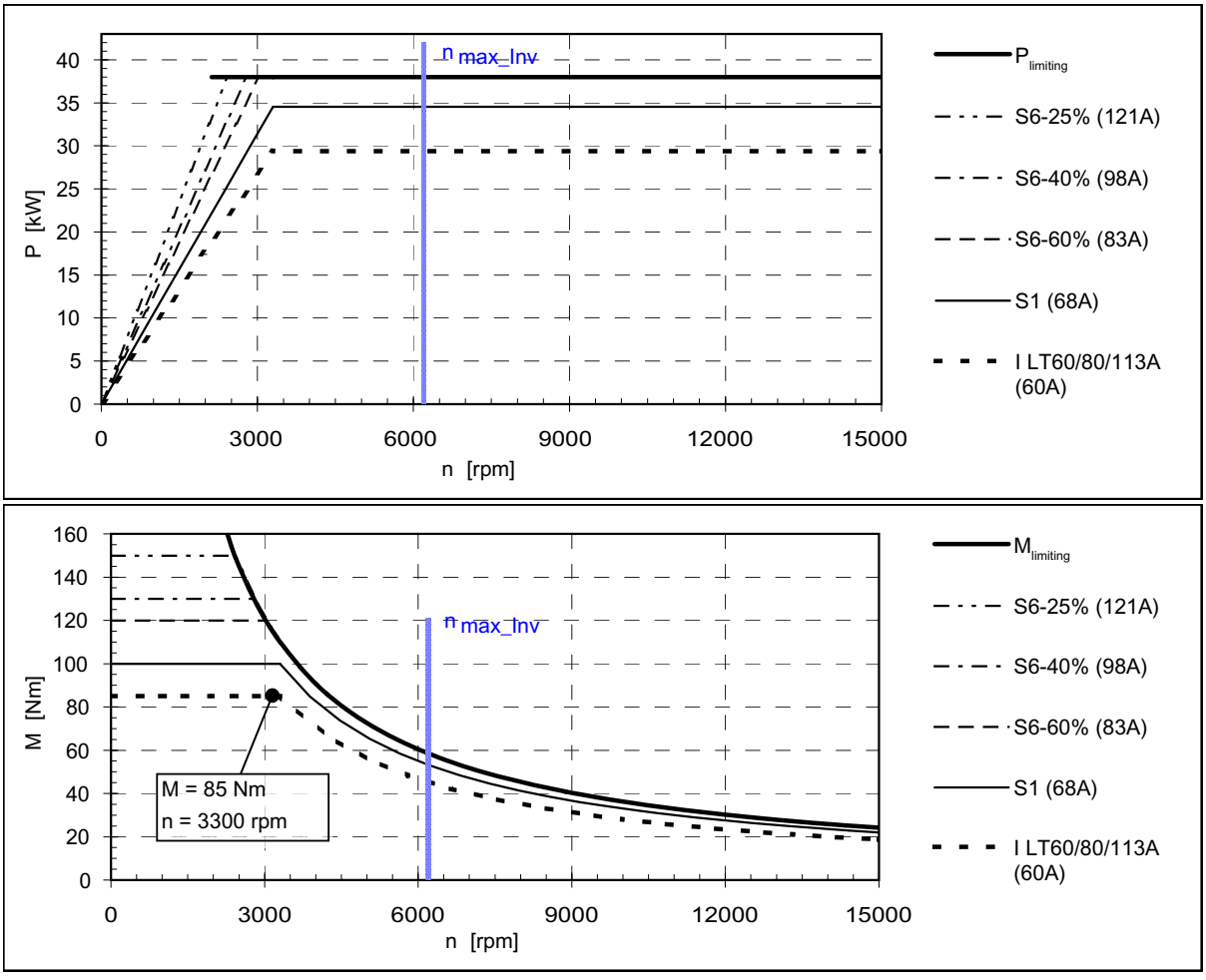
Rated power	P_N	kW	30.9
Rated speed	n_N	rpm	2950
Rated torque	M_N	Nm	100
Rated current	I_N	A	68
Maximum current	I_{max}	A	136
Maximum speed	n_{max}	rpm	15000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	6200
Maximum torque	M_{max}	Nm	158
Spindle moment of inertia	J	kg m^2	0.037
Voltage constant / EMF	k_E	V/1000 rpm	93
Thermal time constant	T_{therm}	min	3



The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 17 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1253-1HB□□-1D□2 (only star circuit configuration)

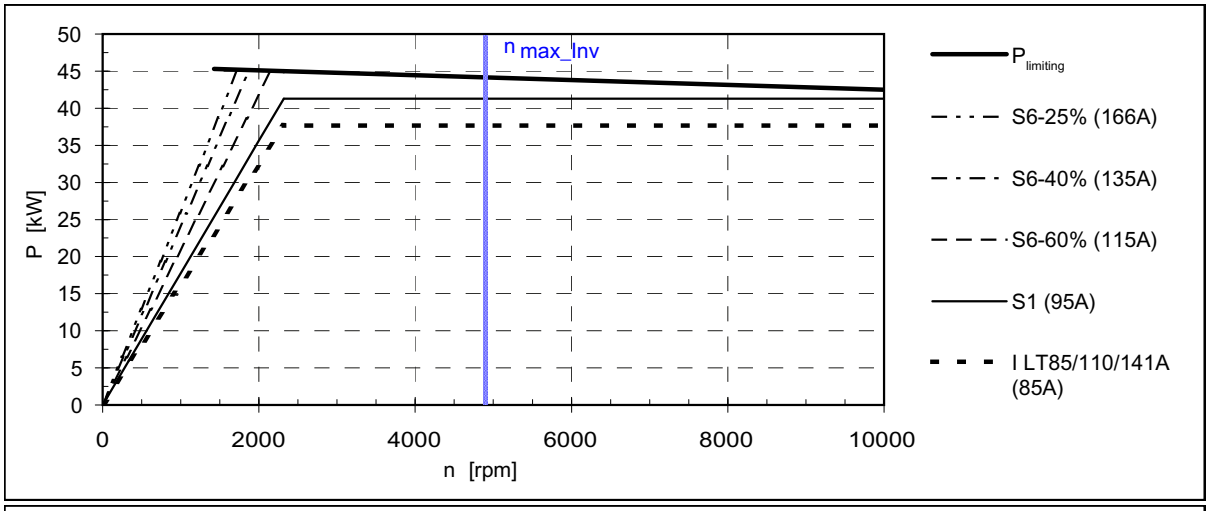
Rated power	P_N	kW	35
Rated speed	n_N	rpm	3300
Rated torque	M_N	Nm	100
Rated current	I_N	A	68
Maximum current	I_{max}	A	136
Maximum speed	n_{max}	rpm	15000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	6200
Maximum torque	M_{max}	Nm	158
Spindle moment of inertia	J	kg m^2	0.037
Voltage constant / EMF	k_E	V/1000 rpm	93
Thermal time constant	T_{therm}	min	3

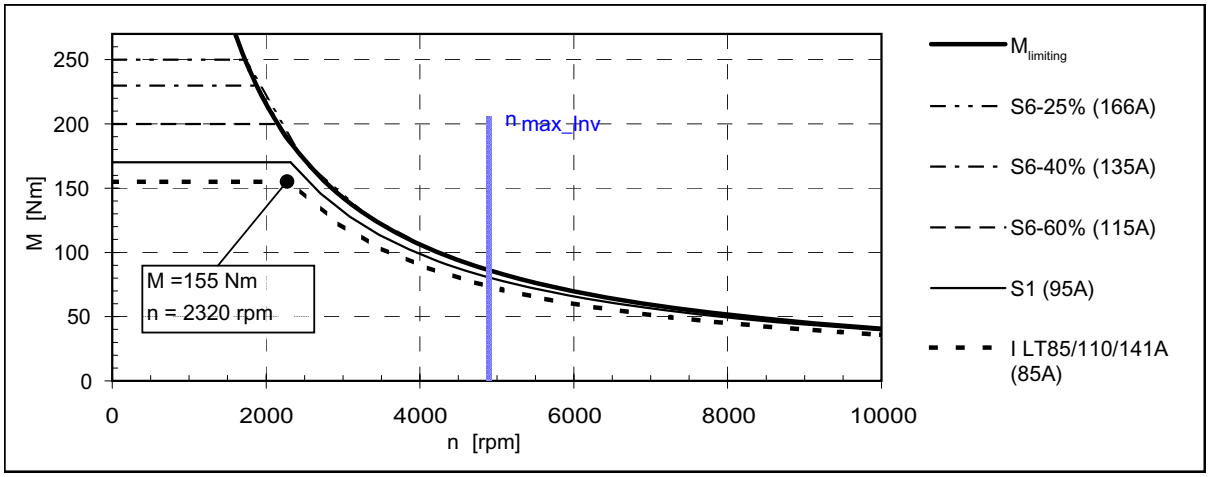


The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 18 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1255-1HAD□-0□□2 (only star circuit configuration)

Rated power	P_N	kW	41.3
Rated speed	n_N	rpm	2320
Rated torque	M_N	Nm	170
Rated current	I_N	A	95
Maximum current	I_{max}	A	190
Maximum speed	n_{max}	rpm	10000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	4900
Maximum torque	M_{max}	Nm	265
Spindle moment of inertia	J	kg m^2	0.055
Voltage constant / EMF	k_E	V/1000 rpm	116
Thermal time constant	T_{therm}	min	3

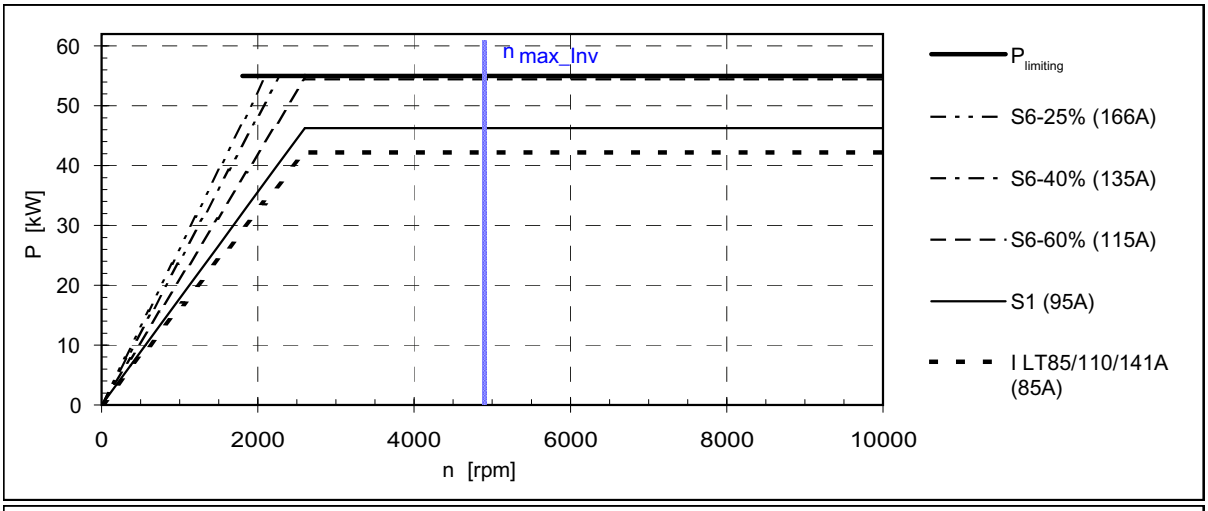


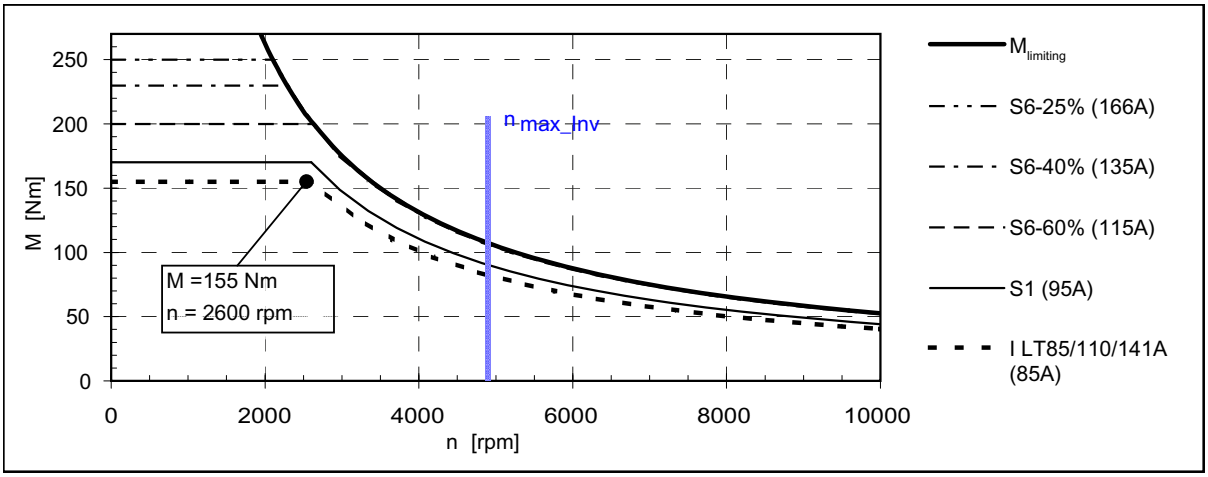


The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 19 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1255-1HA□□-0□□2 (only star circuit configuration)

