KUKA

ROBOT

(V)KR 40 PA with KR C4

Operating Instructions

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KUKA Roboter GmbH
Zugspitzstrasse 140
D-86165 Augsburg

Translation of the original documentation

Contents

Valid for **(V)KR 40 PA with KR C4**

1 Introduction

1.1 Documentation of the industrial robot

The documentation of these industrial robots comprises the following parts:

- Operating instructions for KR 40 PA with KR C4
- Parts catalog on storage medium

Each of these parts is a separate document that is attached to the industrial robot.

The operating instructions and parts catalog for the controller are not part of this documentation.

1.2 Representation of warnings and notes

Warnings marked with this pictogram are relevant to safety and must be observed.

This warning means that death, severe physical injury or substantial material damage may occur, if no precautions are taken.

This warning means that minor physical injuries or minor material damage may occur, if no precautions are taken.

Notes marked with this pictogram contain tips to make your work easier or references to further information.

2 Purpose

2.1 Intended use

Use

Handling of tools or fixtures for processing or transferring components or products, e.g.

- Palletizing,
- Handling and
- Depalletizing.

Use is only permitted under the environmental conditions specified in Chapter 1.

Misuse

Any use or application deviating from the intended use is deemed to be impermissible misuse; examples of such misuse include:

- Transportation of persons and animals
- Use as a climbing aid
- Operation outside the permissible operating parameters
- Use in potentially explosive environments

Changing the structure of the manipulator, e.g. by drilling holes, etc., can result in damage to the components. This is considered improper use and leads to loss of guarantee and liability entitlements.

2.2 Target group

This documentation is aimed at users with the following knowledge and skills:

- Advanced knowledge of mechanical engineering
- Advanced knowledge of electrical and electronic systems
- Knowledge of the robot controller system

For optimal use of our products, we recommend that our customers take part in a course of training at KUKA College. Information about the training program can be found at www.kuka.com or can be obtained directly from our subsidiaries.

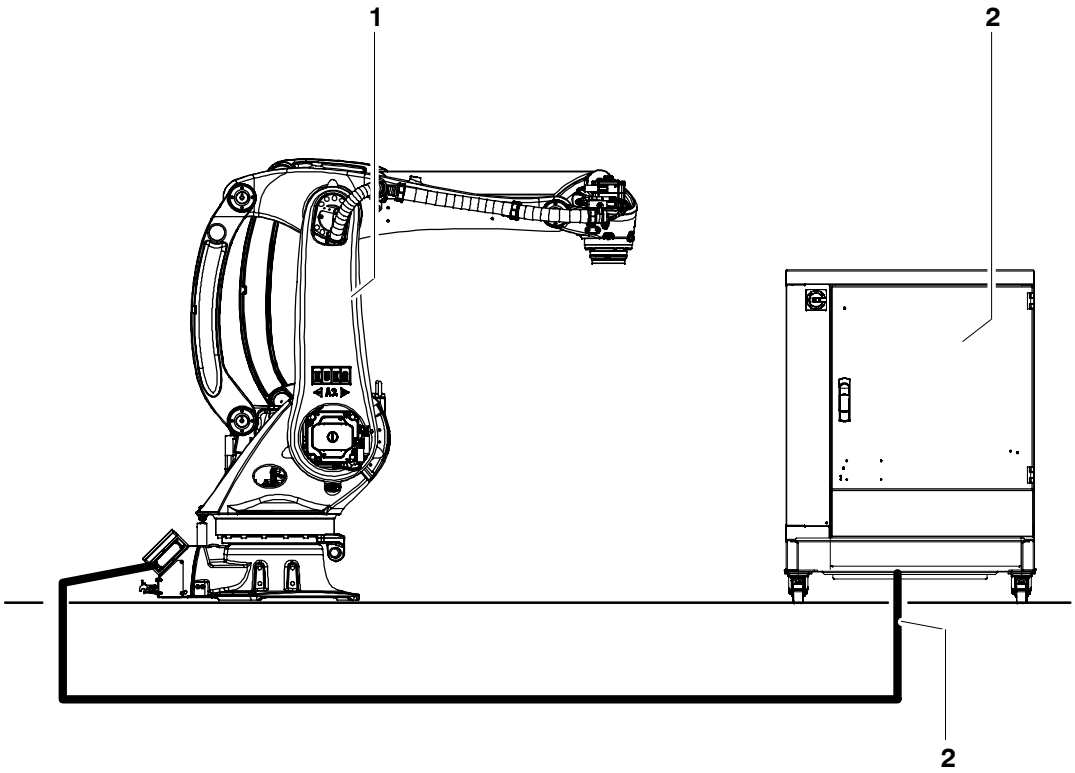
3 Product description

This description applies analogously to all of the industrial robots listed in Chapter 1, regardless of the variant or model shown in the illustrations.

3.1 General

The KR 40 PA industrial robot is a four-axis manipulator, driven in its four axes by AC servomotors. The fifth axis is positively driven by a parallel kinematic system.

The industrial robot consists of the manipulator (= robot arm and electrical installations), control cabinet, KCP and connecting cables (Fig. 1). The manipulator is dealt with in this document. The control cabinet, KCP and connecting cables are described in separate documentation.



1 Manipulator
2 Control cabinet
3 Connecting cables

Fig. 1 Industrial robot

This section is subdivided in accordance with the breakdown of the manipulator into its main subassemblies.

3.2 Wrist

The KR 40 PA manipulator is equipped with a single-axis wrist (Fig. 2) for a payload of 40 kg.

The wrist is fastened to the arm (4) via bearing (2) and is driven by the parallel arm (3) via bearing (1). Mounted on the swing frame (8) is the motor unit for axis 6 with the corresponding gear unit (6). The output side of axis 6 is embodied by the mounting flange (5). The motor unit consists of a brushless AC servomotor (9) with a permanent-magnet single-disk brake and hollow-shaft resolver, both integrated.

The permanent-magnet single-disk brake performs a holding function when the servomotor is at rest and contributes to the braking of axis 6 in the event of short-circuit braking (e.g. if one or more of the enabling switches is released while in Test mode). Short-circuit braking is not used to stop the manipulator under normal circumstances.

The mounting flange (5) of axis 6 is the interface for the tool. Tools are mounted on the manipulator via this standardized interface. The wrist assembly also has a gauge mount with a gauge cartridge (7), through which the mechanical zero of the axis can be determined by means of either a dial gauge or an electronic measuring tool (accessory) and transferred directly to the controller by the electronic measuring tool (EMT), if used.

Other technical data for the wrist may be found in Chapter 4, “Technical data”.

1 Bearing in parallel arm
2 Bearing in arm
3 Parallel arm
4 Arm
5 Mounting flange
6 Gear unit
7 Gauge mount with gauge cartridge
8 Swing frame
9 AC servomotor

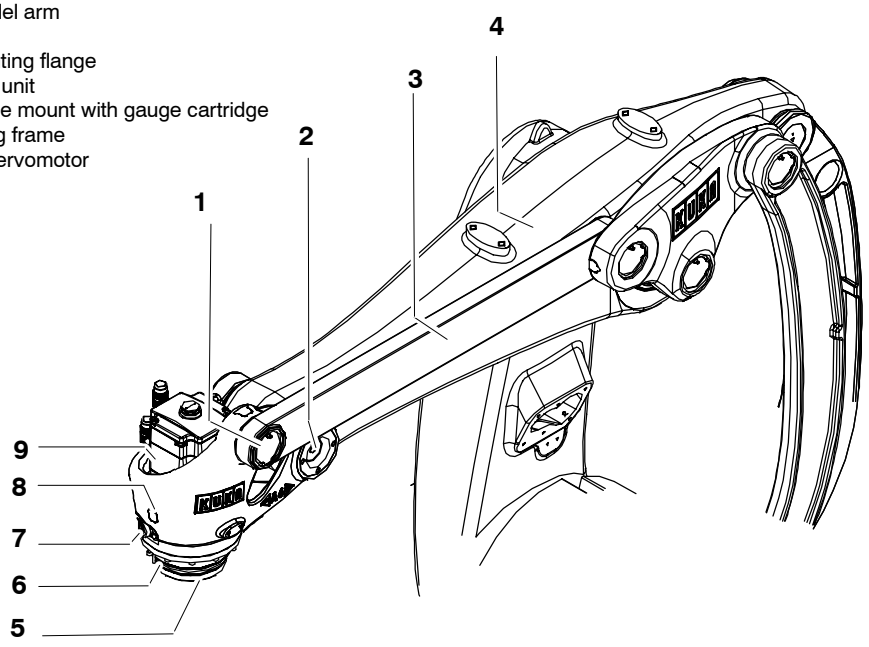


Fig. 2 Wrist

3.3 Arm

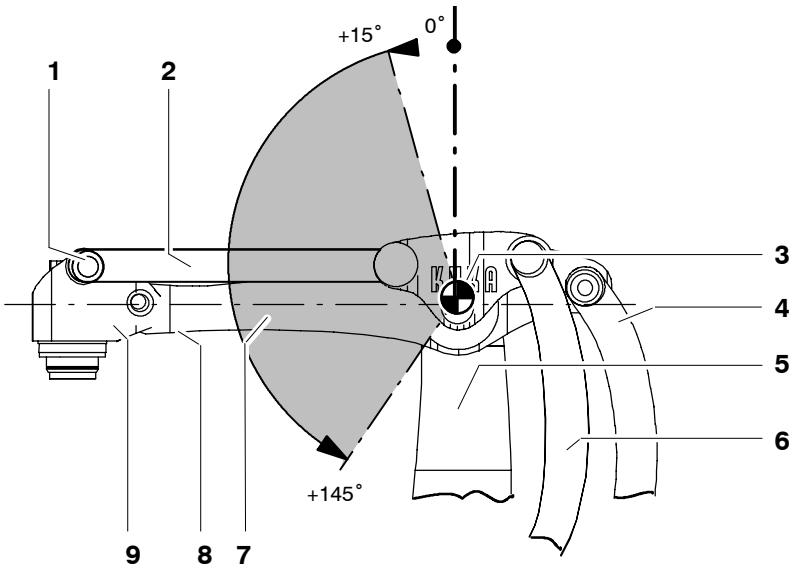
The arm assembly (Fig. 3/7) embodies the driven element of axis 3 of the manipulator. The arm is flange-mounted to the side of the link arm (5) through a bearing and is driven by main axis motor unit A3 via the parallel link arm (4). The drive motor is installed in the rotating column at the same height as rotational axis A2.

The effective software swivel range extends from +15° to +145°, referred to the electrical zero position of axis 3, and depends on the position of axis 2 (as depicted in Fig. 3). The swivel range is limited by mechanical limit stops with a buffer function in addition to the software limit switches.

The arm assembly comprises the parallel arm (2), the arm (7), the coupler (3) and the coupling rod (6). The latter are the connecting and guide elements used to drive the wrist (9).

The arm (7) is optimized by means of CAD and FEM and manufactured using CRP technology. This technology ensures high strength at the same time as the lowest possible weight.

The wrist (9) is fastened to the front end of the arm via a bearing (8); the wrist is driven by the parallel arm (2).

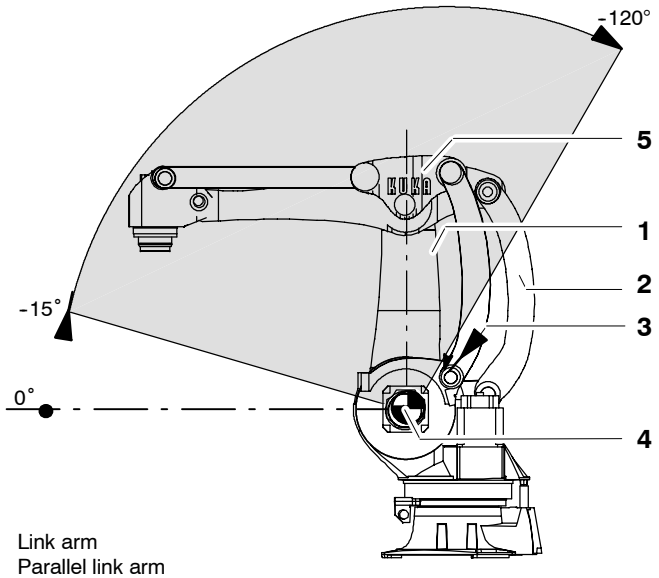


1	Bearing in parallel arm	6	Coupling rod
2	Parallel arm	7	Arm
3	Coupler	8	Bearing in arm
4	Parallel link arm	9	Wrist
5	Link arm		

Fig. 3 Arm

3.4 Link arm

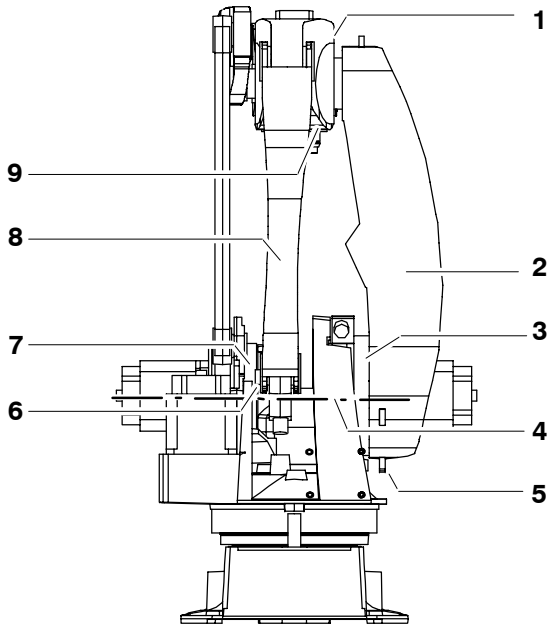
The link arm (Fig. 4/1) is the driven element of axis 2. It pivots about rotational axis 2 (4) through an effective software range from –15° to –120° – referred to the electrical zero position of axis 2. The mechanical zero position corresponds to the horizontal position of the link arm (1) in Fig. 4. The link arm assembly also includes the parallel link arm (2). Driven by a crank, the parallel link arm moves the arm. The link arm is driven by main axis motor unit A2 (3) via a gear unit.
The effective software swivel range is limited by mechanical limit stops with a buffer function in addition to the software limit switches.



1 Link arm
2 Parallel link arm
3 Main axis motor unit A2 (hidden)
4 Rotational axis 2
5 Coupler

Fig. 4 Link arm with turning range

The link arm (Fig. 5/2) contains the gear unit A2 (3) at its lower end. The gear unit A2 (3) is used both as the drive element and to support the link arm assembly (2). Reference notches (5, 9) are provided to define the mechanical zero position of axes 2 and 3. The signal cables and power supply lines of the electrical installations are routed in the interior of the link arm housing from the rotating column to the arm (see Chapter 8, “Electrical installations”).