Rated power	P_N	kW	46.3
Rated speed	n_N	rpm	2600
Rated torque	M_N	Nm	170
Rated current	I_N	A	95
Maximum current	I_{max}	A	190
Maximum speed	n_{max}	rpm	10000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	4900
Maximum torque	M_{max}	Nm	265
Spindle moment of inertia	J	kg m^2	0.055
Voltage constant / EMF	k_E	V/1000 rpm	116
Thermal time constant	T_{therm}	min	3

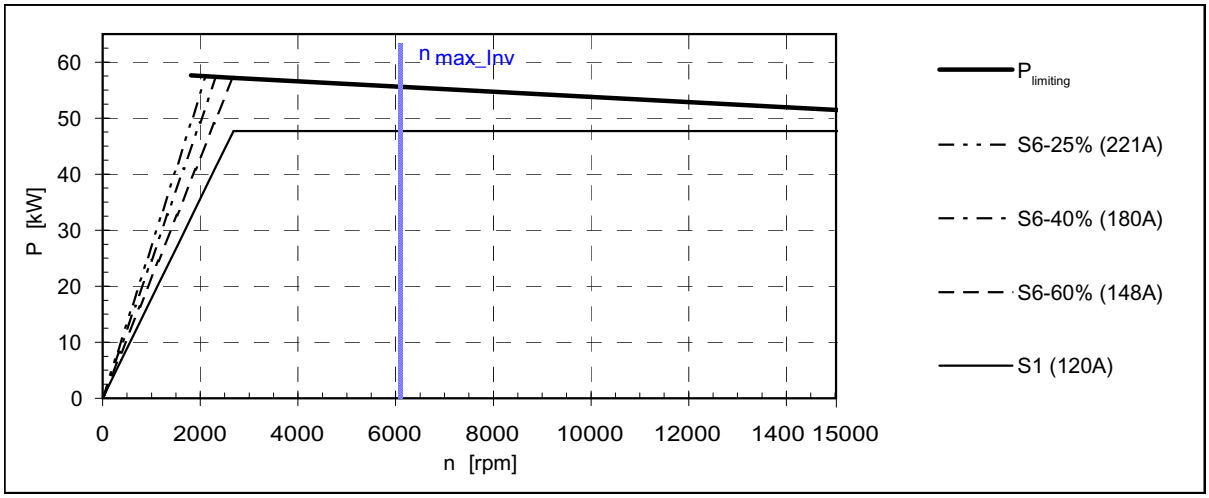


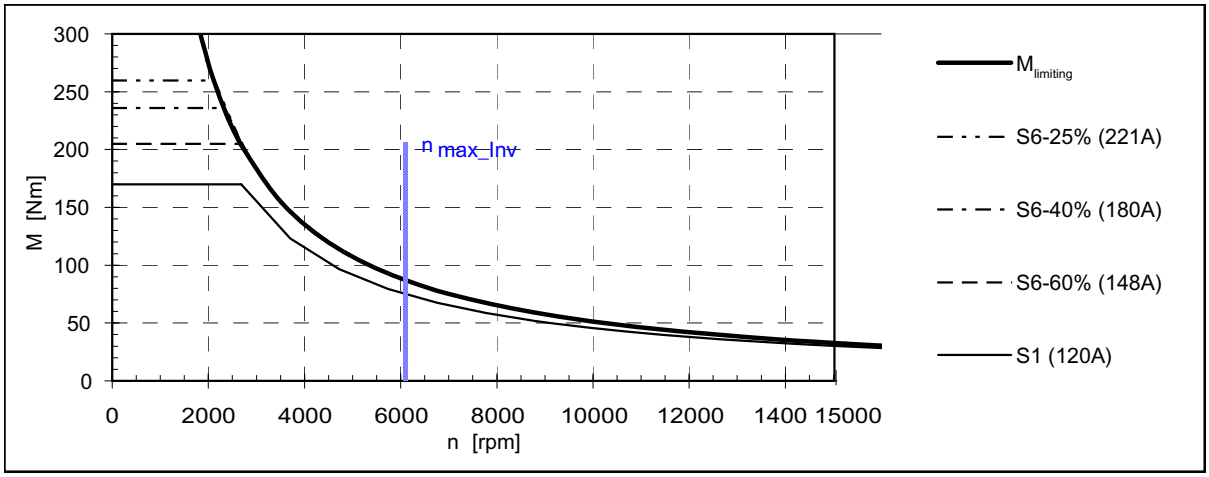


The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 20 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1255-1HB□□-1D□2 (only star circuit configuration)

Rated power	P_N	kW	47.7
Rated speed	n_N	rpm	2680
Rated torque	M_N	Nm	170
Rated current	I_N	A	120
Maximum current	I_{max}	A	240
Maximum speed	n_{max}	rpm	15000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	6100
Maximum torque	M_{max}	Nm	265
Spindle moment of inertia	J	kg m^2	0.055
Voltage constant / EMF	k_E	V/1000 rpm	94
Thermal time constant	T_{therm}	min	3

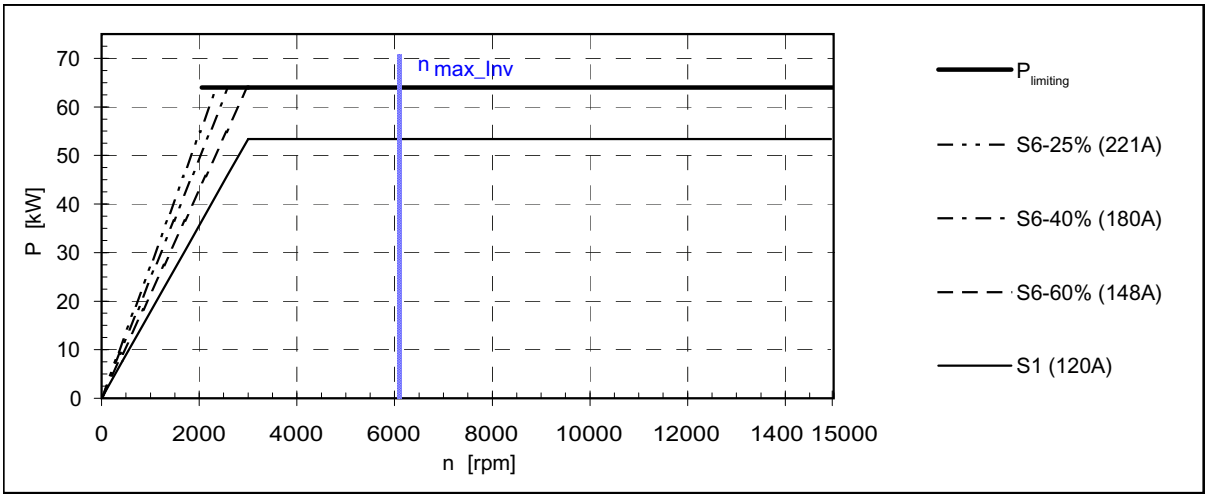


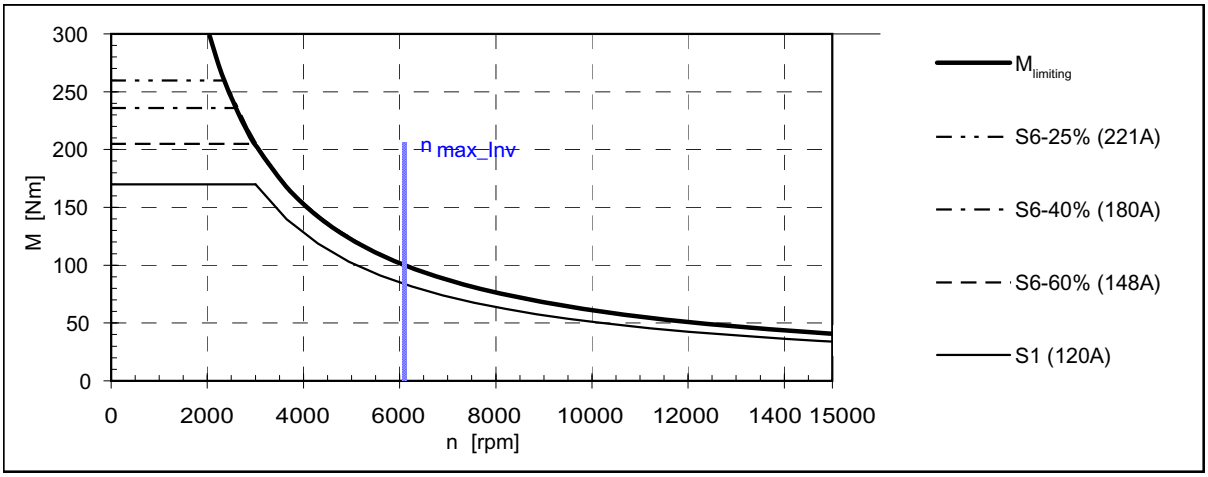


The data for duty type S6 are valid for a 2 min. duty cycle.

Table 10- 21 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1255-1HB□□-1D□2 (only star circuit configuration)

Rated power	P_N	kW	53.4
Rated speed	n_N	rpm	3000
Rated torque	M_N	Nm	170
Rated current	I_N	A	120
Maximum current	I_{max}	A	240
Maximum speed	n_{max}	rpm	15000
Max. permissible speed (converter)	$n_{max\ Inv}$	rpm	6100
Maximum torque	M_{max}	Nm	265
Spindle moment of inertia	J	kg m^2	0.055
Voltage constant / EMF	k_E	V/1000 rpm	94
Thermal time constant	T_{therm}	min	3



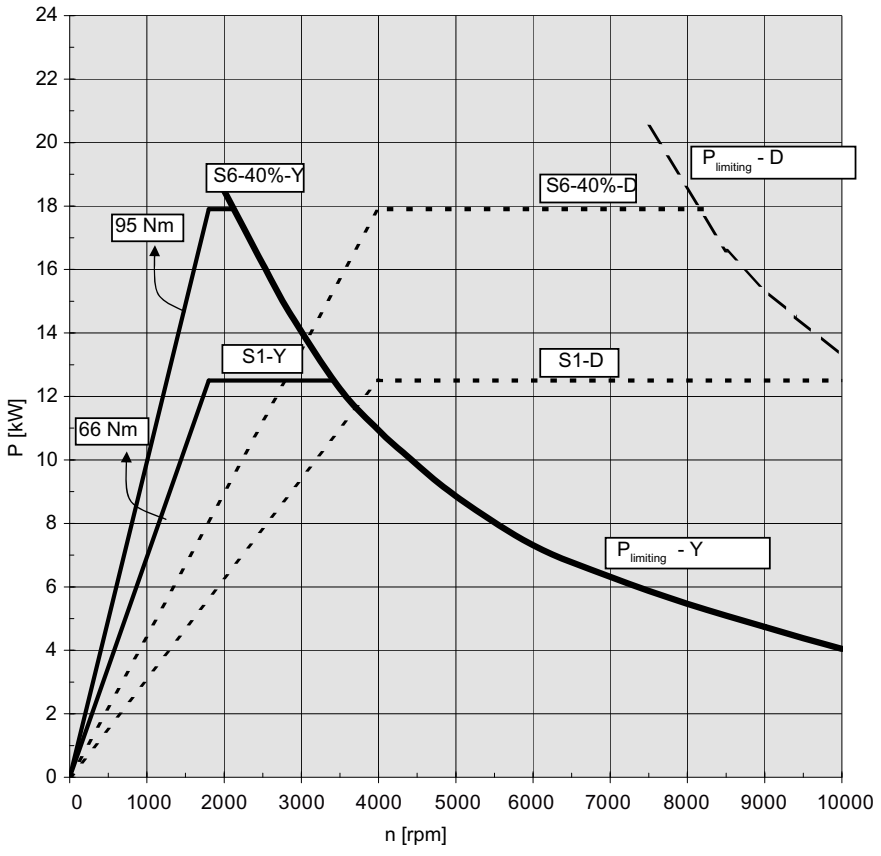


The data for duty type S6 are valid for a 2 min. duty cycle.

10.2.3 2SP125x induction motor

Table 10- 22 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1253-8HA□□-0□□2

			Star	Delta
Rated power (S1)	P_N	kW	12.5	12.5
Rated power (S6-40 %))	P_N	kW	17.9	17.9
Rated speed	n_N	rpm	1800	4000
Rated torque (S1)	M_N	Nm	66	30
Rated torque (S6-40%)	M_N	Nm	94	43
Rated current (S1)	I_N	A	27.0	28.0
Rated current (S6-40 %))	I_N	A	40.0	37.0
Maximum speed	n_{max}	rpm	10000	10000
Moment of inertia	J_{rot}	kg m^2	0.037	0.037
Thermal time constant	T_{therm}	min	2	2
Stator weight	m	kg	approx. 130	approx. 130



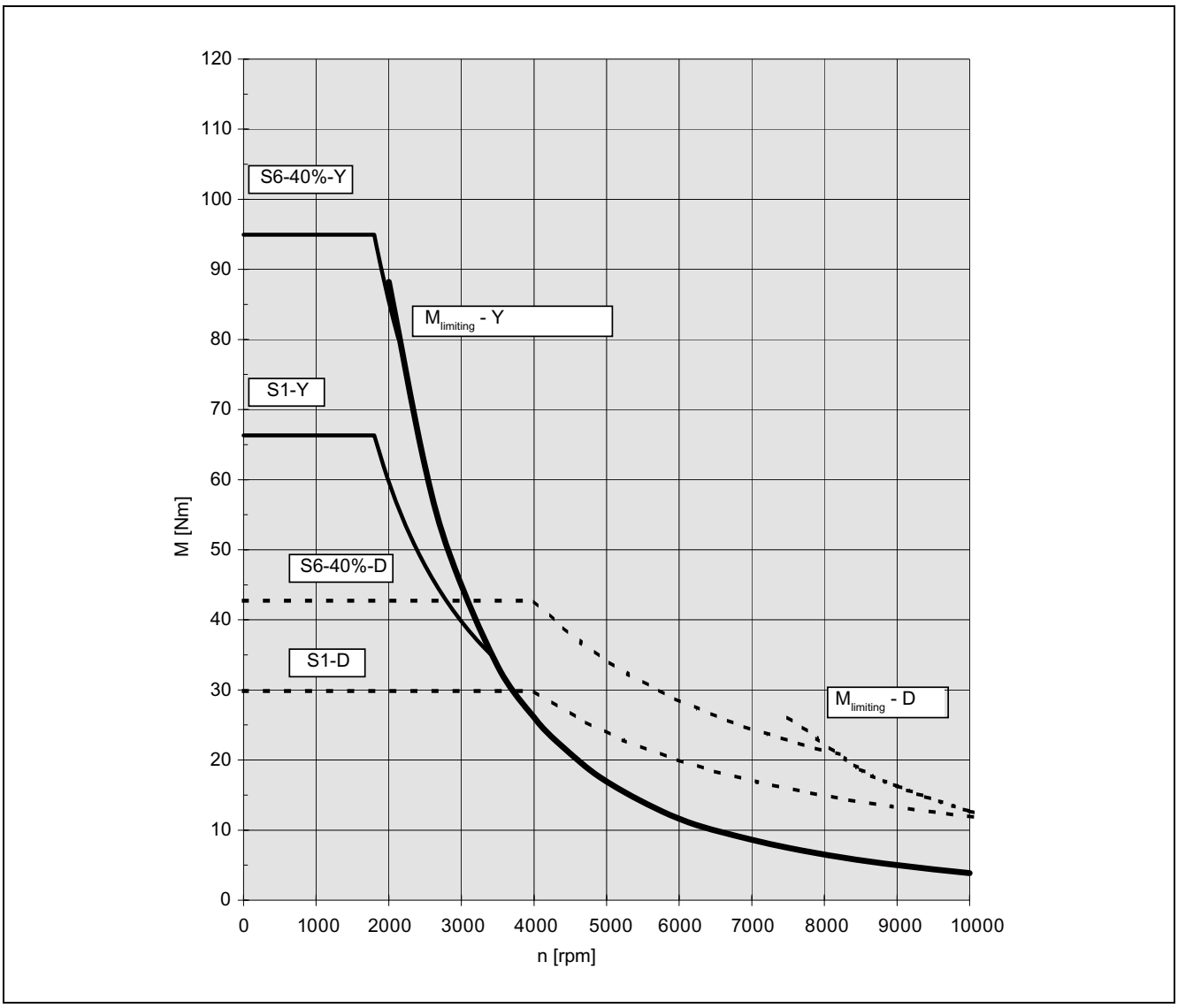
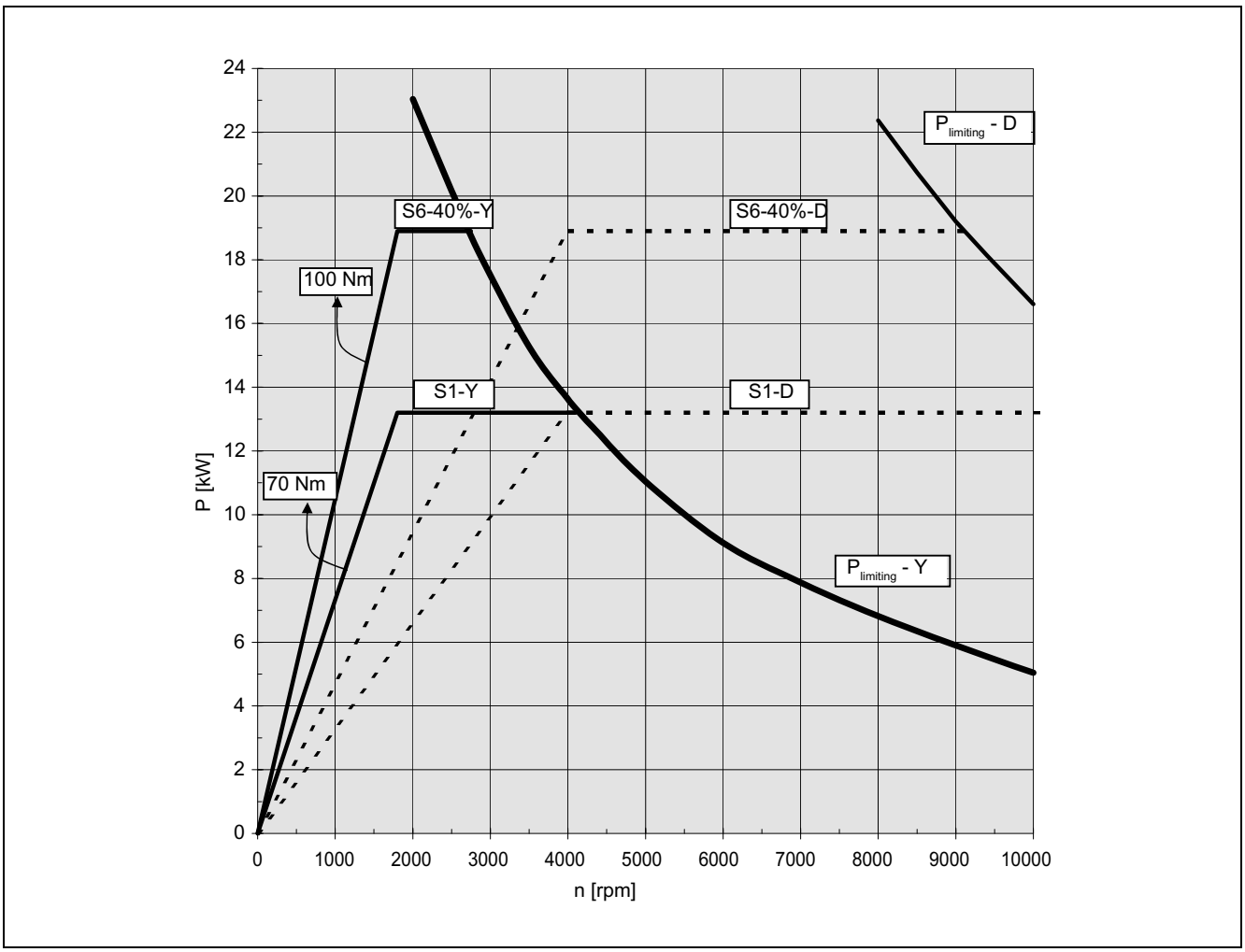

120
110
100
90
80
70
60
50
40
30
20
10
0
M [Nm]
S6-40%-Y
M limiting - Y
S1-Y
S6-40%-D
S1-D
M limiting - D
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
n [rpm]

Table 10- 23 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1253-8HA□□-0□□2

			Star	Delta
Rated power (S1)	P_N	kW	13.2	13.2
Rated power (S6-40 %))	P_N	kW	18.9	18.9
Rated speed	n_N	rpm	1800	4000
Rated torque (S1)	M_N	Nm	70	32
Rated torque (S6-40%)	M_N	Nm	100	45
Rated current (S1)	I_N	A	28.0	29.0
Rated current (S6-40 %))	I_N	A	39.0	39.0
Maximum speed	n_{max}	rpm	10000	10000
Moment of inertia	J_{rot}	kg m^2	0.037	0.037
Thermal time constant	T_{therm}	min	2	2
Stator weight	m	kg	approx. 130	approx. 130


P [kW]
n [rpm]
0
2
4
6
8
10
12
14
16
18
20
22
24
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
S6-40%-Y
S6-40%-D
100 Nm
S1-Y
S1-D
70 Nm
P limiting - D
P limiting - Y

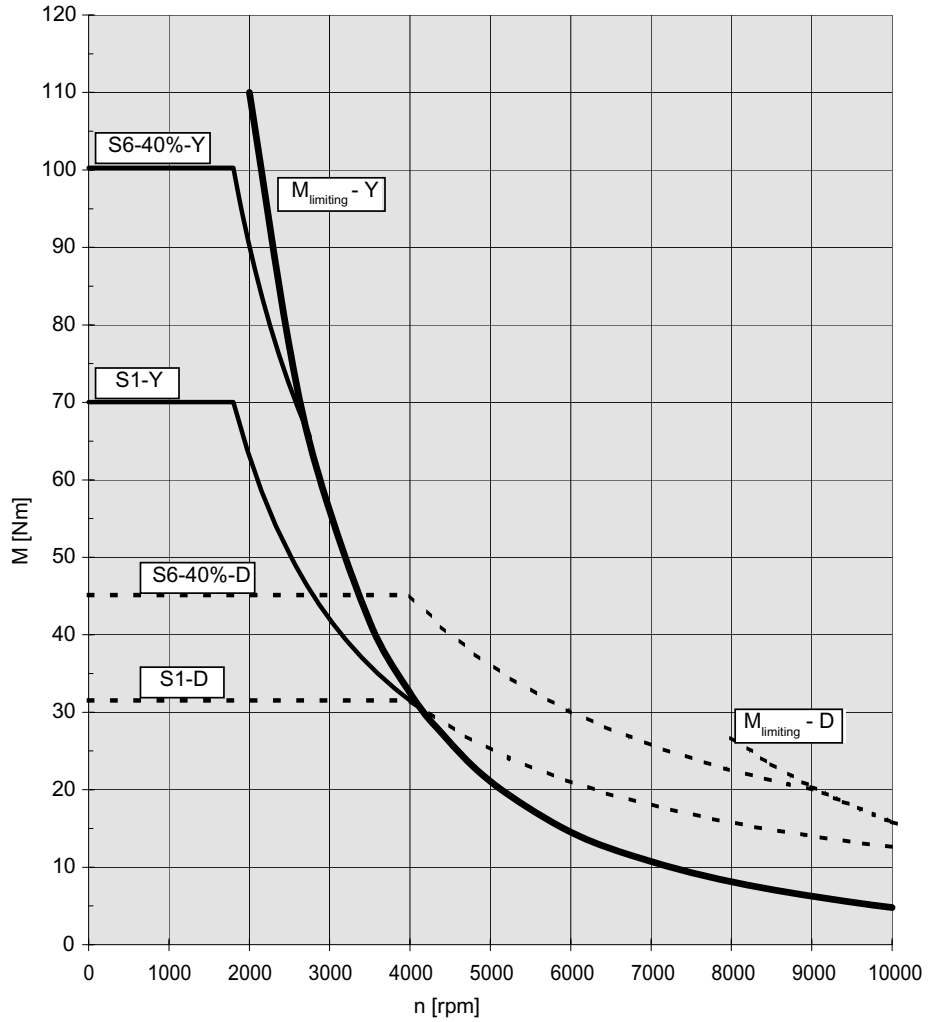
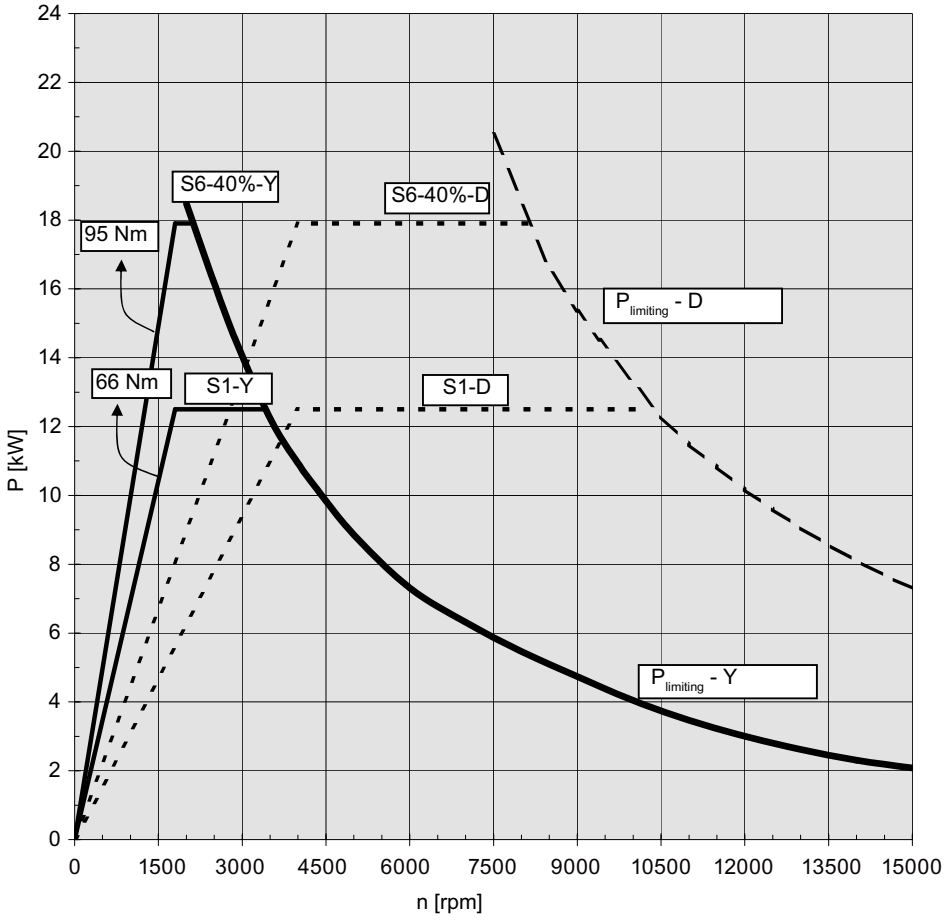