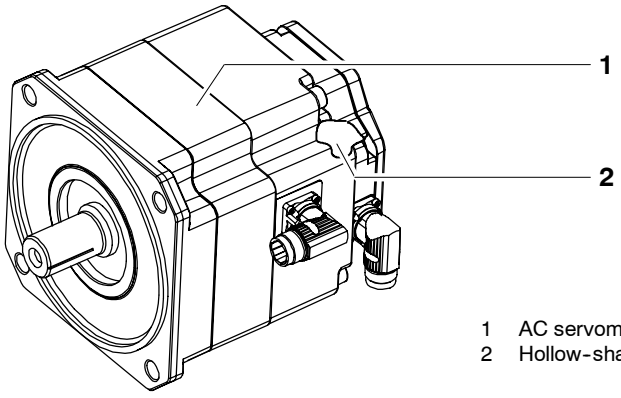
1 Arm
2 Link arm
3 Gear unit A2
4 Rotational axis 2
5 Reference notch A2
6 Crank
7 Gear unit A3
8 Parallel link arm
9 Reference notch A3

Fig. 5 Structure of link arm

3.4.1 Main axis motor units A1 to A3

The manipulator axes 1, 2 and 3 (main axes) are driven by motor units as shown in Fig. 6. Each motor unit for the main axis drives consists of a brushless AC servomotor (Fig. 6/1) with a permanent-magnet single-disk brake and hollow-shaft resolver (2), both integrated in the AC servomotor. The motor units for axes 1 and 3 have the same design, function, and rated power.

The permanent-magnet single-disk brake performs a holding function when the servomotors are at rest and contributes to the braking of the respective axis in the event of short-circuit braking (e.g. if one or more of the enabling switches is released while in Test mode). Short-circuit braking is not used to stop the manipulator under normal circumstances.

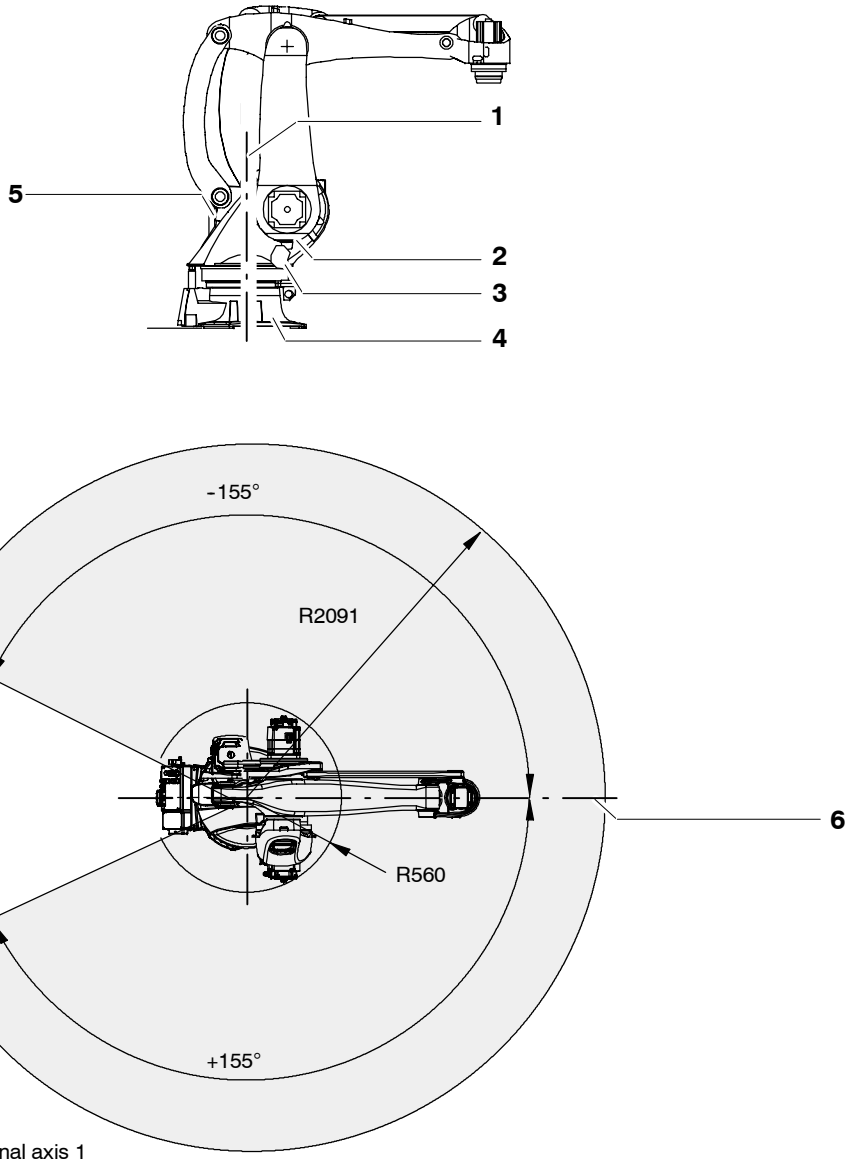


1 AC servomotor
2 Hollow-shaft resolver

Fig. 6 Motor unit for main axis drive

3.5 Rotating column

The rotating column (Fig. 7/2) is the assembly located between the link arm and the base frame. Screwed to the base frame (4) through a special reduction gear unit (3), which allows it to rotate, it performs movements about rotational axis 1 (1). It has an effective software turning range of 155° in both the (+) and (–) directions, measured from the mechanical zero position of A1 (6). This range is limited by mechanical limit stops with a buffer function in addition to the software limit switches.

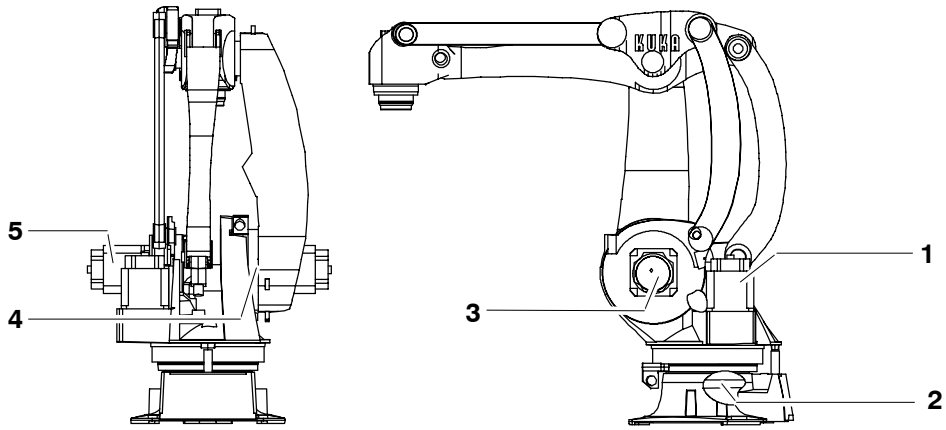


1 Rotational axis 1
2 Rotating column
3 Special reduction gear unit
4 Base frame
5 Main axis motor unit A1
6 Zero position A1

Fig. 7 Rotating column with turning range

Installed in the rotating column is the main axis motor unit for axis 1 (Fig. 8/1), together with the special reduction gear unit (2). Mounted on the side of the rotating column is the main axis motor unit for axis 2 (3) and axis 3 (5) together with its special reduction gear unit (4).

Part of the electrical installations is routed inside the rotating column of the manipulator (see Chapter 8, “Electrical installations”).



1 Main axis motor unit A1
2 Special reduction gear unit A1
3 Main axis motor unit A2
4 Special reduction gear unit A2
5 Main axis motor unit A3

Fig. 8 Structure of rotating column

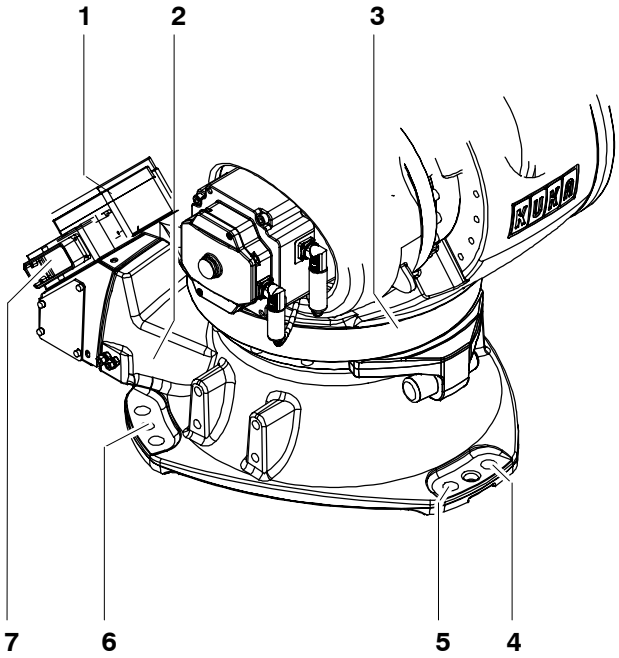
3.6 Base frame

The base frame (Fig. 9) is the stationary part of the manipulator, on which the rotating column turns with the link arm, the arm and the wrist. Its base flange (5) features six fastening holes (4) for holding the manipulator down and two locating boreholes (6), with which the manipulator can be placed on two locating pins (accessories, see also Chapter 7, “Installation”). These pins serve to center the manipulator on the mounting platform, and ensure a consistently reproducible installation position.

Attached to the base frame housing (2) is the gear unit (3) with the motor unit for axis 1. Also integrated into this housing (2) is the double-acting stop, which together with a stop block on the rotating column mechanically safeguards the software-limited movement range of 310° about rotational axis 1.

In the base frame, the installation cables leading to the rotating column are routed stress-free about rotational axis 1 of the manipulator in a flexible tube. If an energy supply system is installed, this flexible tube will also contain the hose lines and control cables. The space between the rotating column and the base frame is open.

The connectors for the connecting cables from the manipulator to the control cabinet are located on the side of the RDC box (1) and the MFH (multi-function housing) (7). The connections for the energy supply system A1-A5 are also installed in this area.



1 Junction box
2 Base frame housing
3 Gear unit A1
4 Fastening holes (6x)
5 Base flange
6 Locating boreholes (2x)
7 MFH (multi-function housing)

Fig. 9 Structure of the base frame

3.7 Working range limitation for A1

Mechanical stops for axis 1 can be supplied as the “Working range limitation” accessory. Working range limitation can be used to provide task-related mechanical safeguarding, i.e. the electronically specified working ranges (software limit switches) are in addition limited mechanically.

The working range limitation system is described in separate documentation.

3.8 Working range monitoring for A1 and A2

Axes 1 and 2 can be equipped with working range monitoring (accessory). This consists of position switches and slotted rings as accessories to which adjustable cams are attached (see the documentation “Working Range Monitoring”). Depending on the axis position, the cams activate a switch, whose signal allows the continuous monitoring of the manipulator position.

A maximum of three sectors of the movement range can be monitored for A1, and a maximum of two can be monitored for A2.

If axis 2 is equipped with working range monitoring, an energy supply system with an additional control cable is required.

The working range monitoring is described in separate documentation.

3.9 Energy supply system

The manipulator is fitted as standard with an integrated energy supply system for axes 1 to 5, which is installed in the cable harness of the electrical installations. It consists of an air line, a Multibus cable and a control cable with the accompanying connectors and connections. It runs from the base frame to the interface on the arm.

For use in certain production technologies, the manipulator also can be equipped with an “energy supply system A1 – A5”, integrated in the area from the base frame A1 to the wrist A5, and an “energy supply system A5 – A6”. The energy supply system A1 – A5 consists of a hose and cable bundle for transmitting the energy, fluids and signals typical of the technological process concerned. The hose and cable bundle comprises electric cables and hoses, the flexible tube A 1 and the interface A5 on the wrist. The flexible tube accommodates the cables and hoses, thereby minimizing the stress to which they are subjected. It is fastened in such a way that it does not impair the motion of the manipulator and is protected against damage.

The energy supply system is described in separate documentation.

4 Technical data

This description applies analogously to all of the industrial robots listed in Chapter 1, regardless of the variant or model shown in the illustrations.

4.1 General

The industrial robot is a four-axis manipulator for installation on the floor. It is suitable for all continuous-path controlled tasks.

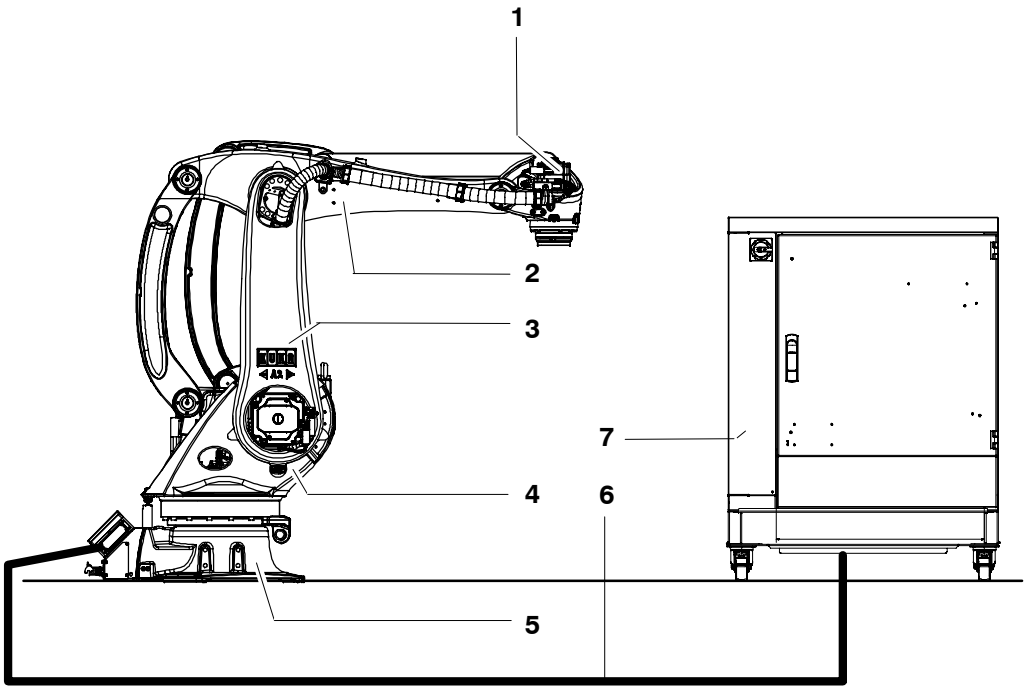
The main areas of application are:

- Palletizing,
- Handling and
- Depalletizing.

Using the manipulator for purposes other than those mentioned above is considered contrary to its designated use (see Chapter 2, "Purpose").

Fig. 10 shows the industrial robot, which consists of the manipulator (= robot arm and electrical installations), control cabinet and connecting cables.

The maintenance intervals and the specified service life are based on typical gear unit temperatures and axis motions. If special functions or applications result in atypical gear unit temperatures or axis motions, this can lead to increased wear. In this case, the maintenance intervals or service life may be shortened. If you have any questions, please contact KUKA Customer Support.



1	Wrist	5	Base frame
2	Arm	6	Connecting cables
3	Link arm	7	Control cabinet (see separate documentation)
4	Rotating column		

Fig. 10 Main components of the industrial robot

4.2 Principal data

Type KR 40 PA

Number of axes 4

Load limits see following table and Fig. 11

Industrial robot type	KR 40 PA
Rated payload [kg]	40
Suppl. load, arm [kg]	20
Max. total load [kg]	60

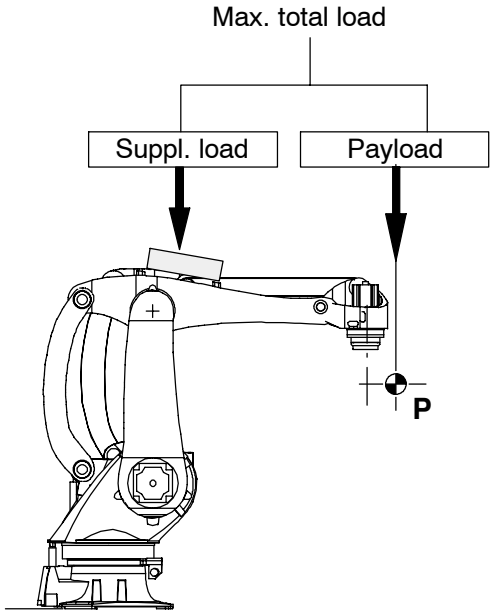


Fig. 11 Load distribution

Axis data See the following table

All specifications in the “Range of motion” column are referred to the electrical zero of the manipulator axis concerned.