120
110
100
90
80
70
60
50
40
30
20
10
0
M [Nm]
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
n [rpm]
S6-40%-Y
M limiting - Y
S1-Y
S6-40%-D
S1-D
M limiting - D

Table 10- 24 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1253-8HA□□-1D□2

			Star	Delta
Rated power (S1)	P_N	kW	12.5	12.5
Rated power (S6-40 %))	P_N	kW	17.9	17.9
Rated speed	n_N	rpm	1800	4000
Rated torque (S1)	M_N	Nm	66	30
Rated torque (S6-40%)	M_N	Nm	94	43
Rated current (S1)	I_N	A	27.0	28.0
Rated current (S6-40 %))	I_N	A	40.0	37.0
Maximum speed	n_{max}	rpm	15000	15000
Moment of inertia	J_{rot}	kg m^2	0.037	0.037
Thermal time constant	T_{therm}	min	2	2
Stator weight	m	kg	approx. 130	approx. 130



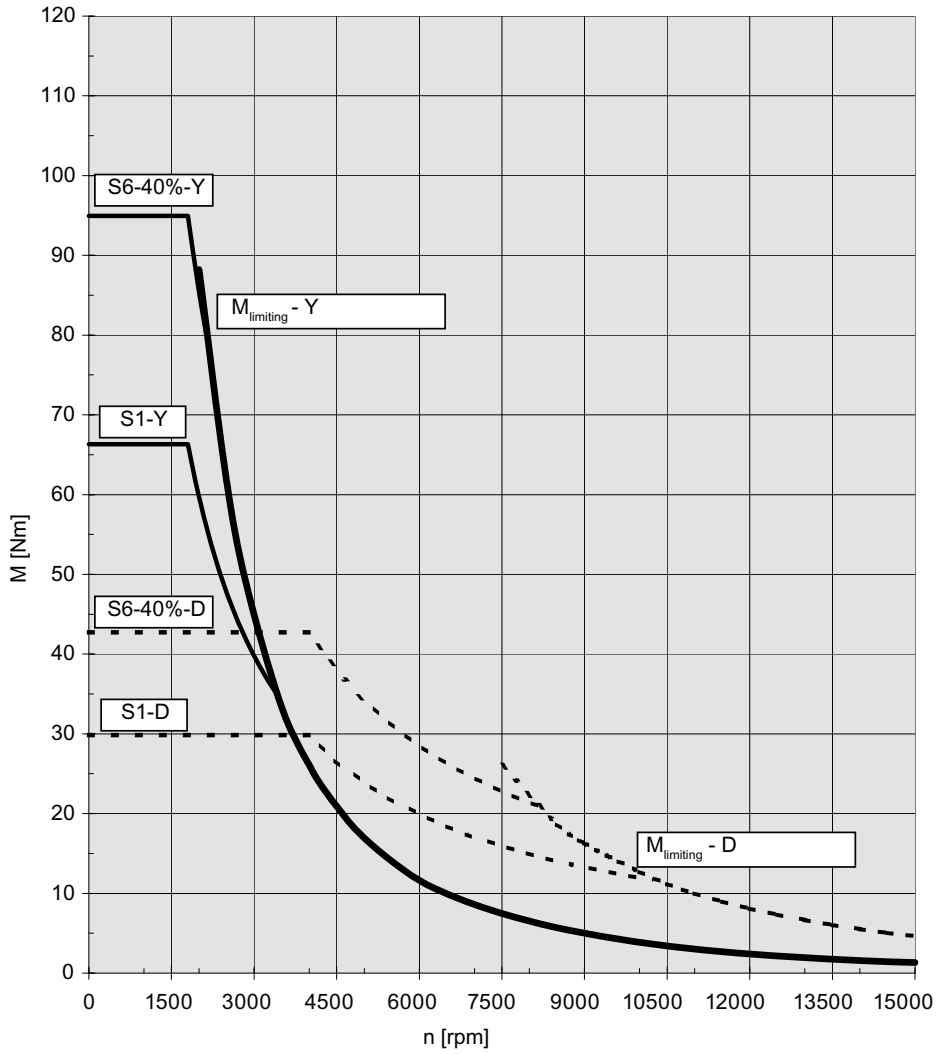
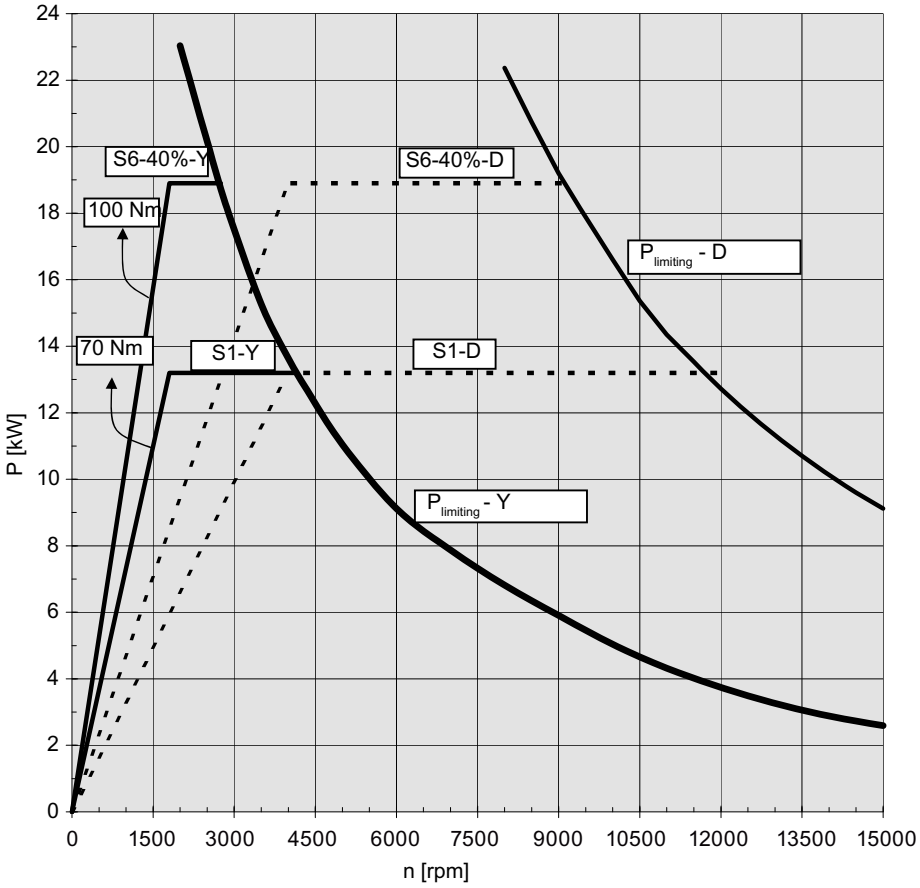

120
110
100
90
80
70
60
50
40
30
20
10
0
M [Nm]
S6-40%-Y
$M_{limiting}$ - Y
S1-Y
S6-40%-D
S1-D
$M_{limiting}$ - D
0
1500
3000
4500
6000
7500
9000
10500
12000
13500
15000
n [rpm]

Table 10- 25 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1253-8HA□□-1D□2

			Star	Delta
Rated power (S1)	P_N	kW	13.2	13.2
Rated power (S6-40 %))	P_N	kW	18.9	18.9
Rated speed	n_N	rpm	1800	4000
Rated torque (S1)	M_N	Nm	70	32
Rated torque (S6-40%)	M_N	Nm	100	45
Rated current (S1)	I_N	A	28.0	29.0
Rated current (S6-40 %))	I_N	A	39.0	39.0
Maximum speed	n_{max}	rpm	15000	15000
Moment of inertia	J_{rot}	kg m^2	0.037	0.037
Thermal time constant	T_{therm}	min	2	2
Stator weight	m	kg	approx. 130	approx. 130



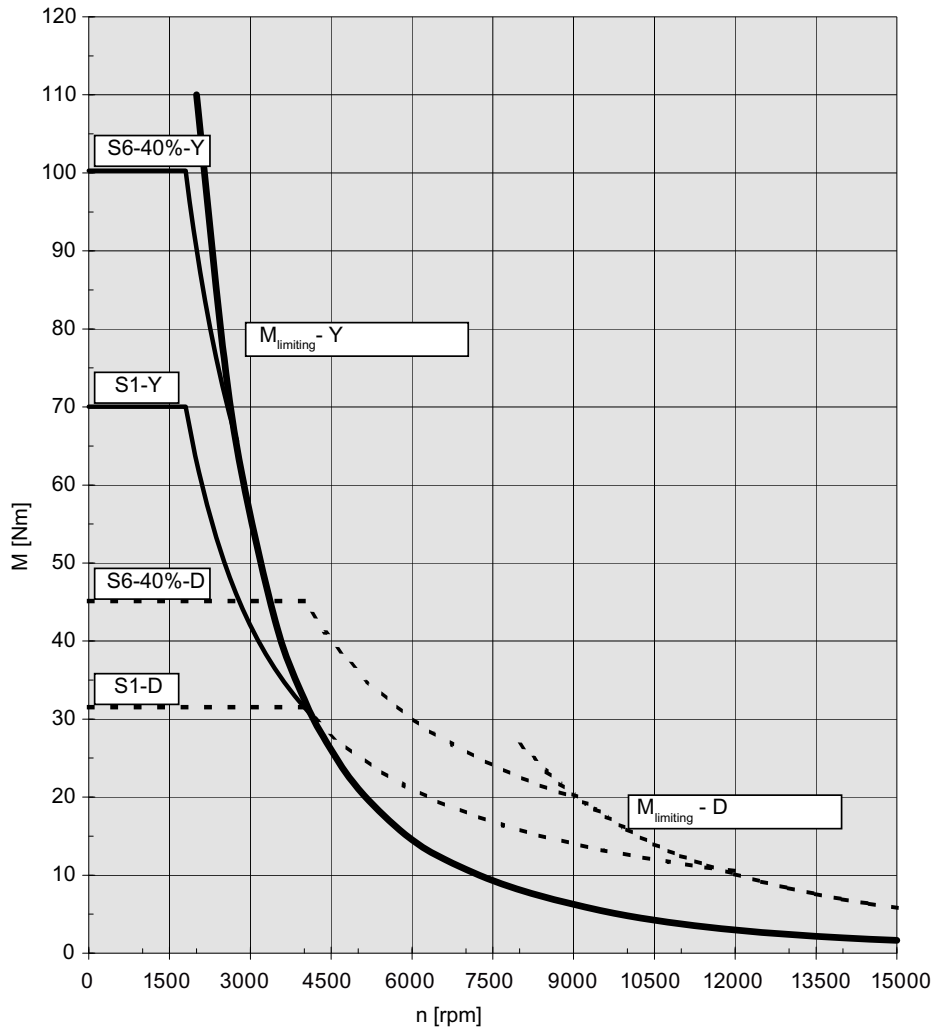
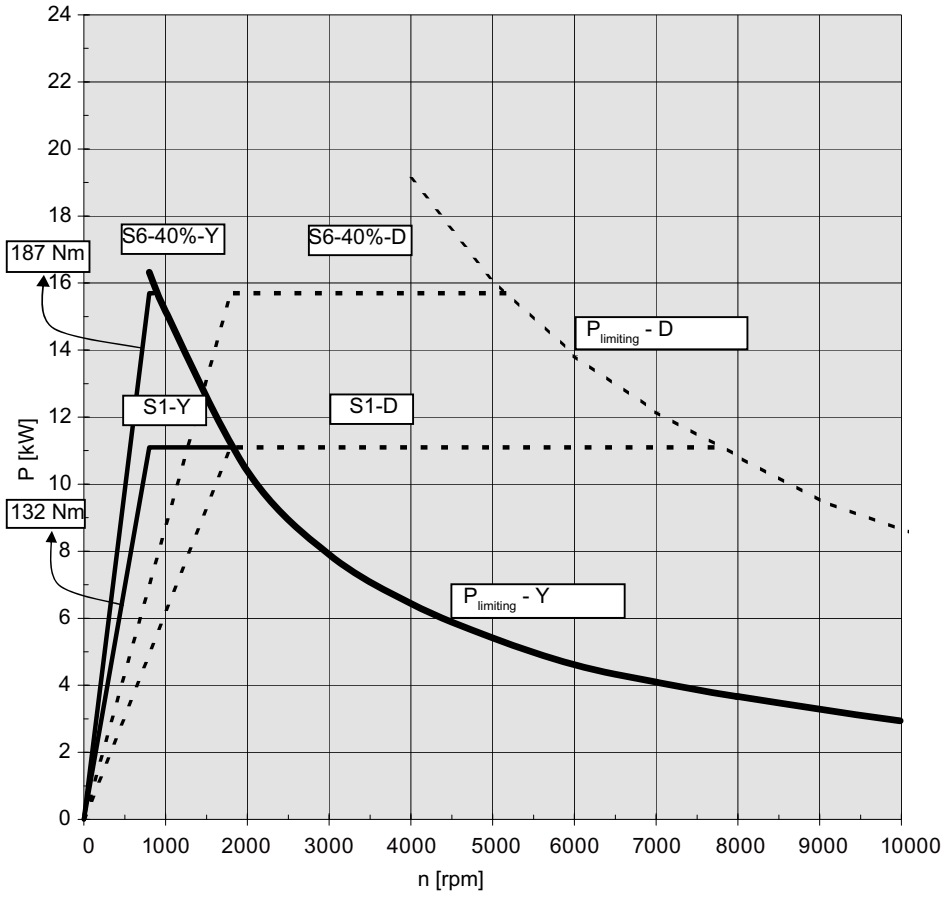