KR 40 PA

- **Wrist, rated payload 40 kg**

Axis	Range of motion software-limited	Speed
1	±155°	183°/s
2	−15° to −120°	153°/s
3	+15°* to +145° *	212°/s
6	±350°	374°/s

* Maximum value, referred to the link arm, depending on the position of axis 2

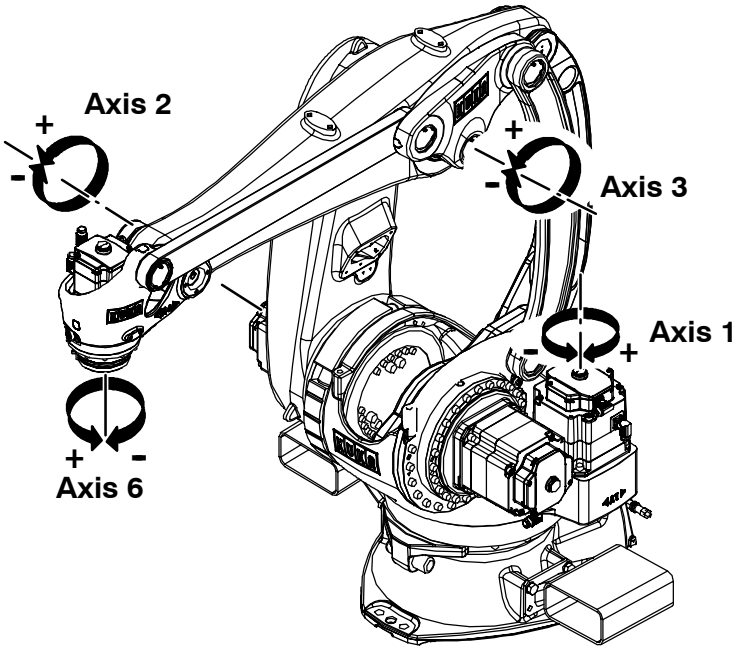


Fig. 12 Manipulator axes and their possible motions

Pose repeatability (ISO 9283)	± 0.05 mm
Mounting position	Floor
Principal dimensions	see Fig. 14
Working envelope	see Fig. 14
Volume of working envelope	approx. 12.6 m^3 The reference point is the intersection of the mounting flange face with axis 6.
Load center of gravity P	see Fig. 13.

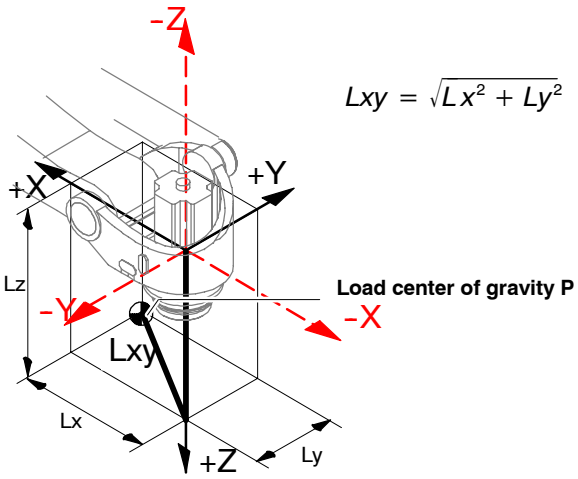
Mounting flange	DIN/ISO[1] mounting flange (Fig. 16). The mounting flange is depicted with axis 6 in its zero position. The symbol ♦ indicates the position of the locating element (bushing). M8 screws of grade 10.9 are to be used for attaching payloads. The grip length of the screws in the flange must be at least 1.5 x nominal diameter. Depth of engagement: min. 12 mm / max. 14 mm
Weight	695 kg
Principal dynamic loads	See Fig. 17
Drive system	Electromechanical, with transistor-controlled AC servomotors.
Installed motor capacity	10.2 kW
Protection classification of the electrical installations	IP 65 Ready for operation, with connecting cables plugged in (acc. to EN 60529)
Ambient temperature	During operation: 278 K to 328 K (+5 °C to +55 °C). During storage/transportation: 233 K to 333 K (-40 °C to +60 °C). Other temperature limits available on request.
Sound level	< 75 dB (A) outside the working envelope.
Zero adjustment	For zero adjustment with the electronic probe (accessory) when the tool is mounted, the latter must be designed to allow sufficient space for installation and removal of the probe (Fig. 18).
Color	Base (stationary): black (RAL 9005) Moving parts: KUKA orange 2567
Plates	see Fig. 19 to Fig. 29.
Stopping distances and times	see separate documentation

[1] DIN/ISO 9409-1-A100

Loading curves (Fig. 13) correspond to the maximum load capacity! The values of the payload and the principal moment of inertia must be checked in all cases. Exceeding this capacity will reduce the service life of the robot and generally overload the motors and the gears; in any such case KUKA must be consulted beforehand.

The values determined here are necessary for planning the application.
For commissioning the industrial robot, additional input data are required in accordance with the KUKA software documentation.

Robot flange coordinate system



$$Lxy = \sqrt{Lx^2 + Ly^2}$$

Load center of gravity P

Permissible mass inertia at the design point (Lxy = 100 mm, Lz = 200 mm) 10 kgm^2.

CAUTION:
The mass inertia must be calculated using KUKA Load.
It is imperative for the load data to be entered in the controller!

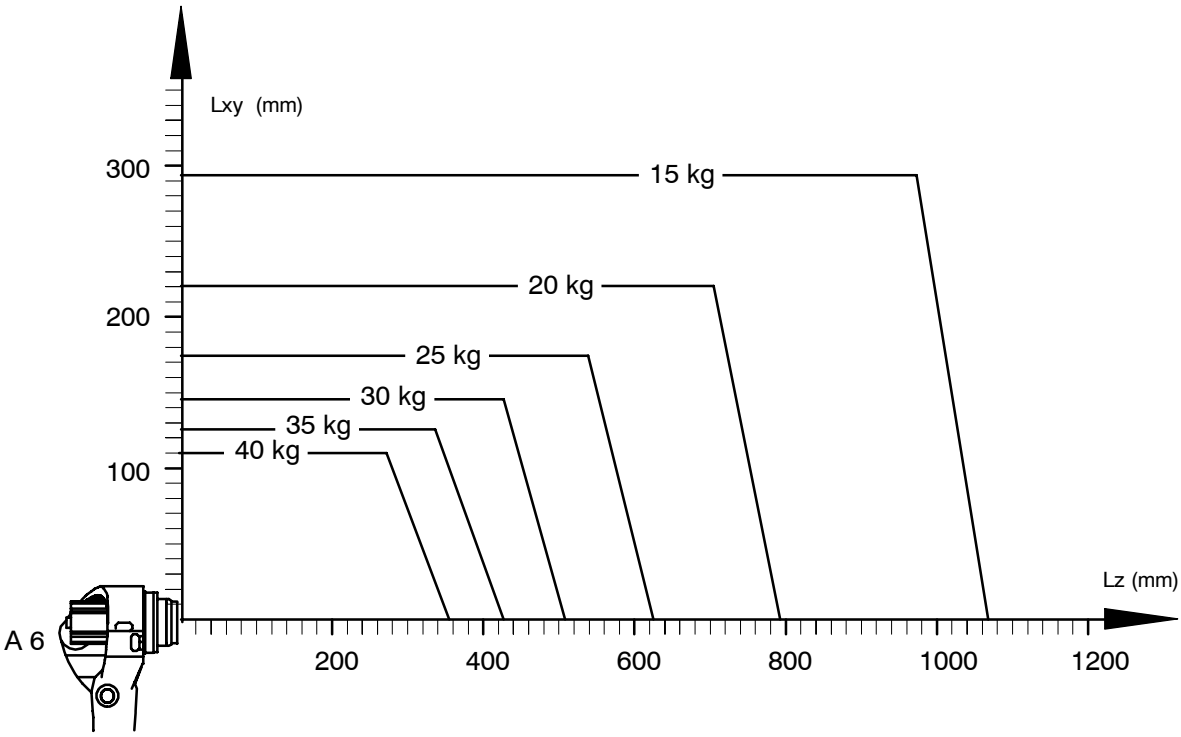
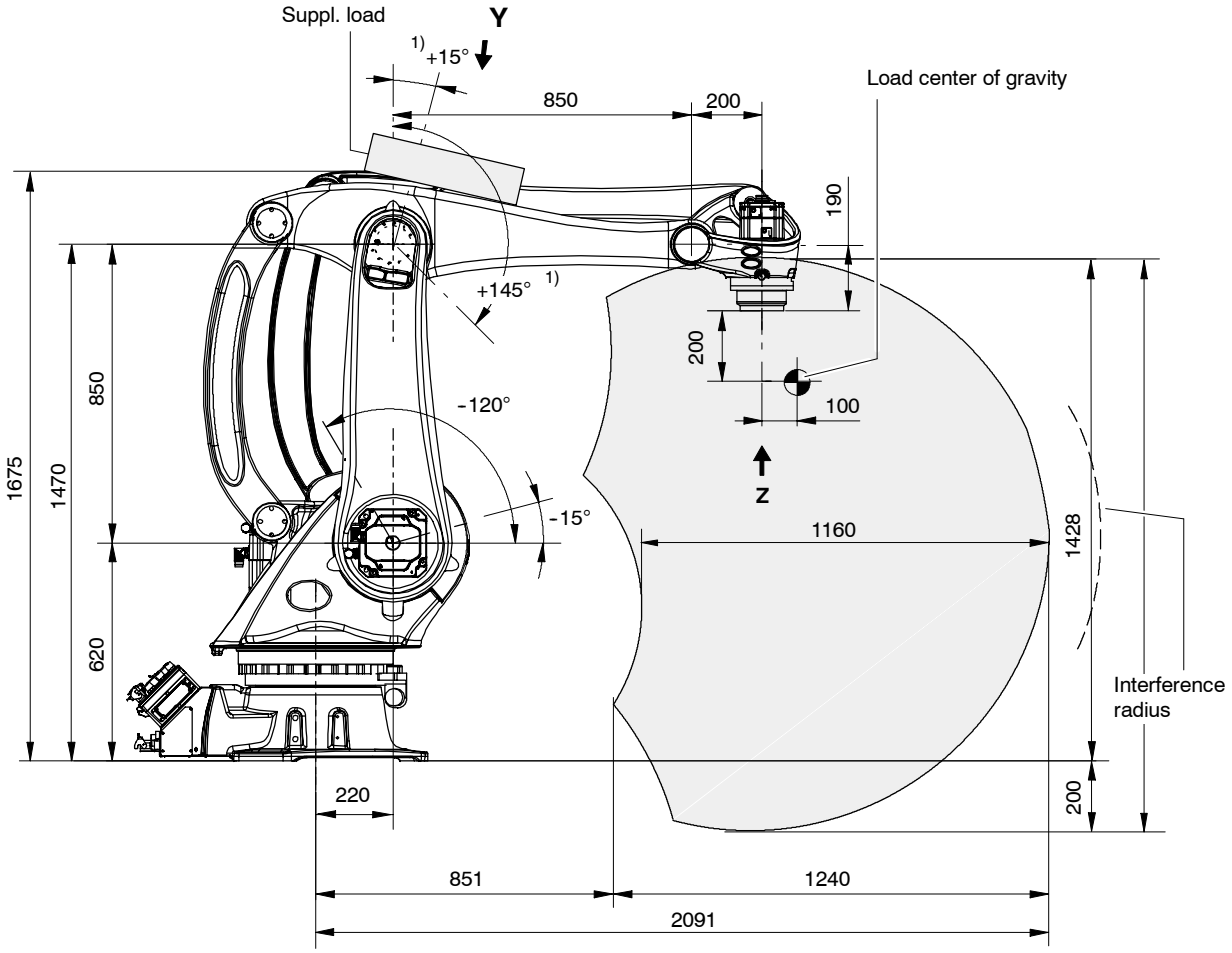
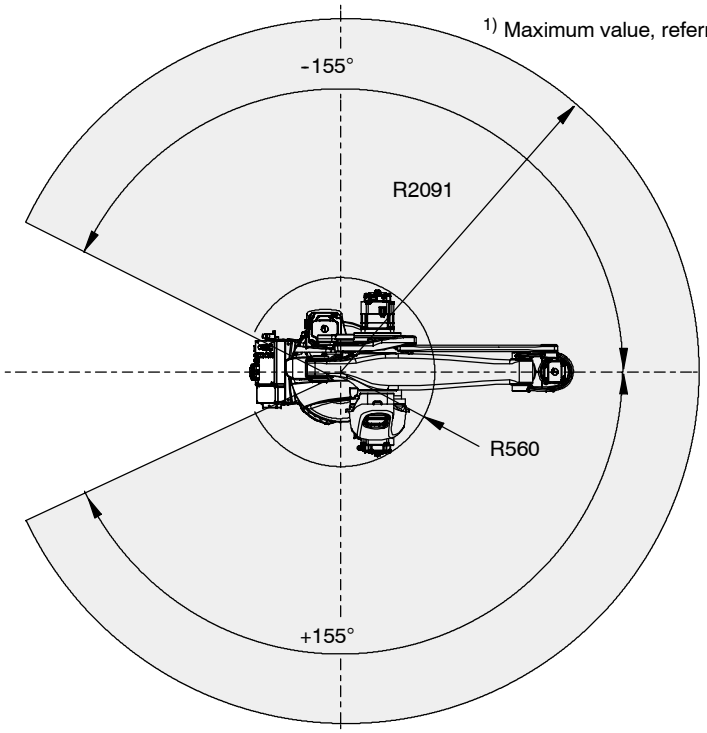


Fig. 13 Load center of gravity P and loading curves for KR 40 PA



1) Maximum value, referred to the link arm, depending on the position of axis 2

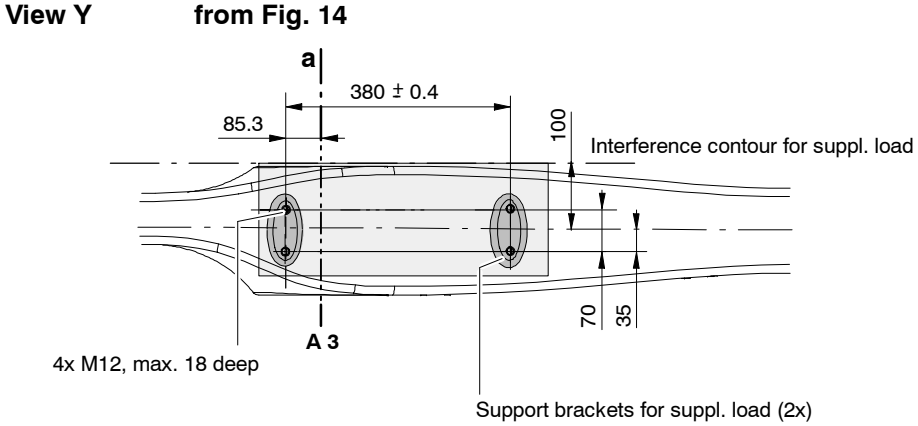


NOTE: The supplementary load center of gravity must be located as close as possible to rotational axis A3 and to line a in Fig. 15.