120
110
100
90
80
70
60
50
40
30
20
10
0
M [Nm]
S6-40%-Y
S1-Y
S6-40%-D
S1-D
$M_{limiting}$ - Y
$M_{limiting}$ - D
0
1500
3000
4500
6000
7500
9000
10500
12000
13500
15000
n [rpm]

Table 10- 26 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1255-8HA□□-0□□2

			Star	Delta
Rated power (S1)	P_N	kW	11.1	11.1
Rated power (S6-40 %))	P_N	kW	15.7	15.7
Rated speed	n_N	rpm	800	1800
Rated torque (S1)	M_N	Nm	132	59
Rated torque (S6-40%)	M_N	Nm	188	83
Rated current (S1)	I_N	A	29.0	28.0
Rated current (S6-40 %))	I_N	A	39.0	36.0
Maximum speed	n_{max}	rpm	10000	10000
Moment of inertia	J_{rot}	kg m^2	0.055	0.055
Thermal time constant	T_{therm}	min	2	2
Stator weight	m	kg	approx. 165	approx. 165



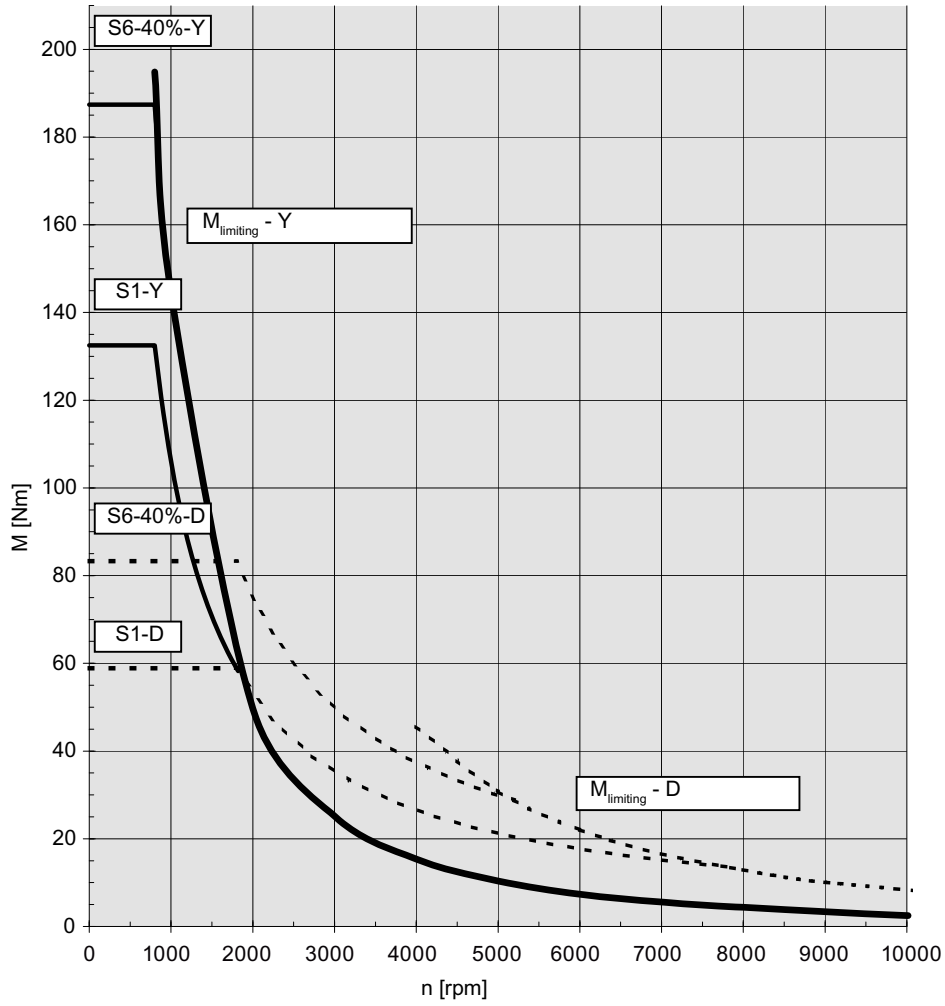
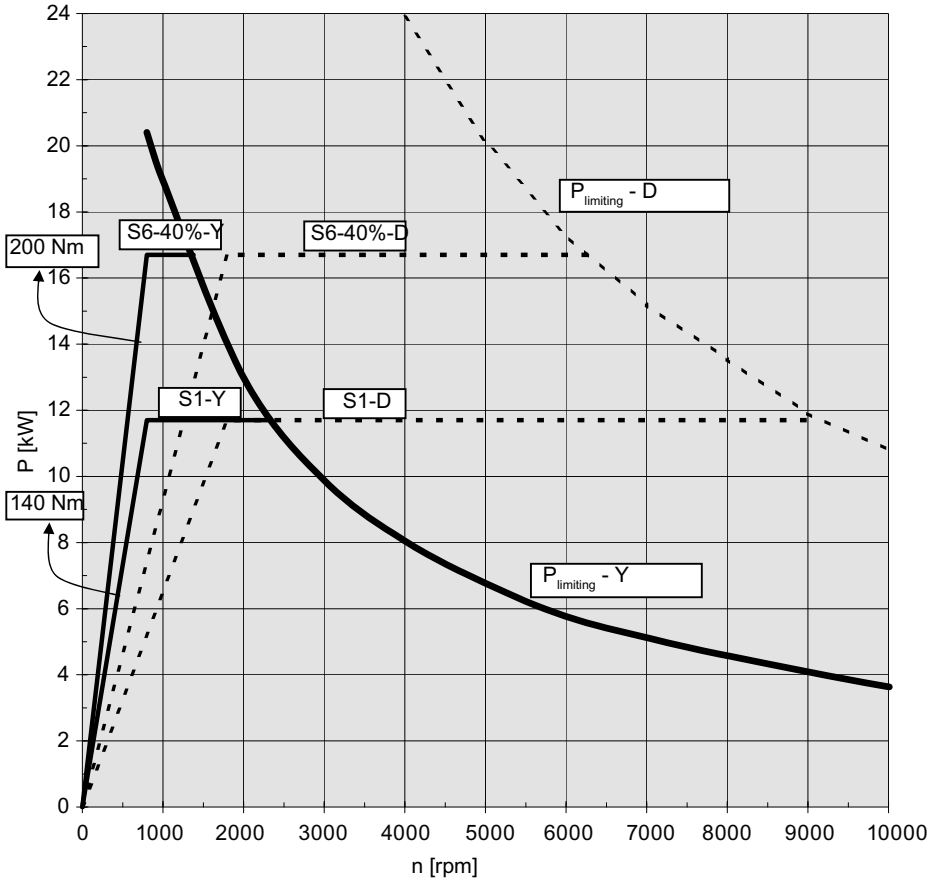

S6-40%-Y
M limiting - Y
S1-Y
S6-40%-D
S1-D
M limiting - D
M [Nm]
n [rpm]
0
20
40
60
80
100
120
140
160
180
200
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

Table 10- 27 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1255-8HA□□-0□□2

			Star	Delta
Rated power (S1)	P_N	kW	11.7	11.7
Rated power (S6-40 %))	P_N	kW	16.7	16.7
Rated speed	n_N	rpm	800	1800
Rated torque (S1)	M_N	Nm	140	62
Rated torque (S6-40%)	M_N	Nm	200	89
Rated current (S1)	I_N	A	30.0	29.0
Rated current (S6-40 %))	I_N	A	40.0	37.0
Maximum speed	n_{max}	rpm	10000	10000
Moment of inertia	J_{rot}	kg m^2	0.055	0.055
Thermal time constant	T_{therm}	min	2	2
Stator weight	m	kg	approx. 165	approx. 165



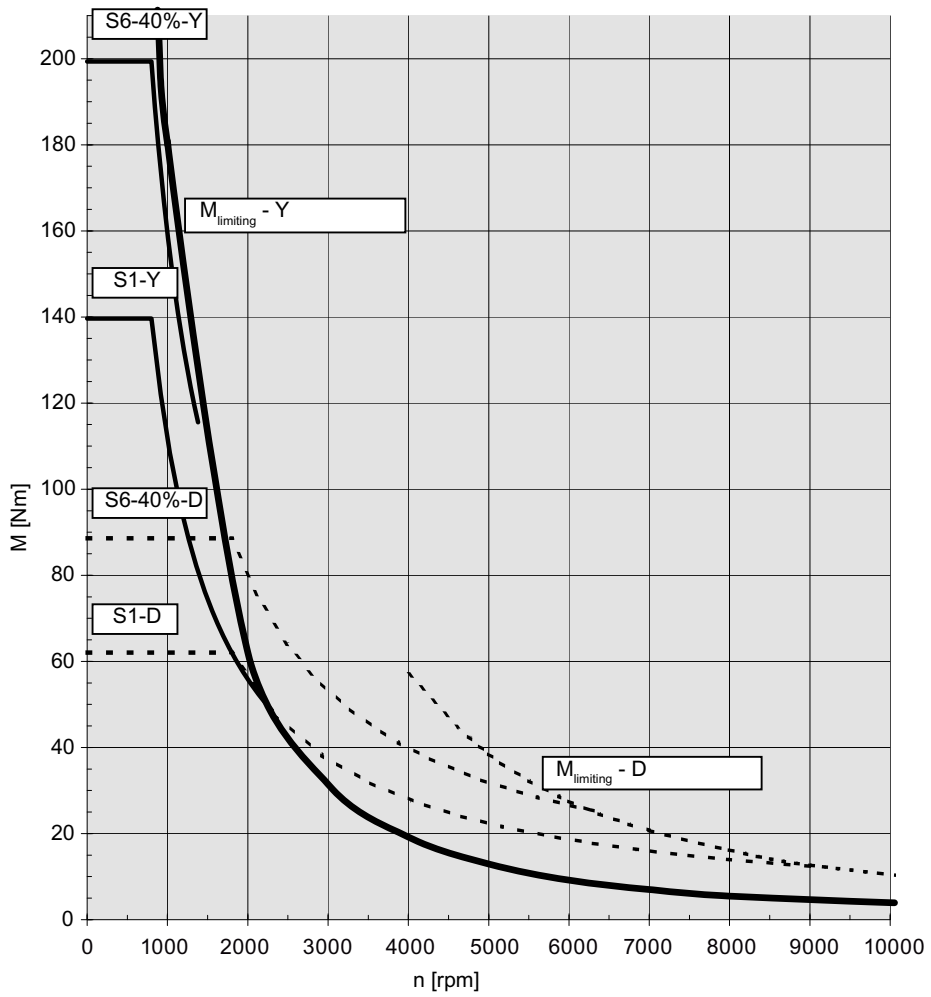
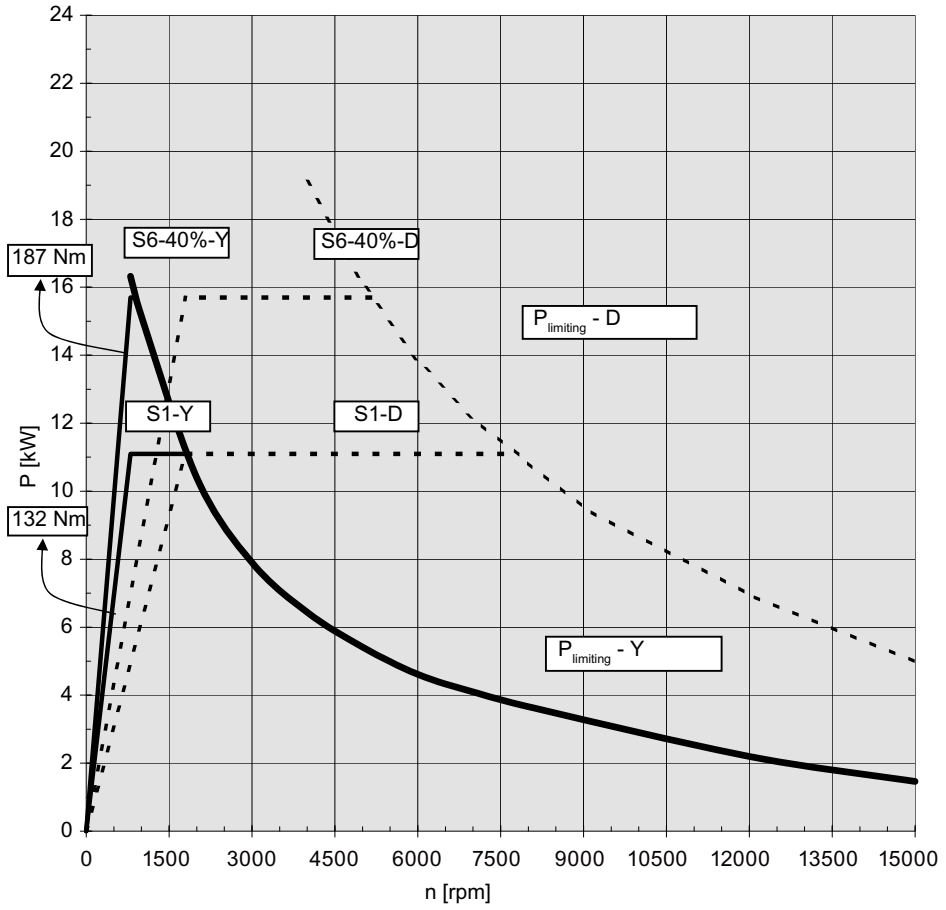

S6-40%-Y
M limiting - Y
S1-Y
S6-40%-D
S1-D
M limiting - D
M [Nm]
n [rpm]
0
20
40
60
80
100
120
140
160
180
200
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

Table 10- 28 SINAMICS, 3-ph. 380 V AC, Smart Line Module, (SLM), 2SP1255-8HA□□-1D□2

			Star	Delta
Rated power (S1)	P_N	kW	11.1	11.1
Rated power (S6-40 %))	P_N	kW	15.7	15.7
Rated speed	n_N	rpm	800	1800
Rated torque (S1)	M_N	Nm	132	59
Rated torque (S6-40%)	M_N	Nm	188	83
Rated current (S1)	I_N	A	29.0	28.0
Rated current (S6-40 %))	I_N	A	39.0	36.0
Maximum speed	n_{max}	rpm	15000	15000
Moment of inertia	J_{rot}	kg m^2	0.055	0.055
Thermal time constant	T_{therm}	min	2	2
Stator weight	m	kg	approx. 165	approx. 165



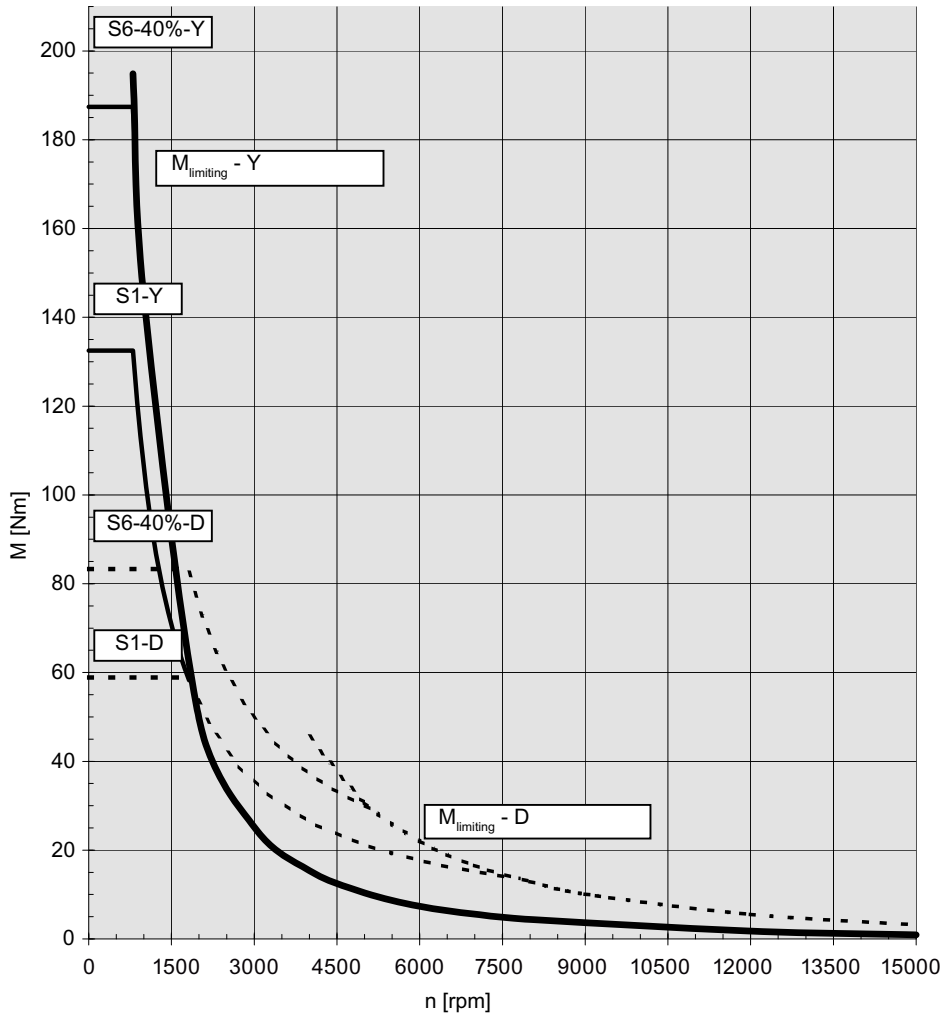
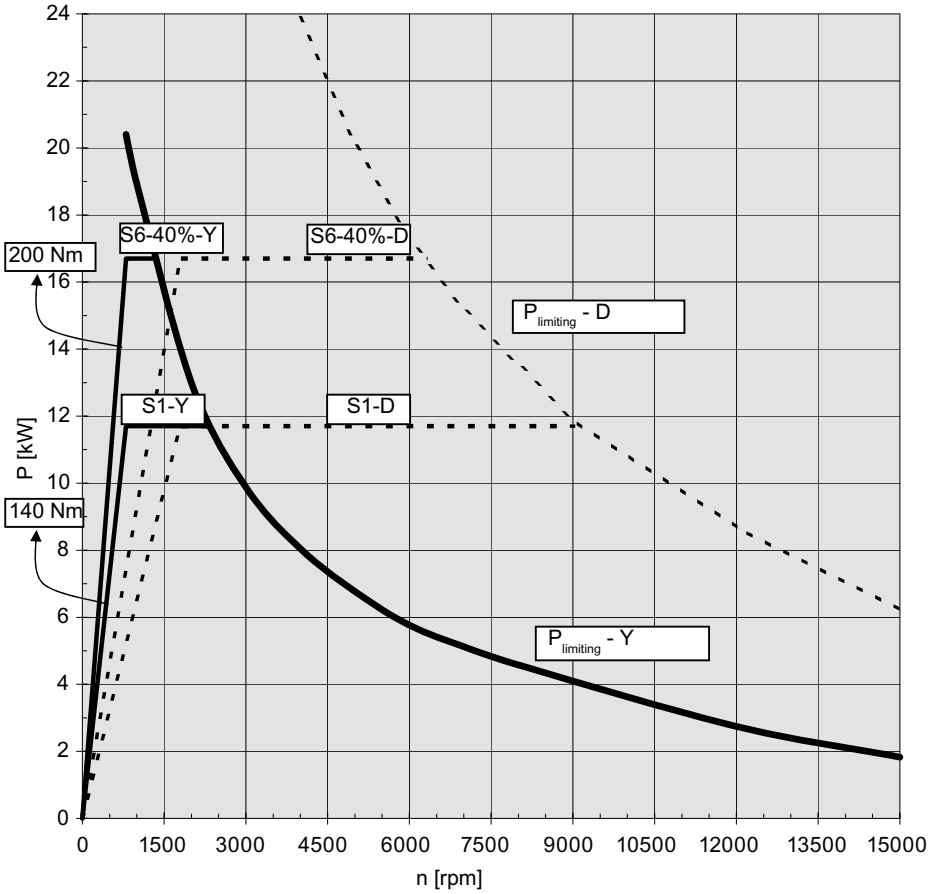
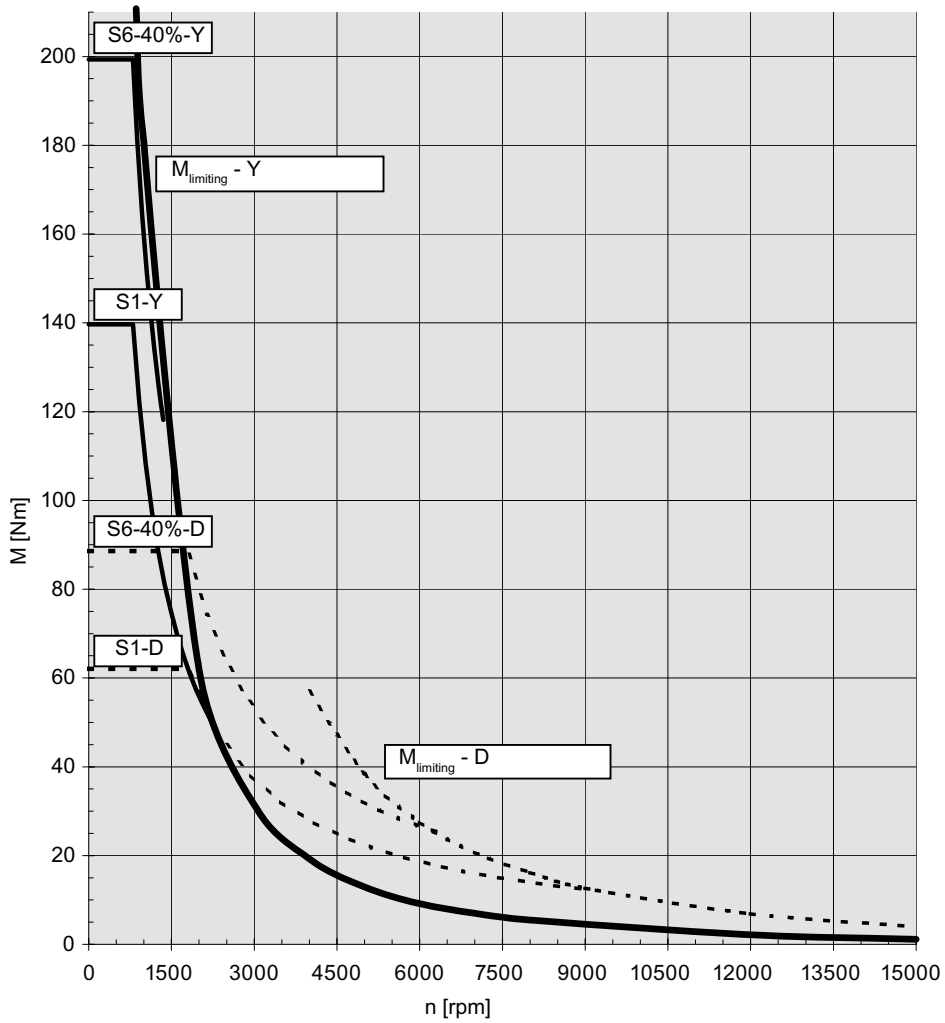