The reference point for the working envelope is the intersection of the mounting flange face with axis 6.

View Y, see Fig. 15.

Fig. 14 Principal dimensions and working envelope (software values)



For attaching the supplementary load, all four of the M12x18 tapped holes must be used. The maximum tightening torque is 35 Nm.
The depth of engagement of 18 mm must not be exceeded under any circumstances.

Fig. 15 Attachment holes for supplementary load

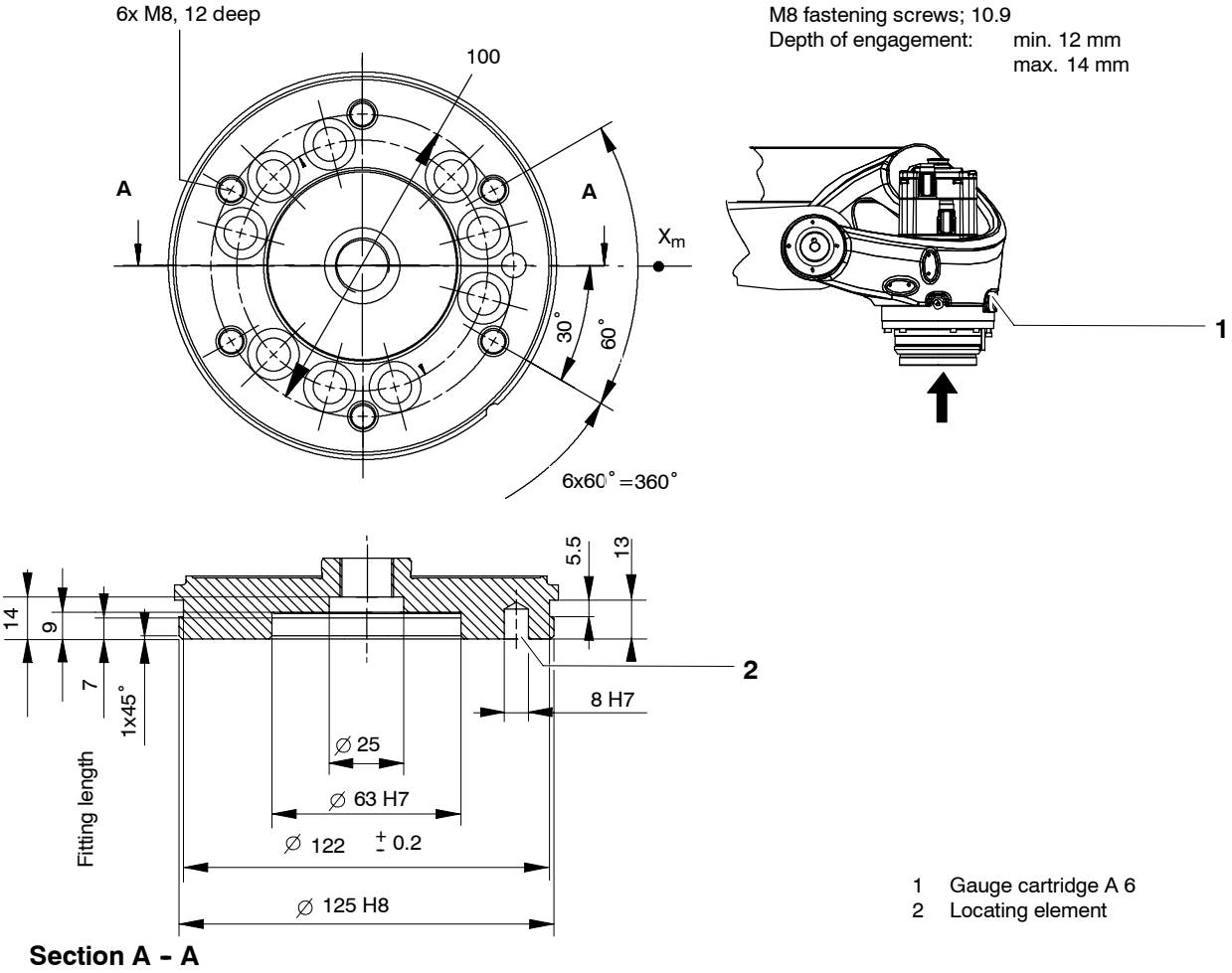
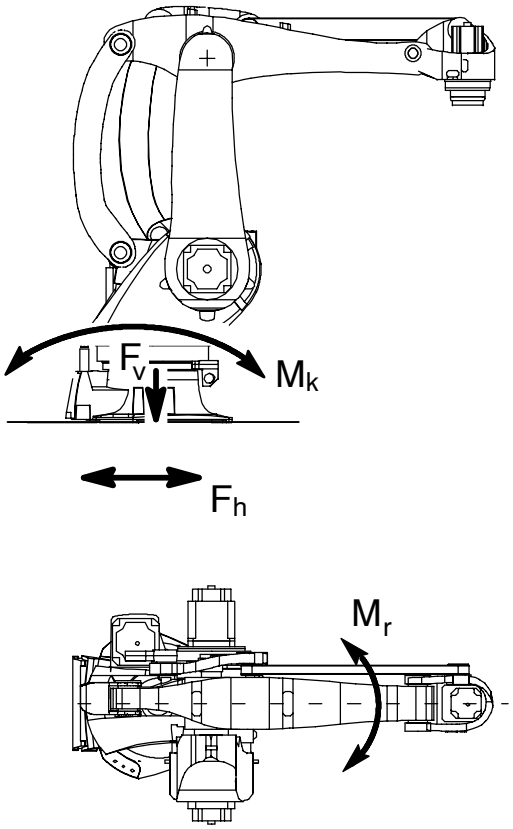


Fig. 16 DIN/ISO mounting flange for wrist



F_v	=	Vertical force	F_{vmax}	=	18,000 N
F_h	=	Horizontal force	F_{hmax}	=	9,000 N
M_k	=	Tilting moment	M_{kmax}	=	22,000 Nm
M_r	=	Turning moment about axis 1	M_{rmax}	=	13,000 Nm

Total mass	=	manipulator	+	total load	for type
		695 kg	+	60 kg	KR 40 PA

Fig. 17 Principal loads acting on floor due to manipulator and total load

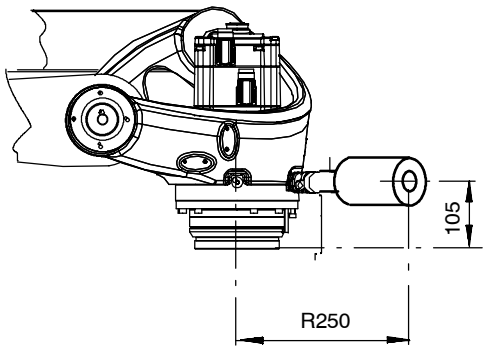


Fig. 18 Electronic probe, installation on A 6

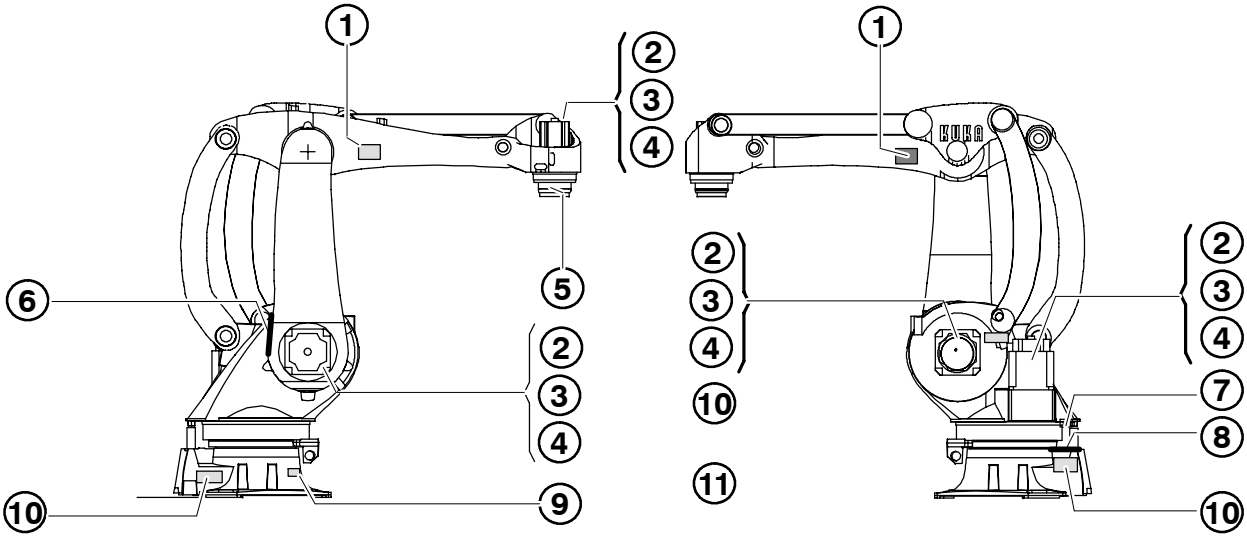
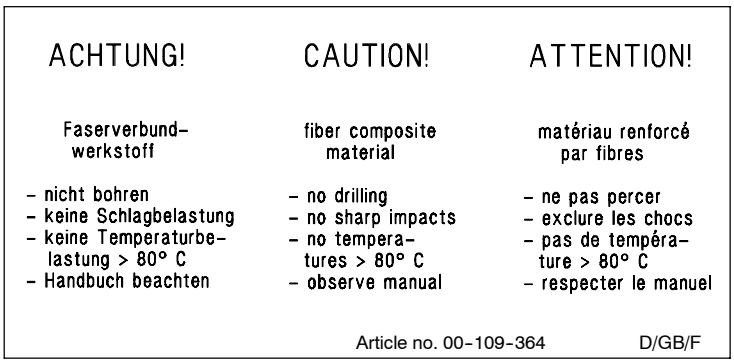


Fig. 19 Plates on manipulator (see also Fig. 20 to Fig. 29)



2x

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Fig. 20 Warning sign, fiber composite material

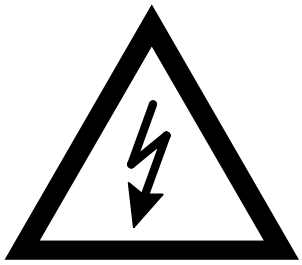

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Fig. 21 High voltage warning sign

4x on all motors.

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Fig. 22 Hot surface warning sign

On all motors.

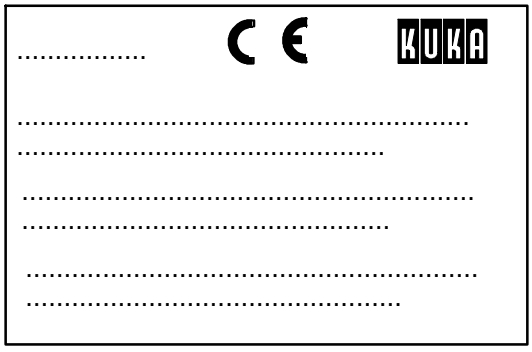

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Fig. 23 Drive motor rating plate

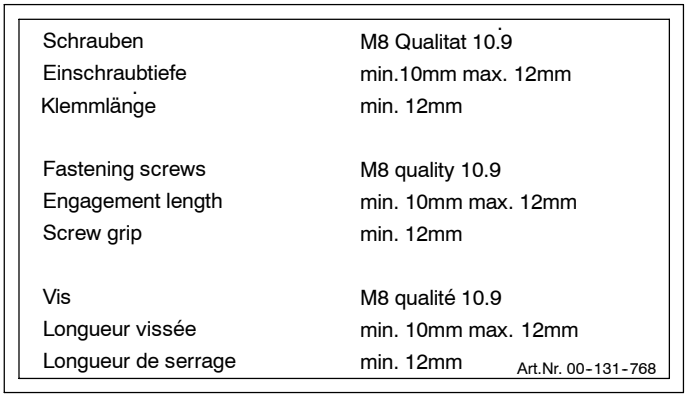

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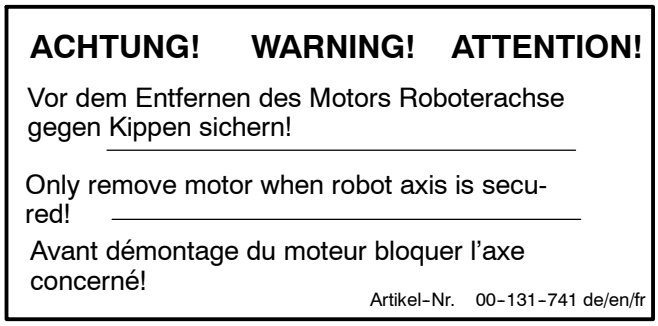
Fig. 24 Fastening instructions on the wrist



2x
⑥

Fig. 25 Instructions for safeguarding against toppling of A 2, A 3

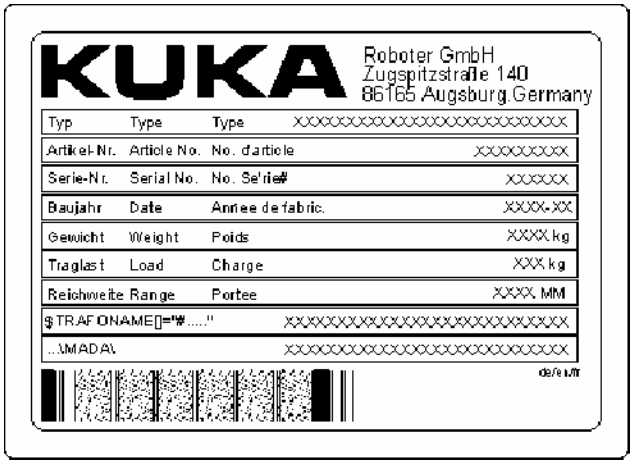


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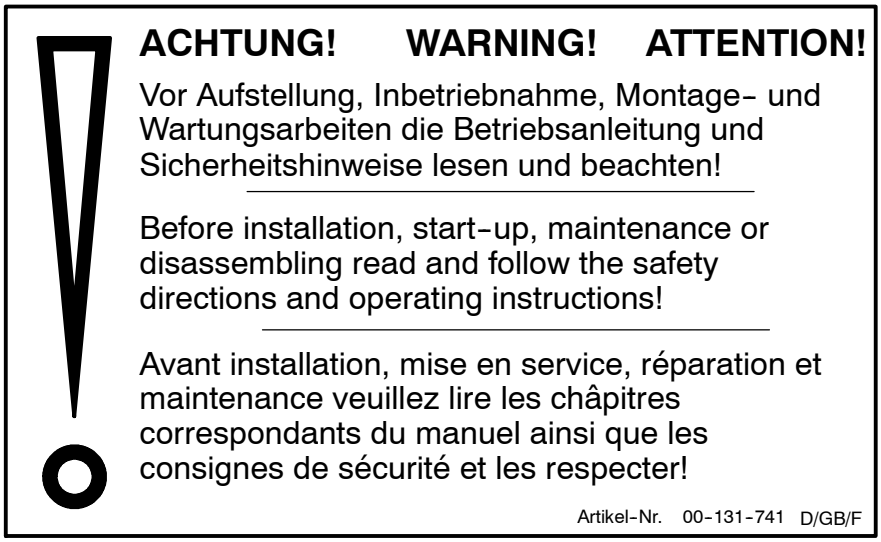
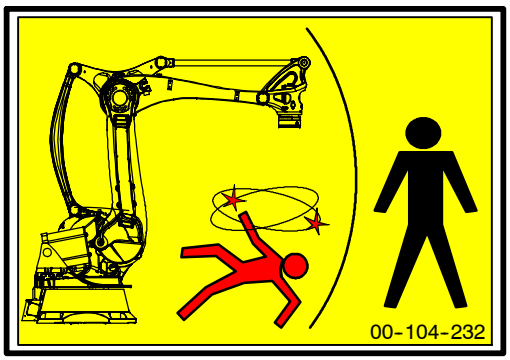
Fig. 26 Manipulator identification plate (example)



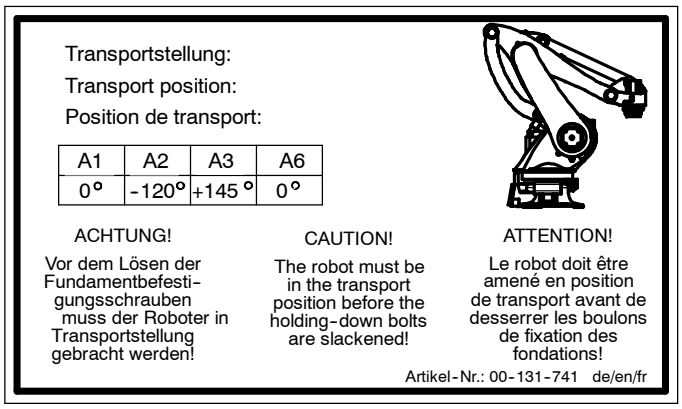
⑧

Fig. 27 Reference to operating instructions



⑨
3x

Fig. 28 Danger zone



2x
⑩

Fig. 29 Transport position plate

5 Safety

5.1 General

This “Safety” chapter refers to a mechanical component of an industrial robot.