S6-40%-Y
M limiting - Y
S1-Y
S6-40%-D
S1-D
M limiting - D
M [Nm]
n [rpm]
0
20
40
60
80
100
120
140
160
180
200
0
1500
3000
4500
6000
7500
9000
10500
12000
13500
15000

Table 10- 29 SINAMICS, 3-ph. 400 V AC, Active Line Module, (ALM), 2SP1255-8HA□□-1D□2

			Star	Delta
Rated power (S1)	P_N	kW	11.7	11.7
Rated power (S6-40 %))	P_N	kW	16.7	16.7
Rated speed	n_N	rpm	800	1800
Rated torque (S1)	M_N	Nm	140	62
Rated torque (S6-40%)	M_N	Nm	200	89
Rated current (S1)	I_N	A	30.0	29.0
Rated current (S6-40 %))	I_N	A	40.0	37.0
Maximum speed	n_{max}	rpm	15000	15000
Moment of inertia	J_{rot}	kg m^2	0.055	0.055
Thermal time constant	T_{therm}	min	2	2
Stator weight	m	kg	approx. 165	approx. 165




S6-40%-Y
M limiting - Y
S1-Y
S6-40%-D
S1-D
M limiting - D
M [Nm]
n [rpm]
0
20
40
60
80
100
120
140
160
180
200
0
1500
3000
4500
6000
7500
9000
10500
12000
13500
15000

10.3 Dimension drawings

Note

Siemens AG reserves the right to change the motor dimensions as part of design improvements without prior notification. The dimension drawings, provided in this documentation, can go out-of-date.

Current dimension drawings can be requested at no charge from your local Siemens office.

Table 10- 30 Dimension table for 2SP120x-1 spindle

MLFB	Speed [rpm]	Motor	Release unit	Moment of inertia [kgm²]	A [mm]	A* [mm]	B [mm]	Power connector, optional
2SP1202-1HA3x-1xx2	15000	1FE082-4WP51	Hydraulic	0.015	617	572	236	Size 1.5
2SP1202-1HA2x-1xx2	15000	1FE082-4WP51	Pneumatic	0.015	735	692	236	Size 1.5
2SP1202-1HB3x-2xx2	18000	1FE082-4WN51	Hydraulic	0.015	617	572	236	Size 1.5
2SP1202-1HB2x-2xx2	18000	1FE082-4WN51	Pneumatic	0.015	735	692	236	Size 1.5
2SP1204-1HA3x-1xx2	15000	1FE084-4WT51	Hydraulic	0.023	717	672	336	Size 3
2SP1204-1HA2x-1xx2	15000	1FE084-4WT51	Pneumatic	0.023	835	792	336	Size 3
2SP1204-1HB3x-2xx2	18000	1FE084-4WP51	Hydraulic	0.023	717	672	336	Size 3
2SP1204-1HB2x-2xx2	18000	1FE084-4WP51	Pneumatic	0.023	835	792	336	Size 3
Dimension A* without rotary gland								

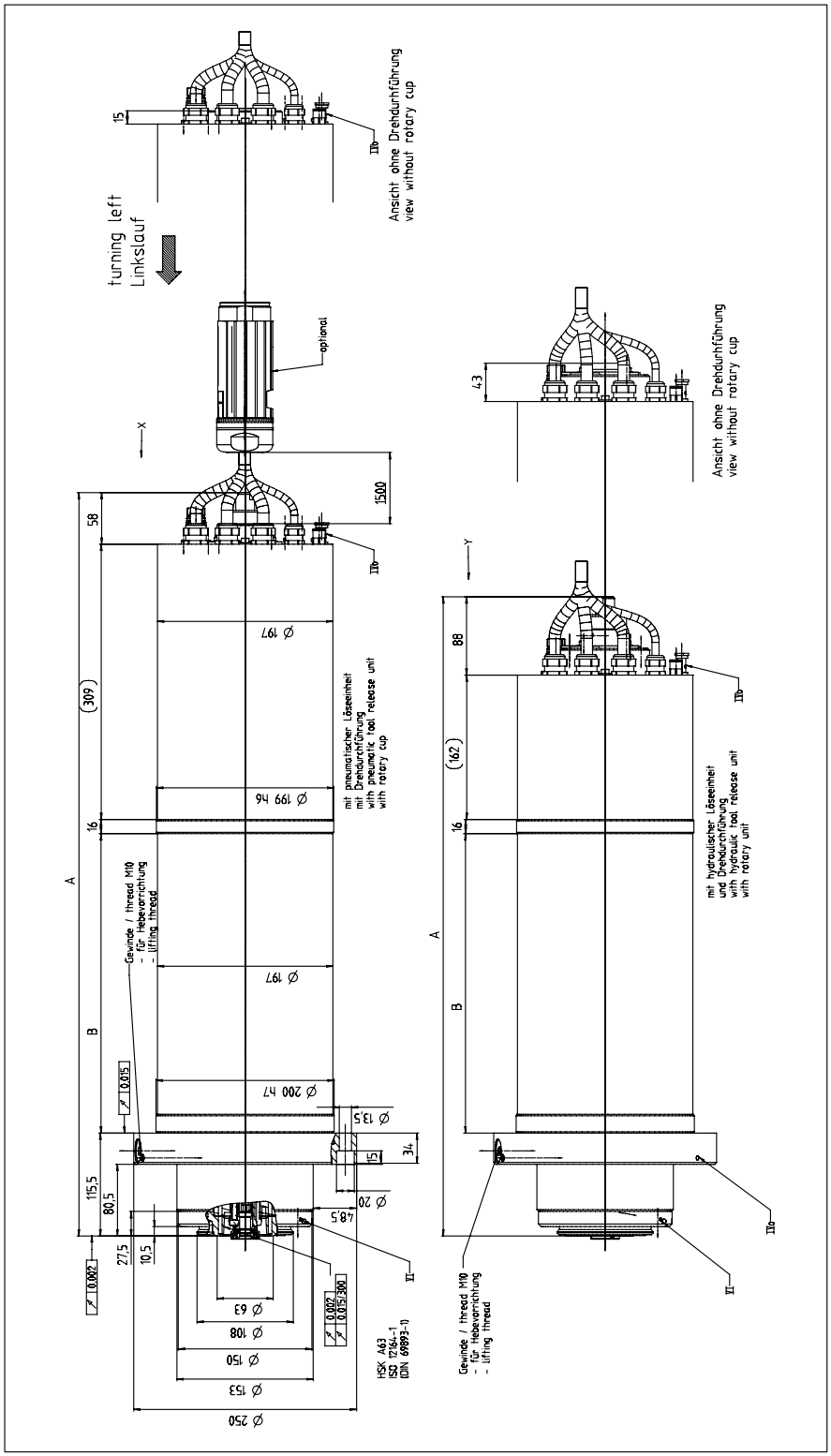


Figure 10-3 Spindle 2SP120x-1

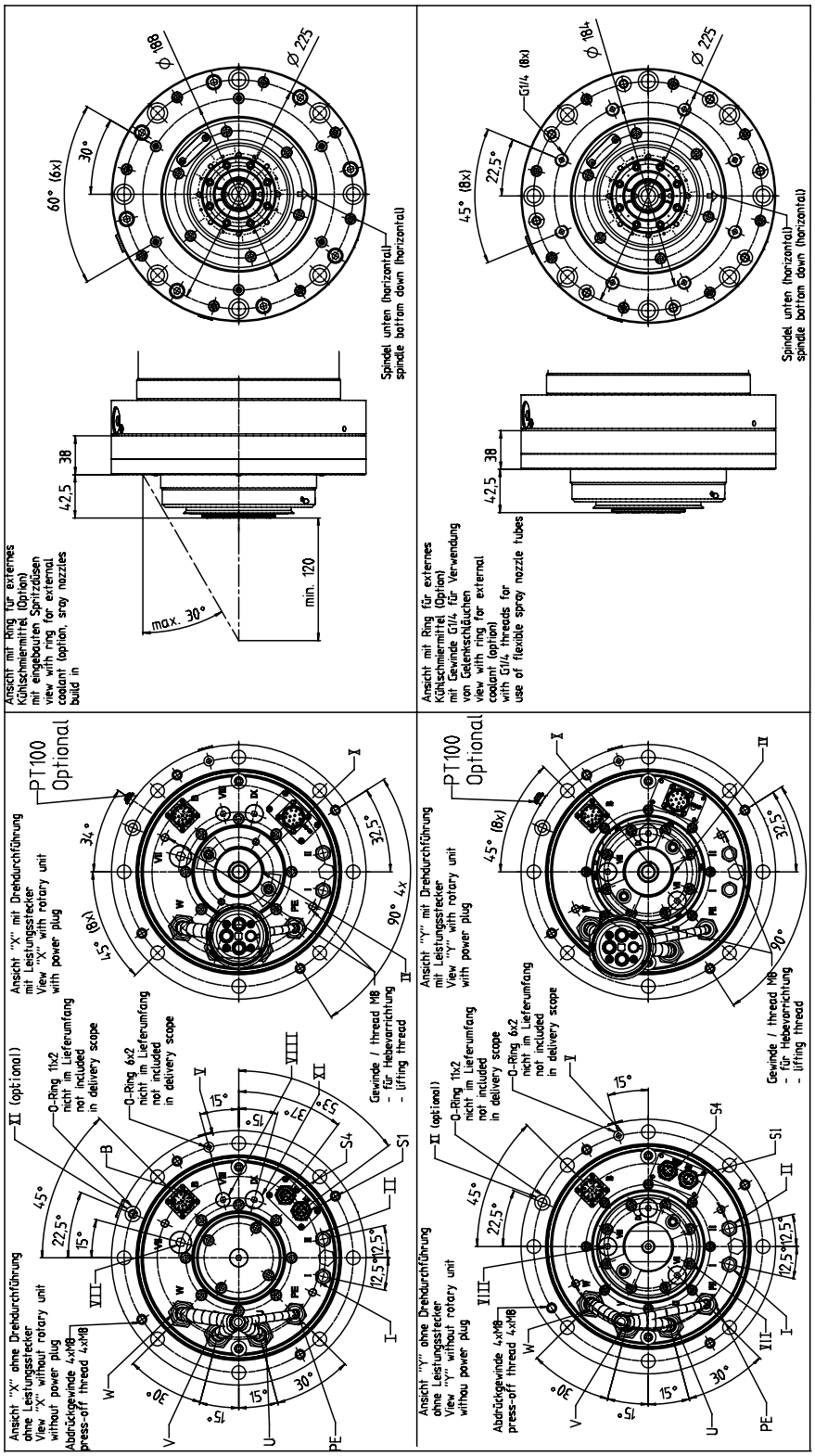


Figure 10-4 Spindle 2SP120V-1, spindle nose and spindle connections

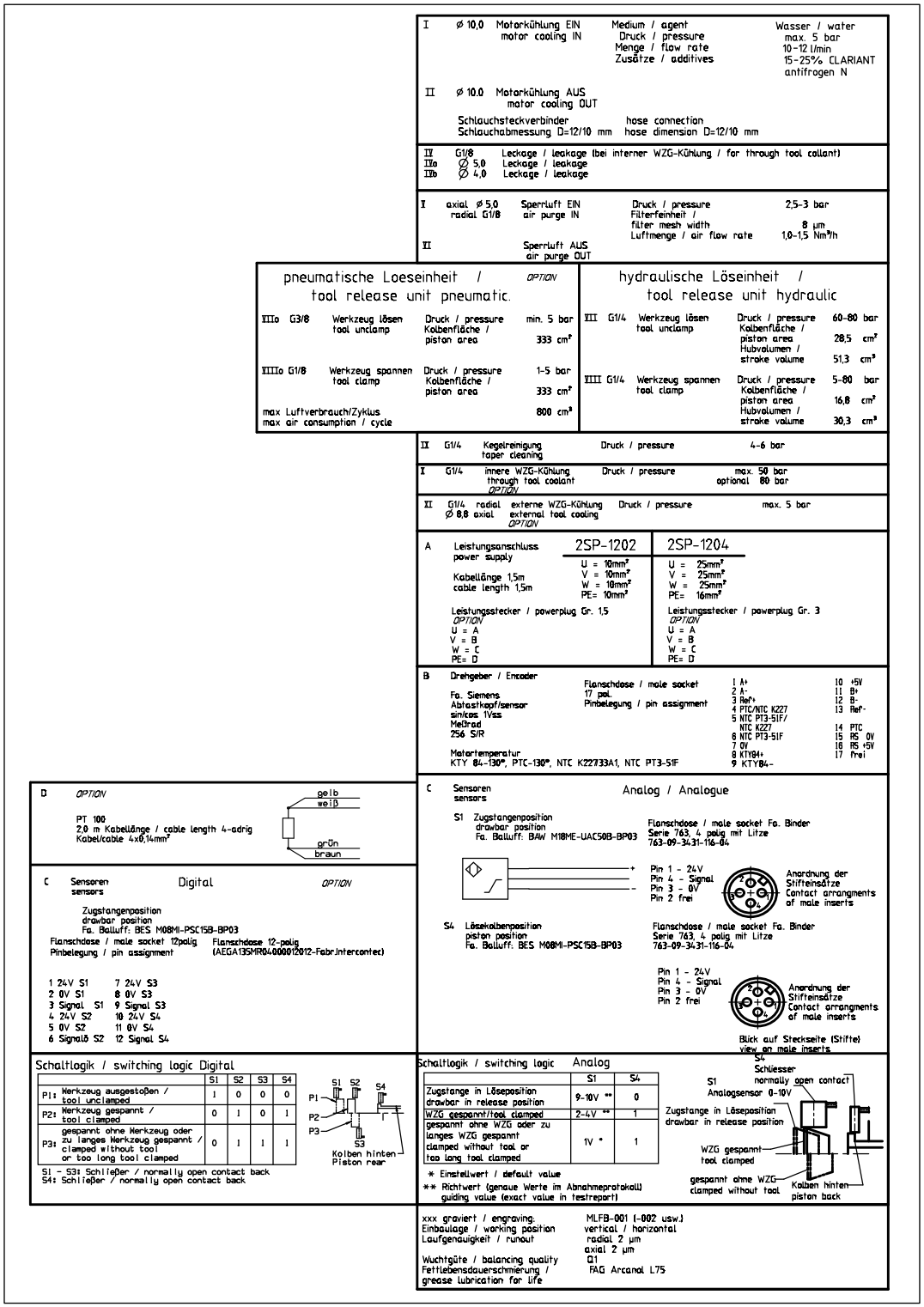


Figure 10-5 Spindle 2SP120x-1, connection designations and connection conditions

Table 10- 31 Dimension table for spindle 2SP125x-1

MLFB	Interface	Motor type	A [mm]	B [mm]	B* [mm]	C [mm]	C* [mm]
2SP1253-1xxxx-xxxx	SK/BT/CAT 40	Synchronous	305.0	71.3	114.3	775.3	818.3
2SP1255-1xxxx-xxxx	SK/BT/CAT 40	Synchronous	405.0	71.3	114.3	775.3	818.3
2SP1253-1xxxx-xxxx	HSK A63	Synchronous	305.0	71.3	114.3	775.3	818.3
2SP1255-1xxxx-xxxx	HSK A63	Synchronous	405.0	71.3	114.3	775.3	818.3
2SP1253-8xxxx-xxxx	SK/BT/CAT 40	Induction	305.0	71.3	114.3	775.3	818.3
2SP1255-8xxxx-xxxx	SK/BT/CAT 40	Induction	405.0	71.3	114.3	775.3	818.3
2SP1253-8xxxx-xxxx	HSK A63	Induction	305.0	71.3	114.3	775.3	818.3
2SP1255-8xxxx-xxxx	HSK A63	Induction	405.0	71.3	114.3	775.3	818.3
Dimension B* and C* without rotary gland							

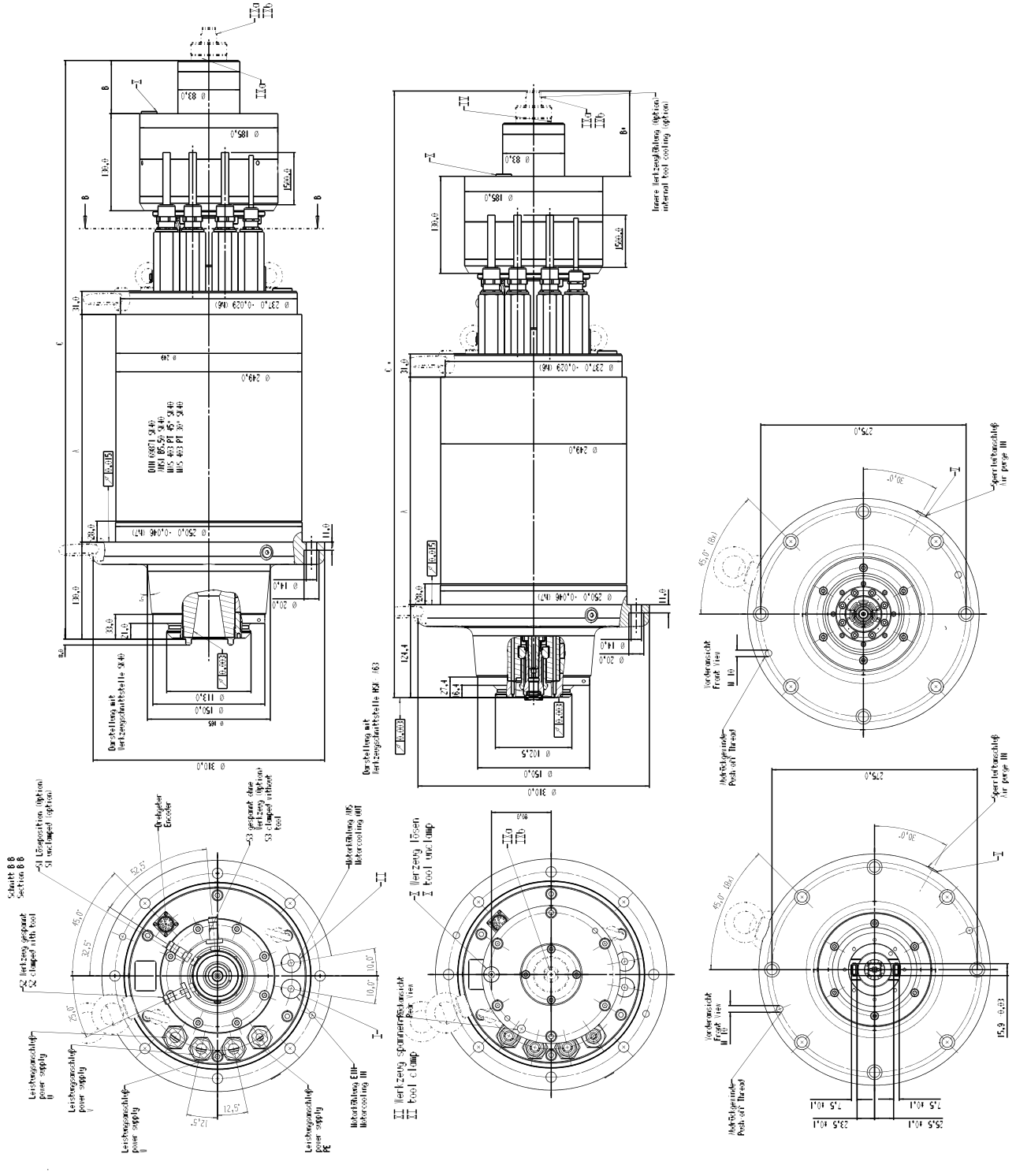


Figure 10-6 Spindle 2SP125x-1

Connection designations and connection conditions for spindle 2SP125x-1			
I	G1/2" ∅9 mm	Motor cooling/bearing cooling inlet	Medium: Water pressure: Max. 5 bar Quantity: 10 l/min Additives: 25% CLARIANT Antifrogen N
II	G1/2" ∅9 mm	Motor cooling/bearing cooling inlet	
V	G1/8" ∅5 mm	Sealing air inlet	Pressure: 1.5 to 3 bar Filter mesh: 8 µm Air quantity: 1 to 1.5 Nm^3/h
VI	G1/8" ∅5 mm	Sealing air outlet	
IXa	G1/4"	Air purge	max. 6 bar
IXb	G1/4"	Cooling-lubricating medium	max. 50 bar
IV	G1/8"	Leakage, rotary gland	
X	M16 x 1.5	Release tool	5 to 6 bar
XI	G1/8"	Clamp tool/unload	5 to 6 bar
Release unit	Release piston area		311 cm^2
	Clamp piston area		159 cm^2
	Force at 5 bar		min. 13 kN
	Max. air usage per cycle when resetting with air		846 cm^3
	Max. air usage per cycle when resetting with spring		559 cm^3
XXX	engraved	Weiss spindle number acc. to parts list (-002 etc.)	
Speed		refer to Table	
Mounting position		Horizontal/vertical	
Running precision		Radial 3 µm	
Moment of inertia of all rotating parts			xxx kgm^2
Pull-in force		SK 40 = 8 kN HSK A63 = 18 kN	
Rotary encoder, Siemens		Sensor head sin/cos 1 Vpp	Order No.: 6FX2001-6AA11-0AA0
		Measuring wheel 256 pulses/rev	Order No.: 6FX2001-6RB01-4GA0
		Cable assembly	Order No.: 6FX2001-6KC10-1CA0
Sensors	Order No.: BALLUFF BES 516-325-E5-C-S4 / Siemens 3RG4012-3AG33		
S1	Draw bar position/release position		
S2	Draw bar position/clamped with tool		
S3	Draw bar position/clamped without tool		

Appendix

A

A.1 Abbreviations and Terminology

DE	Drive end
IVP	Internal Voltage Protection
MQL	Minimum quantity lubrication
NDE	Non-drive end
Operating speed, max.	Maximum speed
Safety Integrated®	Option to monitor the drive function through two channels
Shutdown speed	Speed limit value; the system initiates that the spindle is shutdown if the shutdown speed is exceeded.
VPM	Voltage Protection Module

A.2 Declaration of conformity

EG-Konformitätserklärung
EC Declaration of Conformity

Hersteller: **WEISS Spindeltechnologie GmbH – A Siemens Company**
Manufacturer:

Anschrift: WEISS Spindeltechnologie GmbH
Address: A Siemens Company
Birkenfelder Weg 14
96126 Maroldsweisach
Germany

Produktbezeichnung: Motorspindeln 2SP1
Product description: Spindles 2SP1

Die bezeichneten Produkte stimmen in der von uns in Verkehr gebrachten Ausführungen mit den Vorschriften folgender Europäischer Richtlinie überein:
The products described above in the form as delivered are in conformity with the provisions of the following European Directive:

73/23/EWG — Richtlinie des Rates zur Angleichung der Rechtsvorschriften der Mitgliedsstaaten betreffend elektrische Betriebsmittel zur Verwendung innerhalb bestimmter Spannungsgrenzen (geändert durch 93/68/EWG).
Council Directive on the approximation of the laws of the Member States related to electrical equipment designed for use within certain Voltage limits (amended by 93/68/EEC).

Die Konformität mit der Richtlinie wird nachgewiesen durch die Einhaltung folgender Normen:
Conformity to the Directive is assured through the application of the following Standards:
EN 60204-1: 2006 EN 60034-1*): 2004
***) mit allen relevanten Teilen / with all relevant parts**

Die Sicherheitshinweise und Betriebsanleitungen sind zu beachten.
The safety and manual documentation have to be considered in detail.

CE – Kennzeichnung: 2006 / CE marking: 2006

EG-Herstellererklärung nach Art. 4 Abs. 2 der EG-Richtlinie 98/37/EG.
Die gelieferten Produkte erfüllen die Anforderungen der Norm EN 60204-1.
Die gelieferten Produkte sind ausschließlich zum Einbau in eine Maschine bestimmt.
Die Inbetriebnahme ist solange untersagt, bis die Konformität des Endproduktes mit der Richtlinie 98/37/EG festgestellt ist. Alle Sicherheitshinweise der zugehörenden Produktdokumentation sind zu beachten sowie dem Endanwender zur Kenntnis zu geben. Diese Erklärung stellt keine Beschaffenheits- und Haltbarkeitsgarantie gemäß § 443 BGB dar.

EU Manufacturer's Declaration according to Article 4 Paragraph 2 of the EU Directive 98/37/EU.
The products supplied fulfil the requirements of standard EN 60204-1.
The products supplied are intended exclusively for installation in a machine. Commissioning is prohibited until it has been established that the end product conforms with the Directive 98/37/EU. All safety instructions in the associated product documentation must be observed and given to the end user for his/her information.
This declaration contains no condition and durability guarantee to § 443 BGB.

Maroldsweisach, den 11.05.2009
Weiss Spindeltechnologie GmbH

Claus- Peter Lehnert
Geschäftsführung

i.V. Werner Hellwig
Leiter Qualitätsmanagement

Diese Erklärung bescheinigt die Übereinstimmung mit der genannten Richtlinie, ist jedoch keine Zusicherung von Eigenschaften.
This declaration certifies the conformity to the specified derective, but contains no assurance of properties.

Weiss Spindeltechnologie

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