If the mechanical component is used together with a KUKA robot controller, the “Safety” chapter of the operating instructions or assembly instructions of the robot controller must be used!
This contains all the information provided in this “Safety” chapter. It also contains additional safety information relating to the robot controller which must be observed.

Where this “Safety” chapter uses the term “industrial robot”, this also refers to the individual mechanical component if applicable.

5.1.1 Liability

The device described in this document is either an industrial robot or a component thereof.

Components of the industrial robot:

- Manipulator
- Robot controller
- Teach pendant
- Connecting cables
- External axes (optional), e.g. linear unit, turn-tilt table, positioner
- Software
- Options, accessories

The industrial robot is built using state-of-the-art technology and in accordance with the recognized safety rules. Nevertheless, misuse of the industrial robot may constitute a risk to life and limb or cause damage to the industrial robot and to other material property.

The industrial robot may only be used in perfect technical condition in accordance with its intended use and only by safety-conscious persons who are fully aware of the risks involved in its operation. Use of the industrial robot is subject to compliance with this document and with the declaration of incorporation supplied together with the industrial robot. Any functional disorders affecting the safety of the robot system must be rectified immediately.

Safety information

Safety information cannot be held against KUKA Roboter GmbH. Even if all safety instructions are followed, this is not a guarantee that the industrial robot will not cause personal injuries or material damage.

No modifications may be carried out to the industrial robot without the authorization of KUKA Roboter GmbH. Additional components (tools, software, etc.), not supplied by KUKA Roboter GmbH, may be integrated into the industrial robot. The user is liable for any damage these components may cause to the industrial robot or to other material property.

In addition to the Safety chapter, this document contains further safety instructions. These must also be observed.

5.1.2 Intended use of the industrial robot

The industrial robot is intended exclusively for the use designated in the “Purpose” chapter of the operating instructions or assembly instructions.

Further information is contained in the “Purpose” chapter of the operating instructions or assembly instructions of the component.

Using the industrial robot for any other or additional purpose is considered impermissible misuse. The manufacturer cannot be held liable for any damage resulting from such use. The risk lies entirely with the user.

Operating the industrial robot and its options within the limits of its intended use also involves observance of the operating and assembly instructions for the individual components, with particular reference to the maintenance specifications.

Misuse

Any use or application deviating from the intended use is deemed to be impermissible misuse.

This includes e.g.:

- Transportation of persons and animals
- Use as a climbing aid
- Operation outside the permissible operating parameters
- Use in potentially explosive environments
- Operation without additional safeguards
- Outdoor operation

5.1.3 EC declaration of conformity and declaration of incorporation

This industrial robot constitutes partly completed machinery as defined by the EC Machinery Directive. The industrial robot may only be put into operation if the following preconditions are met:

- The industrial robot is integrated into a complete system.

  Or: The industrial robot, together with other machinery, constitutes a complete system.

  Or: All safety functions and safeguards required for operation in the complete machine as defined by the EC Machinery Directive have been added to the industrial robot.
- The complete system complies with the EC Machinery Directive. This has been confirmed by means of an assessment of conformity.

Declaration of conformity

The system integrator must issue a declaration of conformity for the complete system in accordance with the Machinery Directive. The declaration of conformity forms the basis for the CE mark for the system. The industrial robot must be operated in accordance with the applicable national laws, regulations and standards.

The robot controller is CE certified under the EMC Directive and the Low Voltage Directive.

Declaration of incorporation

The industrial robot as partly completed machinery is supplied with a declaration of incorporation in accordance with Annex II B of the EC Machinery Directive 2006/42/EC. The assembly instructions and a list of essential requirements complied with in accordance with Annex I are integral parts of this declaration of incorporation.

The declaration of incorporation declares that the start-up of the partly completed machinery remains impermissible until the partly completed machinery has been incorporated into machinery, or has been assembled with other parts to form machinery, and this machinery complies with the terms of the EC Machinery Directive, and the EC declaration of conformity is present in accordance with Annex II A.

The declaration of incorporation, together with its annexes, remains with the system integrator as an integral part of the technical documentation of the complete machinery.

5.1.4 Terms used

Term	Description
Axis range	Range of each axis, in degrees or millimeters, within which it may move. The axis range must be defined for each axis.
Stopping distance	Stopping distance = reaction distance + braking distance The stopping distance is part of the danger zone.
Workspace	The manipulator is allowed to move within its workspace. The workspace is derived from the individual axis ranges.
Operator(User)	The user of the industrial robot can be the management, employer or delegated person responsible for use of the industrial robot.
Danger zone	The danger zone consists of the workspace and the stopping distances.
Service lifeService life	The service life of a safety-relevant component begins at the time of delivery of the component to the customer. The service life is not affected by whether the component is used in a robot controller or elsewhere or not, as safety-relevant components are also subject to ageing during storage.
KCP	The KCP (KUKA Control Panel) teach pendant has all the operator control and display functions required for operating and programming the industrial robot.
Manipulator	The robot arm and the associated electrical installations.
Protected space	The safety zone is situated outside the danger zone.
Stop category 0	The drives are deactivated immediately and the brakes are applied. The manipulator and any external axes (optional) perform path-oriented braking. **Note:** This stop category is called STOP 0 in this document.
Stop category 1	The manipulator and any external axes (optional) perform path-maintaining braking. The drives are deactivated after 1 s and the brakes are applied. **Note:** This stop category is called STOP 1 in this document.
Stop category 2	The drives are not deactivated and the brakes are not applied. The manipulator and any external axes (optional) are braked with a normal braking ramp. **Note:** This stop category is called STOP 2 in this document.
System integrator (plant integrator)	System integrators are people who safely integrate the industrial robot into a complete system and commission it.
T1	Test mode, Manual Reduced Velocity (<= 250 mm/s)
T2	Test mode, Manual High Velocity (> 250 mm/s permissible)
External axis	Motion axis which is not part of the manipulator but which is controlled using the robot controller, e.g. KUKA linear unit, turn-tilt table, Posiflex.

5.2 Personnel

The following persons or groups of persons are defined for the industrial robot:

- User
- Personnel

All persons working with the industrial robot must have read and understood the industrial robot documentation, including the safety chapter.

User

The user must observe the labor laws and regulations.
This includes e.g.:

- The user must comply with his monitoring obligations.
- The user must carry out instructions at defined intervals.

Personnel

Personnel must be instructed, before any work is commenced, in the type of work involved and what exactly it entails as well as any hazards which may exist. Instruction must be carried out regularly. Instruction is also required after particular incidents or technical modifications.

Personnel includes:

- System integrator
- Operators, subdivided into:
  - Start-up, maintenance and service personnel
  - Operating personnel
  - Cleaning personnel

Installation, exchange, adjustment, operation, maintenance and repair must be performed only as specified in the operating or assembly instructions for the relevant component of the industrial robot and only by personnel specially trained for this purpose.

System integrator

The industrial robot is safely integrated into a complete system by the system integrator.

The system integrator is responsible for the following tasks:

- Installing the industrial robot
- Connecting the industrial robot
- Performing risk assessment
- Implementing the required safety functions and safeguards
- Issuing the declaration of conformity
- Attaching the CE mark
- Creating the operating instructions for the complete system

User

The operator must meet the following preconditions:

- The operator must be trained for the work to be carried out.
- Work on the industrial robot must only be carried out by qualified personnel. These are people who, due to their specialist training, knowledge and experience, and their familiarization with the relevant standards, are able to assess the work to be carried out and detect any potential hazards.

Example

The tasks can be distributed as shown in the following table:

Tasks	Operating personnel	Programmer	System integrator
Switch robot controller on/off	x	x	x
Start program	x	x	x
Select program	x	x	x
Select operating mode	x	x	x
Calibration (tool, base)		x	x
Master the manipulator		x	x
Configuration		x	x
Programming		x	x
Commissioning			x
Maintenance			x
Repair			x
Decommissioning			x
Transportation			x

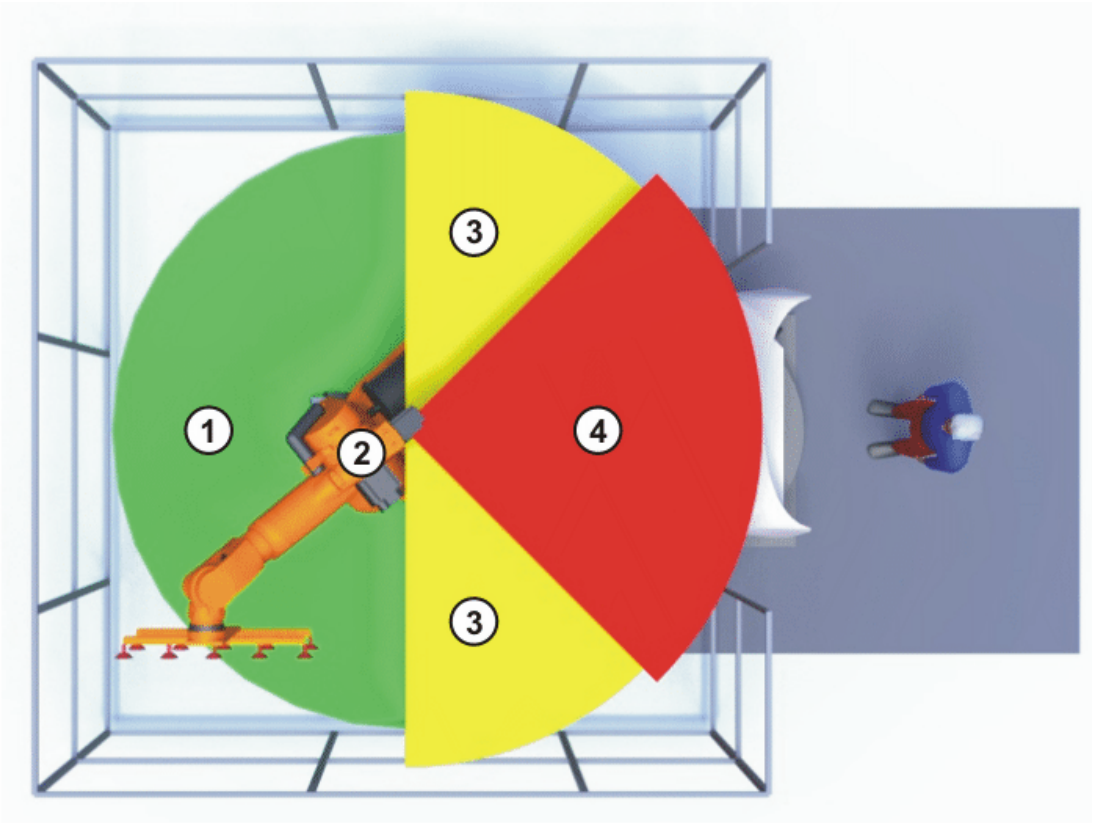
Work on the electrical and mechanical equipment of the industrial robot may only be carried out by specially trained personnel.

5.3 Workspace, safety zone and danger zone

Working zones are to be restricted to the necessary minimum size. A workspace must be safeguarded using appropriate safeguards.

The safeguards (e.g. safety gate) must be situated inside the safety zone. In the case of a stop, the manipulator and external axes (optional) are braked and come to a stop within the danger zone.

The danger zone consists of the workspace and the stopping distances of the manipulator and external axes (optional). It must be safeguarded by means of physical safeguards to prevent danger to persons or the risk of material damage.



(1) Workspace
(2) Manipulator
(3) Stopping distance
(4) Safety zone

Fig. 30 Example: axis range A1

5.4 Overview of protective equipment

The protective equipment of the mechanical component may include:

- Mechanical end stops
- Mechanical axis range limitation (optional)
- Axis range monitoring (optional)
- Release device (optional)
- Labeling of danger areas

Not all equipment is relevant for every mechanical component.

5.4.1 Mechanical end stops

Depending on the robot variant, the axis ranges of the main and wrist axes of the manipulator are partially limited by mechanical end stops.

Additional mechanical end stops can be installed on the external axes.

If the manipulator or an external axis hits an obstruction or a mechanical end stop or axis range limitation, this can result in material damage to the industrial robot. The manipulator must be taken out of operation and KUKA Roboter GmbH must be consulted before it is put back into operation.

5.4.2 Mechanical axis range limitation (optional)

Some manipulators can be fitted with mechanical axis range limitation in axes A1 to A3. The adjustable axis range limitation systems restrict the working range to the required minimum. This increases personal safety and protection of the system.

In the case of manipulators that are not designed to be fitted with mechanical axis range limitation, the workspace must be laid out in such a way that there is no danger to persons or material property, even in the absence of mechanical axis range limitation.

If this is not possible, the workspace must be limited by means of photoelectric barriers, photoelectric curtains or obstacles on the system side. There must be no shearing or crushing hazards at the loading and transfer areas.

This option is not available for all robot models. Information on specific robot models can be obtained from KUKA Roboter GmbH.

5.4.3 Axis range monitoring (optional)

Some manipulators can be fitted with dual-channel axis range monitoring systems in main axes A1 to A3. The positioner axes may be fitted with additional axis range monitoring systems. The safety zone for an axis can be adjusted and monitored using an axis range monitoring system. This increases personal safety and protection of the system.

This option is not available for all robot models. Information on specific robot models can be obtained from KUKA Roboter GmbH.

5.4.4 Devices for moving the manipulator without the robot controller (options)

Description

The following devices are available for moving the manipulator after an accident or malfunction:

- Release device
  The release device can be used for the main axis drive motors and, depending on the robot variant, also for the wrist axis drive motors.
- Brake release device
  The brake release device is designed for robot variants whose motors are not freely accessible.

The devices are only for use in exceptional circumstances and emergencies, e.g. for freeing people.

This option is not available for all robot models. Information on specific robot models can be obtained from KUKA Roboter GmbH.

The motors reach temperatures during operation which can cause burns to the skin. Contact must be avoided. Appropriate safety precautions must be taken, e.g. protective gloves must be worn.

Procedure

Moving the manipulator with the release device:

(1) Switch off the robot controller and secure it (e.g. with a padlock) to prevent unauthorized persons from switching it on again.

(2) Remove the protective cap from the motor.

(3) Push the release device onto the corresponding motor and move the axis in the desired direction.
The directions are indicated with arrows on the motors. It is necessary to overcome the resistance of the mechanical motor brake and any other loads acting on the axis.

Moving an axis with the release device can damage the motor brake. This can result in personal injury and material damage. After using the release device, the affected motor must be exchanged.

If a robot axis has been moved by the release device, all robot axes must be re-mastered. Serious injuries or damage to property may otherwise result.

Procedure

Moving the manipulator with the brake release device:

Use of the brake release device may result in unexpected robot motions, especially sagging of the axes. During use of the brake release device, attention must be paid to motion of this kind in order to be able to prevent physical injuries or damage to property. Standing under moving axes is not permitted.

(1) Switch off the robot controller and secure it (e.g. with a padlock) to prevent unauthorized persons from switching it on again.

(2) Connect the brake release device to the base frame of the robot:
Unplug connector X30 from interface A1. Plug connector X20 of the brake release device into interface A1.

(3) Select the brakes to be released (main axes, wrist axes) via the selection switch on the brake release device.

(4) Press the button on the hand-held device.
The brakes of the main axes or wrist axes are released and the robot can be moved manually.

Further information about the brake release device can be found in the documentation for the brake release device.

5.4.5 Labeling on the industrial robot

All plates, labels, symbols and marks constitute safety-relevant parts of the industrial robot. They must not be modified or removed.

Labeling on the industrial robot consists of:

- Identification plates
- Warning labels
- Safety symbols
- Designation labels
- Cable markings
- Rating plates

Further information is contained in the technical data of the operating instructions or assembly instructions of the components of the industrial robot.

5.5 Safety measures

5.5.1 General safety regulations

The industrial robot may only be used in perfect technical condition in accordance with its intended use and only by safety-conscious persons. Operator errors can result in personal injury and damage to property.

It is important to be prepared for possible movements of the industrial robot even after the robot controller has been switched off and locked. Incorrect installation (e.g. overload) or mechanical defects (e.g. brake defect) can cause the manipulator or external axes to sag. If work is to be carried out on a switched-off industrial robot, the manipulator and external axes must first be moved into a position in which they are unable to move on their own, whether the payload is mounted or not. If this is not possible, the manipulator and external axes must be secured by appropriate means.

In the absence of operational safety functions and safeguards, the industrial robot can cause personal injury or material damage. If safety functions or safeguards are dismantled or deactivated, the industrial robot may not be operated.

Standing underneath the robot arm can cause death or serious injuries. For this reason, standing underneath the robot arm is prohibited!

The motors reach temperatures during operation which can cause burns to the skin. Contact must be avoided. Appropriate safety precautions must be taken, e.g. protective gloves must be worn.

KCP

The user must ensure that the industrial robot is only operated with the KCP by authorized persons.

If more than one KCP is used in the overall system, it must be ensured that each KCP is unambiguously assigned to the corresponding industrial robot. They must not be interchanged.

The operator must ensure that decoupled KCPs are immediately removed from the system and stored out of sight and reach of personnel working on the industrial robot. This serves to prevent operational and non-operational EMERGENCY STOP devices from becoming interchanged.
Failure to observe this precaution may result in death, severe physical injuries or considerable damage to property.

External keyboard, external mouse

An external keyboard and/or external mouse may only be used if the following conditions are met:

- Start-up or maintenance work is being carried out.
- The drives are switched off.
- There are no persons in the danger zone.

The KCP must not be used as long as an external keyboard and/or external mouse are connected.

The external keyboard and/or external mouse must be removed as soon as the start-up or maintenance work is completed or the KCP is connected.

Faults

The following tasks must be carried out in the case of faults in the industrial robot:

- Switch off the robot controller and secure it (e.g. with a padlock) to prevent unauthorized persons from switching it on again.
- Indicate the fault by means of a label with a corresponding warning (tagout).
- Keep a record of the faults.
- Eliminate the fault and carry out a function test.

Modifications

After modifications to the industrial robot, checks must be carried out to ensure the required safety level. The valid national or regional work safety regulations must be observed for this check. The correct functioning of all safety circuits must also be tested.

New or modified programs must always be tested first in Manual Reduced Velocity mode (T1).

After modifications to the industrial robot, existing programs must always be tested first in Manual Reduced Velocity mode (T1). This applies to all components of the industrial robot and includes modifications to the software and configuration settings.

5.5.2 Transportation

Manipulator

The prescribed transport position of the manipulator must be observed. Transportation must be carried out in accordance with the operating instructions or assembly instructions of the robot.

Robot controller

The robot controller must be transported and installed in an upright position. Avoid vibrations and impacts during transportation in order to prevent damage to the robot controller.

Transportation must be carried out in accordance with the operating instructions or assembly instructions of the robot controller.

External axis (optional)

The prescribed transport position of the external axis (e.g. KUKA linear unit, turn-tilt table, etc.) must be observed. Transportation must be carried out in accordance with the operating instructions for the external axis.

5.5.3 Start-up and recommissioning

Before starting up systems and devices for the first time, a check must be carried out to ensure that the systems and devices are complete and operational, that they can be operated safely and that any damage is detected.

The valid national or regional work safety regulations must be observed for this check. The correct functioning of all safety circuits must also be tested.

The passwords for logging onto the KUKA System Software as “Expert” and “Administrator” must be changed before start-up and must only be communicated to authorized personnel.

The robot controller is preconfigured for the specific industrial robot. If cables are interchanged, the manipulator and the external axes (optional) may receive incorrect data and can thus cause personal injury or material damage. If a system consists of more than one manipulator, always connect the connecting cables to the manipulators and their corresponding robot controllers.

If additional components (e.g. cables), which are not part of the scope of supply of KUKA Roboter GmbH, are integrated into the industrial robot, the user is responsible for ensuring that these components do not adversely affect or disable safety functions.

If the internal cabinet temperature of the robot controller differs greatly from the ambient temperature, condensation can form, which may cause damage to the electrical components. Do not put the robot controller into operation until the internal temperature of the cabinet has adjusted to the ambient temperature.

Function test

The following tests must be carried out before start-up and recommissioning.

It must be ensured that:

- The industrial robot is correctly installed and fastened in accordance with the specifications in the documentation.
- There are no foreign bodies or loose parts on the industrial robot.
- All required safety equipment is correctly installed and operational.
- The power supply ratings of the industrial robot correspond to the local supply voltage and mains type.
- The ground conductor and the equipotential bonding cable are sufficiently rated and correctly connected.
- The connecting cables are correctly connected and the connectors are locked.

Machine data

It must be ensured that the rating plate on the robot controller has the same machine data as those entered in the declaration of incorporation.
The machine data on the rating plate of the manipulator and the external axes (optional) must be entered during start-up.

The industrial robot must not be moved if incorrect machine data are loaded. Death, severe injuries or considerable damage to property may otherwise result. The correct machine data must be loaded.

5.5.4 Manual mode

Manual mode is the mode for setup work. Setup work is all the tasks that have to be carried out on the industrial robot to enable automatic operation. Setup work includes:

- Jog mode
- Teach
- Programming
- Program verification

The following must be taken into consideration in manual mode:

- If the drives are not required, they must be switched off to prevent the manipulator or the external axes (optional) from being moved unintentionally.

  New or modified programs must always be tested first in Manual Reduced Velocity mode (T1).
- The manipulator, tooling or external axes (optional) must never touch or project beyond the safety fence.
- Workpieces, tooling and other objects must not become jammed as a result of the industrial robot motion, nor must they lead to short-circuits or be liable to fall off.
- All setup work must be carried out, where possible, from outside the safeguarded area.

If the setup work has to be carried out inside the safeguarded area, the following must be taken into consideration:

In **Manual Reduced Velocity mode (T1)**:

- If it can be avoided, there must be no other persons inside the safeguarded area.

If it is necessary for there to be several persons inside the safeguarded area, the following must be observed:

- Each person must have an enabling device.
- All persons must have an unimpeded view of the industrial robot.
- Eye-contact between all persons must be possible at all times.

- The operator must be so positioned that he can see into the danger area and get out of harm's way.

In **Manual High Velocity mode (T2):**

- This mode may only be used if the application requires a test at a velocity higher than Manual Reduced Velocity.
- Teaching and programming are not permissible in this operating mode.
- Before commencing the test, the operator must ensure that the enabling devices are operational.
- The operator must be positioned outside the danger zone.
- There must be no other persons inside the safeguarded area. It is the responsibility of the operator to ensure this.

5.5.5 Automatic mode

Automatic mode is only permissible in compliance with the following safety measures:

- All safety equipment and safeguards are present and operational.
- There are no persons in the system.
- The defined working procedures are adhered to.

If the manipulator or an external axis (optional) comes to a standstill for no apparent reason, the danger zone must not be entered until an EMERGENCY STOP has been triggered.

5.5.6 Maintenance and repair

After maintenance and repair work, checks must be carried out to ensure the required safety level. The valid national or regional work safety regulations must be observed for this check. The correct functioning of all safety circuits must also be tested.

The purpose of maintenance and repair work is to ensure that the system is kept operational or, in the event of a fault, to return the system to an operational state. Repair work includes troubleshooting in addition to the actual repair itself.

The following safety measures must be carried out when working on the industrial robot:

- Carry out work outside the danger zone. If work inside the danger zone is necessary, the user must define additional safety measures to ensure the safe protection of personnel.
- Switch off the industrial robot and secure it (e.g. with a padlock) to prevent it from being switched on again. If it is necessary to carry out work with the robot controller switched on, the user must define additional safety measures to ensure the safe protection of personnel.
- If it is necessary to carry out work with the robot controller switched on, this may only be done in operating mode T1.
- Label the system with a sign indicating that work is in progress. This sign must remain in place, even during temporary interruptions to the work.
- The EMERGENCY STOP systems must remain active. If safety functions or safeguards are deactivated during maintenance or repair work, they must be reactivated immediately after the work is completed.

Before work is commenced on live parts of the robot system, the main switch must be turned off and secured against being switched on again by unauthorized personnel. The incoming power cable must be deenergized. The robot controller and mains supply lead must then be checked to ensure that it is deenergized.
If the KR C4 or VKR C4 robot controller is used:
It is not sufficient, before commencing work on live parts, to execute an EMERGENCY STOP or a safety stop, or to switch off the drives, as this does not disconnect the robot system from the mains power supply in the case of the drives of the new generation. Parts remain energized. Death or severe injuries may result.

Faulty components must be replaced using new components with the same article number or equivalent components approved by KUKA Roboter GmbH for this purpose.

Cleaning and preventive maintenance work is to be carried out in accordance with the operating instructions.

Robot controller

Even when the robot controller is switched off, parts connected to peripheral devices may still carry voltage. The external power sources must therefore be switched off if work is to be carried out on the robot controller.

The ESD regulations must be adhered to when working on components in the robot controller.

Voltages in excess of 50 V (up to 600 V) can be present in various components for several minutes after the robot controller has been switched off! To prevent life–threatening injuries, no work may be carried out on the industrial robot in this time.

Water and dust must be prevented from entering the robot controller.

Counterbalancing system

Some robot variants are equipped with a hydropneumatic, spring or gas cylinder counterbalancing system.

The hydropneumatic and gas cylinder counterbalancing systems are pressure equipment and, as such, are subject to obligatory equipment monitoring. Depending on the robot variant, the counterbalancing systems correspond to category 0, II or III, fluid group 2, of the Pressure Equipment Directive.

The user must comply with the applicable national laws, regulations and standards pertaining to pressure equipment.

Inspection intervals in Germany in accordance with Industrial Safety Order, Sections 14 and 15. Inspection by the user before commissioning at the installation site.

The following safety measures must be carried out when working on the counterbalancing system:

- The manipulator assemblies supported by the counterbalancing systems must be secured.
- Work on the counterbalancing systems must only be carried out by qualified personnel.

Hazardous substances

The following safety measures must be carried out when handling hazardous substances:

- Avoid prolonged and repeated intensive contact with the skin.
- Avoid breathing in oil spray or vapors.
- Clean skin and apply skin cream.

To ensure safe use of our products, we recommend that our customers regularly request up-to-date safety data sheets from the manufacturers of hazardous substances.

5.5.7 Decommissioning, storage and disposal

The industrial robot must be decommissioned, stored and disposed of in accordance with the applicable national laws, regulations and standards.

5.6 Applied norms and regulations

Name	Definition	Edition
2006/42/EC	Machinery Directive: Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)	2006
2004/108/EC	EMC Directive: Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC	2004
97/23/EC	Pressure Equipment Directive: Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment (Only applicable for robots with hydropneumatic counterbalancing system.)	1997
EN ISO 13850	Safety of machinery: Emergency stop – Principles for design	2008
EN ISO 13849-1	Safety of machinery: Safety-related parts of control systems; Part 1: General principles of design	2008
EN ISO 13849-2	Safety of machinery: Safety-related parts of control systems; Part 2: Validation	2008
EN ISO 12100	Safety of machinery: General principles of design, risk assessment and risk reduction	2010
EN ISO 10218-1	Industrial robots: Safety	2011
EN 614-1	Safety of machinery: Ergonomic design principles – Part 1: Terms and general principles	2006
EN 61000-6-2	Electromagnetic compatibility (EMC): Part 6-2: Generic standards; Immunity for industrial environments	2005
EN 61000-6-4	Electromagnetic compatibility (EMC): Part 6-4: Generic standards; Emission standard for industrial environments	2007
EN 60204-1	Safety of machinery: Electrical equipment of machines Part 1: General requirements	2006

6 Transportation

This description applies analogously to all of the industrial robots listed in Chapter 1, regardless of the variant or model shown in the illustrations.

If the manipulator is transported by fork lift truck, the forks must be placed in the fork slots. It is forbidden to pick up the manipulator in any other way using a fork lift truck!

The fork lift truck, lifting tackle and crane must be suitable for handling the manipulator. For weight, see Chapter 4, “Technical data”.
The manipulator must be moved into its transport position each time it is transported. It must be ensured that the manipulator is stable while it is being transported.

The manipulator must remain in its transport position until it is – depending on the type – fastened to the floor, the ceiling or to a hinged steel base.

Before the manipulator is lifted, it must be ensured that it is free from obstructions. Transport safeguards, such as nails and screws, are all to be removed in advance, as is any rust or glue on contact surfaces.

The manipulator can be transported as follows:

- With lifting tackle and crane (Fig. 33, left-hand side)

The manipulator can be suspended from the hook of a crane by means of lifting tackle attached to two eyebolts on the rotating column and on the parallel link arm. For transportation, two M20 DIN 580 eyebolts (Fig. 31/1) must be installed.

The ropes or belts of the lifting tackle must be positioned so that there is no possibility of the manipulator tilting to the side and of cabling or connectors being damaged.

Only approved handling equipment and lifting tackle with an adequate carrying capacity may be used for transporting the manipulator.
For the weight of the manipulator, see Chapter 4, “Technical data”.
Both eyebolts on the rotating column must always be used to suspend the robot.

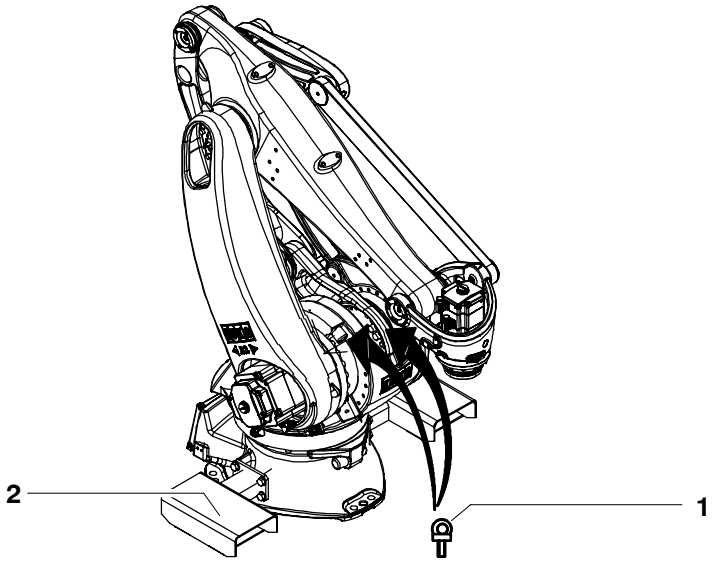


Fig. 31 Transport position

- With fork lift truck (Fig. 33, right-hand side)

The manipulator (Fig. 32/1) can also be lifted by fork lift truck. For transport by fork lift truck, the fork slots (2) (accessory) must be fully and properly installed.

If the manipulator is transported by fork lift truck, the forks must be placed in the fork slots. It is forbidden to pick up the manipulator in any other way using a fork lift truck!

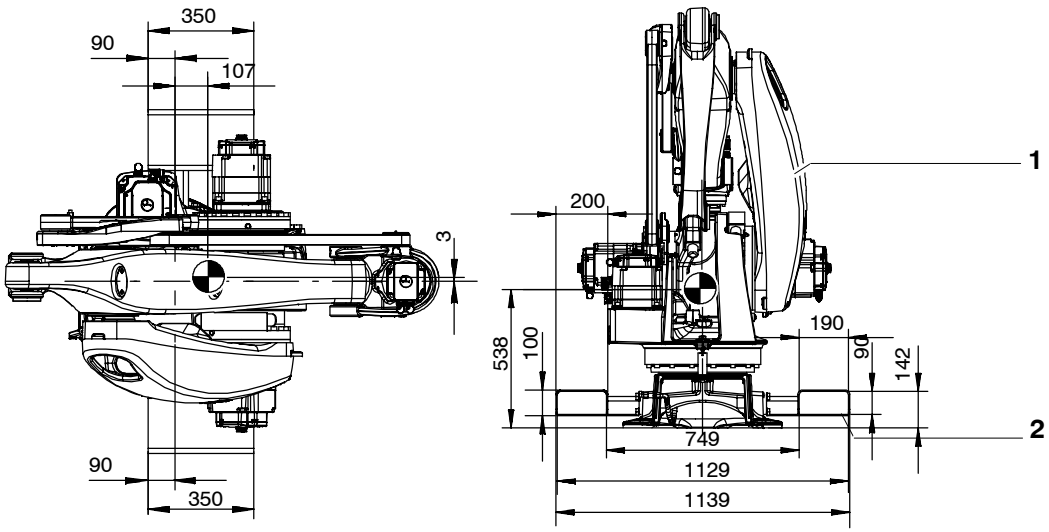


Fig. 32 Fork slots

For transport with a fork lift truck, two open-ended removable fork slots (Fig. 22/2) are provided on the base frame. This allows the manipulator to be picked up from two sides.

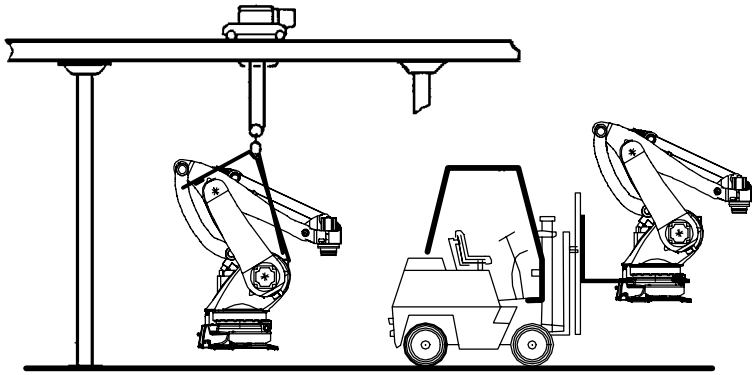


Fig. 33 Transporting the manipulator

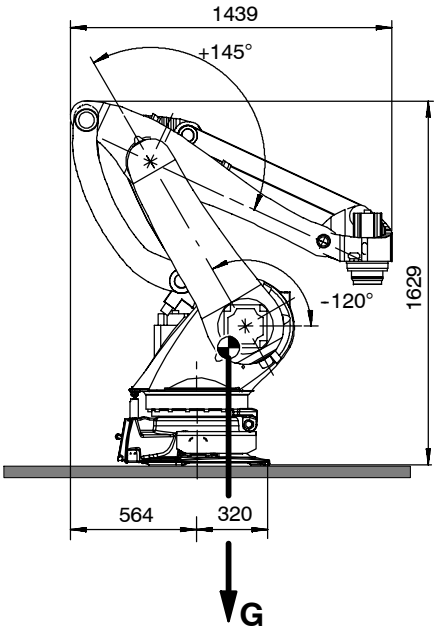
If the manipulator is to be transported away from its site of operation, the following is to be observed:

Turn main switch on the manipulator control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

(1) Remove tools and additional devices should they prevent the transport position from being reached or generally impede transportation.

Before performing the next step, it must be ensured that it is not possible for anyone to be injured within the range of the slowly moving manipulator.
The manipulator may only be moved at jog speed, with all applicable safety rules and regulations being observed.

(2) Put the manipulator into operation and move it into the transport position (Fig. 34).



A 1	A 2	A 3	A 6
0°	-120°	+145°	any

All angles refer to the display on the KCP

Fig. 34 Transport position

Turn main switch on the manipulator control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

For further work steps, see Chapter 7, “Installation”.

7 Installation

This description applies analogously to all of the industrial robots listed in Chapter 1, regardless of the variant or model shown in the illustrations.

7.1 General

Observe Chapter 5, “Safety”!
With all work involving the connection of the manipulator (and of the control cabinet), the control cabinet documentation “Initial Start-up” must be observed.

When putting the manipulator into operation either for the first time or after an exchange, zero adjustment must be carried out in accordance with the Operating Handbook, Software KR C4, Chapter “Start-up”, Section “Mastering/Unmastering”.

Before any installation and exchange work is started, any attached tools or additional equipment that would hinder the installation and exchange work must be dismounted.

The fork lift truck, lifting tackle and crane must be suitable for handling the manipulator. For weight, see Chapter 4, “Technical data”.

If the manipulator is transported by fork lift truck, the forks must be placed in the slots in the base frame. It is forbidden to pick up the manipulator in any other way using a fork lift truck!

The description of the installation and exchange operations is subdivided into job steps with numbers in brackets appearing before them. The text which immediately follows these steps must also be read if it is specially marked by a **warning triangle** or either of the **hand symbols**. This is because many of these marked texts refer to the preceding job step.

Example:
(8) Lower the manipulator slowly without tilting it.

The manipulator must be lowered vertically downwards until both locating pins are free.

Some of the specially marked texts refer exclusively to everything that follows – until the instruction is expressly revoked or the work is completed at the end of a section.

Example:

Turn main switch on the manipulator control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

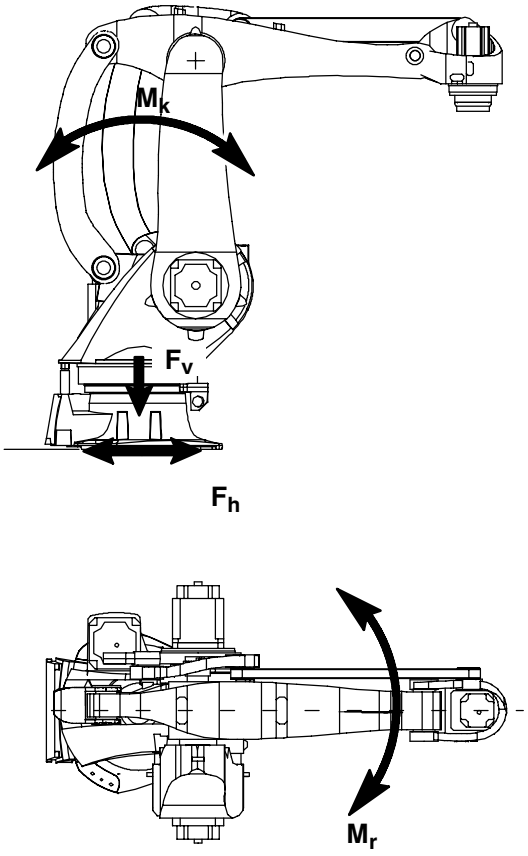
If it is necessary to carry out work in the area beneath a manipulator, the latter must be secured to guard against the risk of unintended motion into this area. This can be done by supporting it from below or by securing it with a rope from above.

Never work or stand under suspended loads!

7.2 Principal loads

Forces occur during operation which must be safely transmitted to the floor structure. The forces that have to be taken into account are specified in Fig. 35. The data given in the illustration can also be used as a basis for more extensive static investigations.

The specified forces and moments already include the payload and the inertia force (weight) of the manipulator.



F_v	=	Vertical force	F_{vmax}	=	18,000 N
F_h	=	Horizontal force	F_{hmax}	=	9,000 N
M_k	=	Tilting moment	M_{kmax}	=	22,000 Nm
M_r	=	Turning moment about axis 1	M_{rmax}	=	13,000 Nm

Total mass =	manipulator	+	total load	for type
	695 kg	+	60 kg	KR 40 PA

Fig. 35 Principal loads acting on floor due to manipulator and total load

7.3 Mounting variants

The manipulator may only be installed on the floor.

There are three mounting variations for installing the manipulator on the floor.

7.3.1 Mounting base with centering

If the manipulator is to be installed on the floor, being mounted directly on a concrete base, all pertinent construction specifications must be observed concerning the grade of concrete (B25 according to DIN 1045:1988 or C20/25 according to DIN EN 206-1:2001/DIN 1045-2:2001) and the load-bearing capacity of the ground when preparing the concrete foundation. It must be ensured that the surface of the foundation is level and sufficiently smooth. The anchors must be inserted with great care to ensure that the forces occurring during the operation of the robot (Fig. 35) are transmitted safely to the ground. Fig. 37 shows the components of this mounting base. In Fig. 38 the dimensions of the concrete base and the orientation to the working envelope are depicted.

To make the anchor holes a drilling template is also available (Fig. 36). The center of the manipulator, axis 1, is defined by the hole (1).

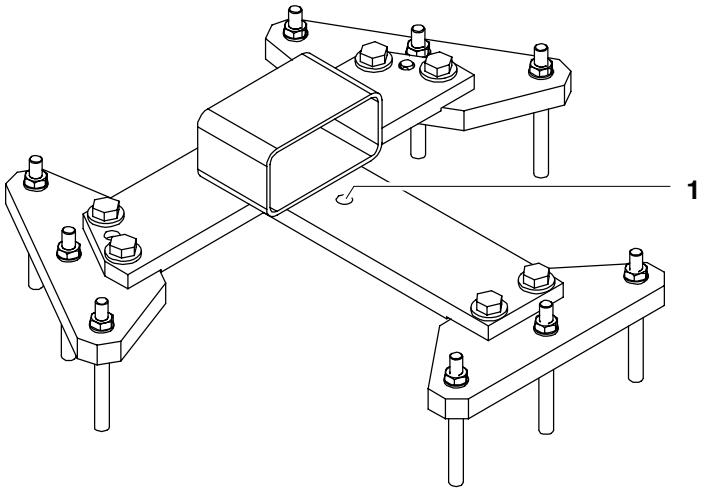


Fig. 36 Drilling template

To avoid distorting the manipulator base frame or the adapter plate when fastening it to the concrete foundation, differences in level between the concrete foundation and the base frame must be corrected using leveling compound (filling compound).

Features:

- Manipulator installed on the concrete foundation.
- Manipulator fastened by means of nine chemical anchors.

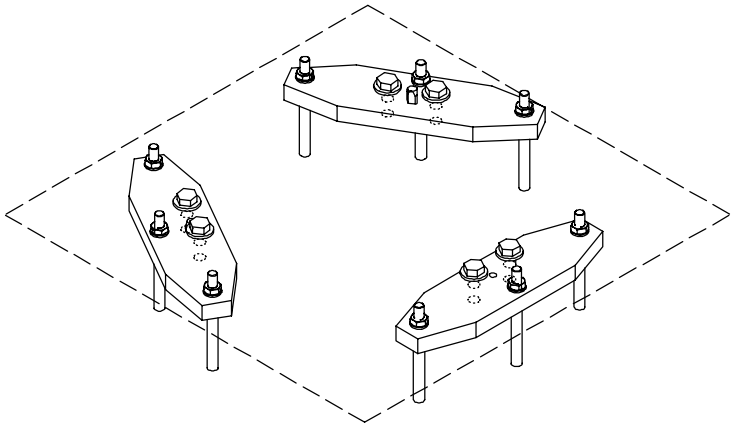


Fig. 37 Mounting base with centering

When using chemical anchors (resin-bonded anchors), only resin capsules and anchors (threaded rods) from the same manufacturer may be used.

No diamond tools or core drills may be used for drilling the anchor holes; for preference, drilling tools supplied by the anchor manufacturer are to be used.

The manufacturer's instructions for the use of resin-bonded anchors must also be observed.

- **Installation**

  (1) Lift the manipulator with fork lift truck or lifting tackle.

  (2) Fasten each of the three bedplates (Fig. 39/3) to the manipulator (2) or to the drilling template by means of two M20x55-8.8-A2K hexagon bolts (1) and lock washers.

  (3) Mark the position of the manipulator in relation to the working envelope (Fig. 38/1) on the concrete foundation (2) and bring the manipulator to the installation position.

  (4) Align the manipulator horizontally.

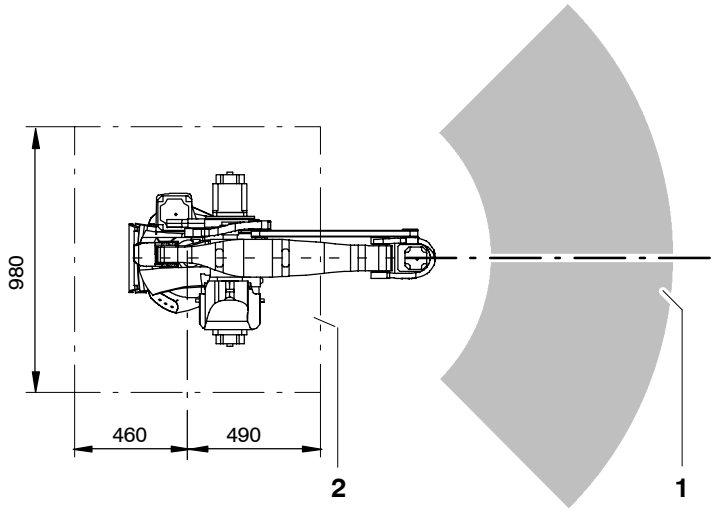


Fig. 38 Orientation of working envelope and concrete foundation

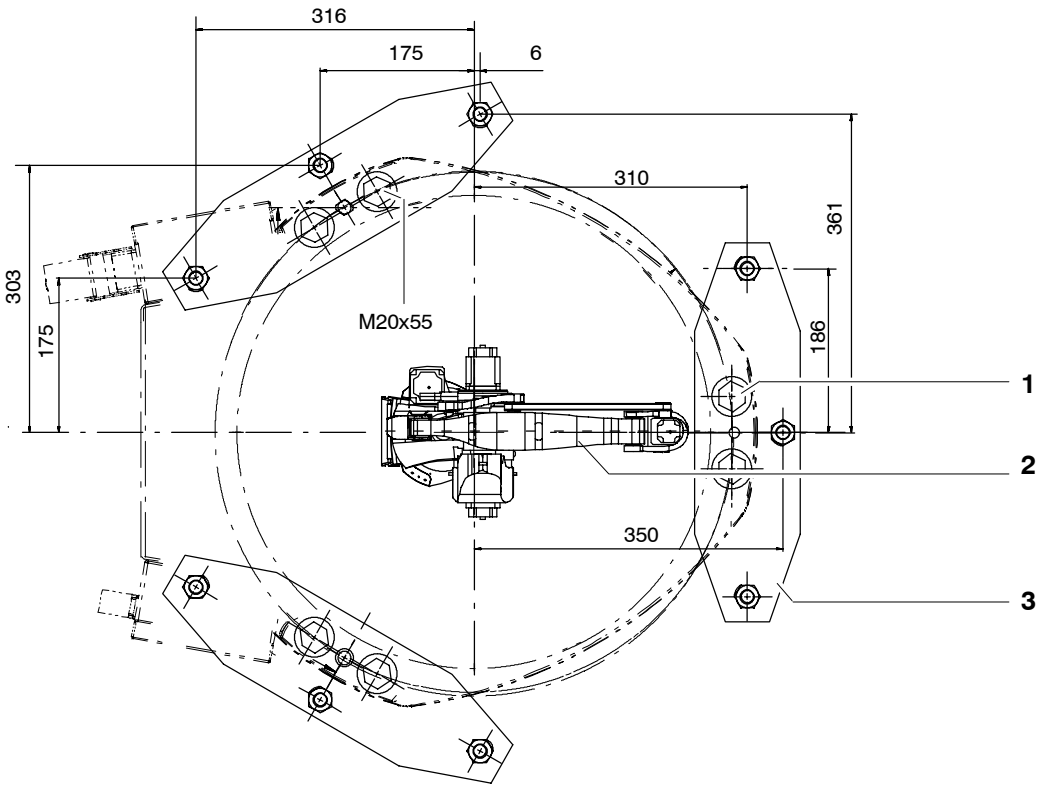


Fig. 39 Bedplates, connecting dimensions

(5) If necessary, determine the differences in level. If large differences in level are present, steps (6) to (9) must be followed.

(6) Apply leveling compound (Fig. 40/2) to the concrete foundation (4) or the underside of the bedplates.
The area (3) under each hexagon bolt (1) must be kept free from leveling compound or it must be cleared after the compound has been applied.

(7) Set the manipulator or the drilling template down in the still plastic leveling compound and adjust its position slightly if necessary.

(8) Remove excess leveling compound.

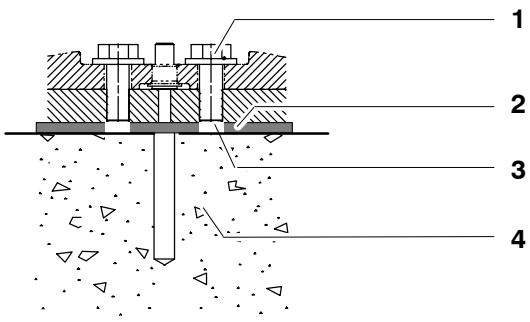


Fig. 40 Leveling compound

If large differences in level need to be compensated for, more leveling compound must be applied. The maximum leveling compound thickness specified by the manufacturer must not be exceeded.

(9) Allow the leveling compound to set in accordance with the manufacturer's instructions. The curing time is longer at temperatures below 20 °C.

At the end of the curing time, the anchor holes can be drilled.

(10) Drill nine anchor holes (Fig. 41/5) through the holes of the bedplates; depth in concrete 125 mm.

(11) Insert nine resin capsules (4).

(12) Insert one threaded rod (3) into each anchor hole (5). To do this, secure the setting tool (2) in a hammer drill (1), attach the threaded rod, and insert it in the anchor hole at max. 750 r.p.m. The threaded rod is set correctly if the resin is completely mixed and the anchor hole in the concrete is completely filled to the upper edge. If the anchor hole is not completely filled, the threaded rod must be pulled out again immediately and a new resin capsule inserted.

(13) Allow the resin to cure.
The curing time is as follows:

Temperature		Time:
293 K	(+20 °C)	20 minutes
283 K	(+10 °C)	30 minutes
273 K	(0 °C)	1 hour
268 K	(–5 °C)	5 hours

(14) Mount the hexagon nuts (6) together with washers and tighten the hexagon nuts with a torque wrench in diagonally opposite sequence, increasing the tightening torque to the specified value in several stages (M_A = 80 Nm).

Retighten the hexagon nuts (6) after 100 hours of operation.

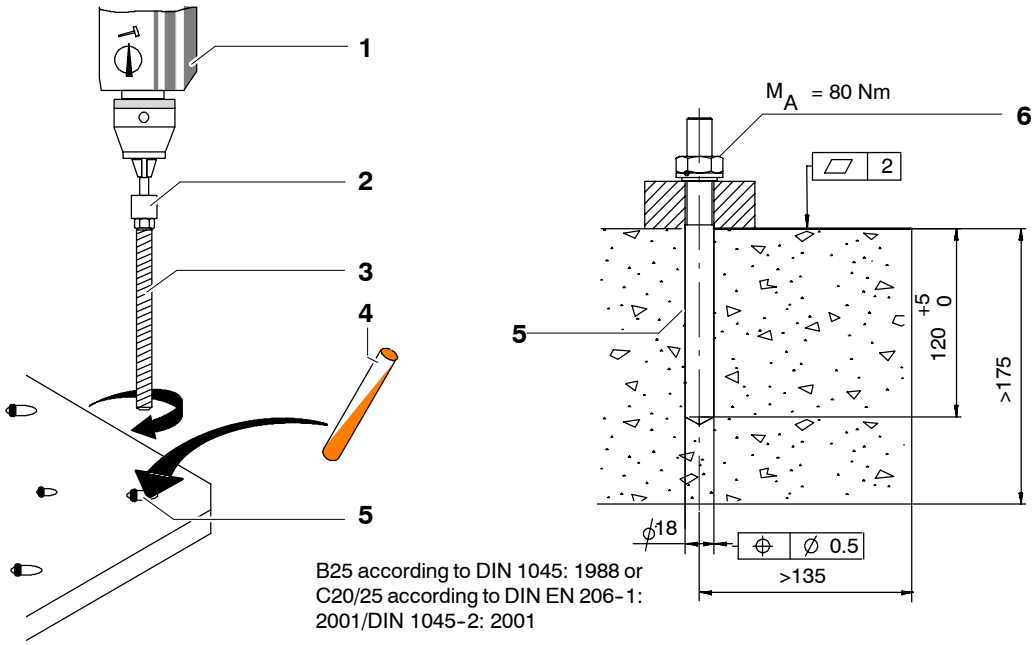


Fig. 41 Installation with resin-bonded anchors

The manipulator is now ready for connection to the controller. If the bedplates were positioned using the drilling template, this must be removed and the manipulator installed as described in Section 7.6.1.

7.4 Machine frame mounting

The machine frame mounting is used to install the manipulator on a customer-provided steel structure. Fig. 42 shows the components of this mounting base. Fig. 43 gives the dimensions for the substructure and the orientation to the working envelope.

Features:

- Manipulator installed on a steel structure prepared by the customer or on a KUKA linear unit.
- Manipulator fastened by means of six M20x55 ISO 4017 hexagon bolts.

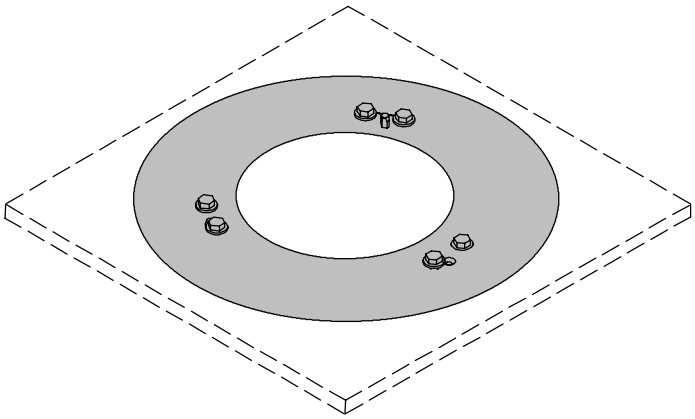


Fig. 42 Machine frame mounting

- **Installation**

(1) Prepare the mounting surfaces (Fig. 43/2) on the steel structure in accordance with Fig. 43.

The maximum permissible difference in level between the individual mounting surfaces (2) is 0.5 mm.

(2) Prepare six M20 tapped holes for the fastening screws (3) and two locating holes for the locating pins (1, 4).

(3) Insert the locating pins (1, 4).

The position of the different locating pins in relation to the working envelope is important:
Looking forwards from the manipulator towards the working envelope – the arm of the manipulator points in this direction when A1 is in its zero position – the long locating pin (1) must be on the left and the short locating pin (4) must be situated on the right.

The intended installation position of the manipulator, i.e. the correct orientation in relation to the working envelope (Fig. 38/1), must be taken into account when drilling the holes.

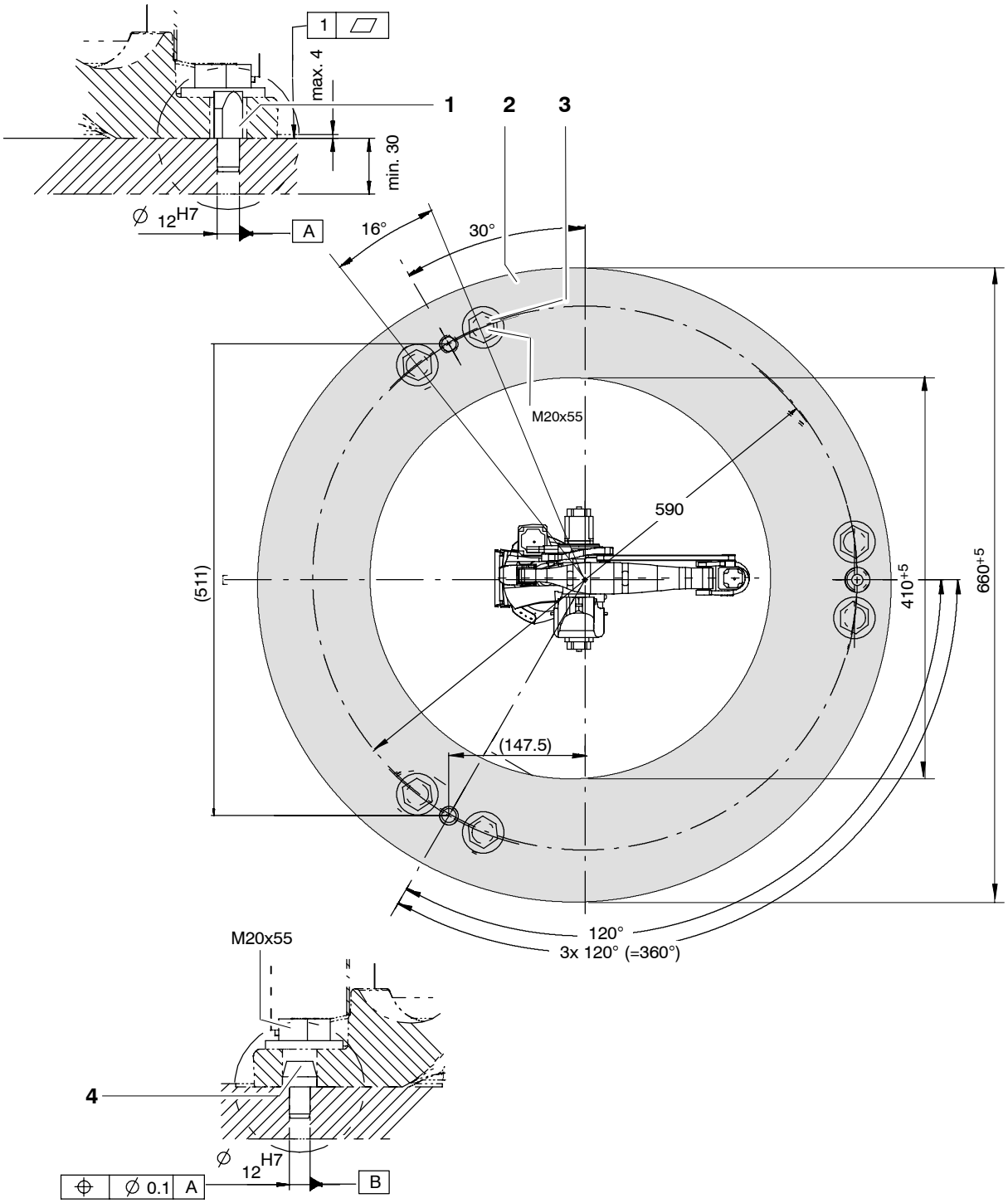


Fig. 43 Machine frame mounting, connecting dimensions

The steel foundation is now ready for the installation and connection of the manipulator. This is carried out in accordance with the procedures given in Section 7.6.1.

7.5 Adapter plate

Features:

- For floor-mounted manipulators.
- Manipulator installed on steel structure or a KUKA linear unit.
- Easy removal and installation with optimum repeatability of the installation position.

Accessory: Machine frame mounting

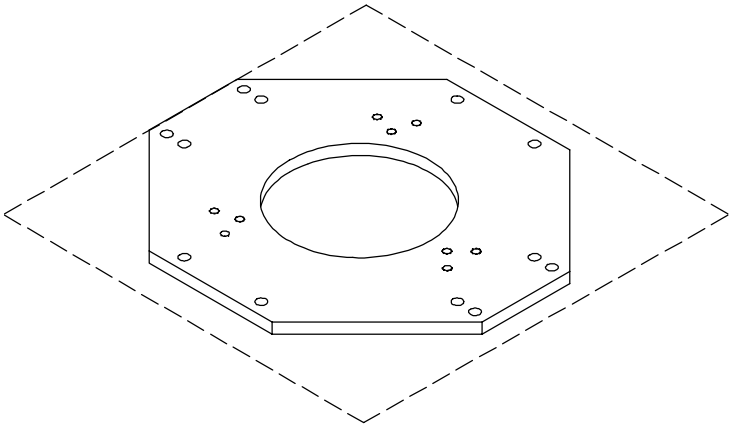


Fig. 44 Adapter base plate

The adapter plate is mounted and screwed onto a substructure that is prepared by the user. It must be ensured that the substructure is able to withstand safely the loads specified in Fig. 35.

- **Installation**

  (1) Prepare the substructure in accordance with Fig. 45.

  (2) Bring the adapter plate (1) to the site of installation, set it down and align it.

  (3) Insert eight M24x60 ISO 4017 Allen screws (4) and tighten them with a torque wrench.

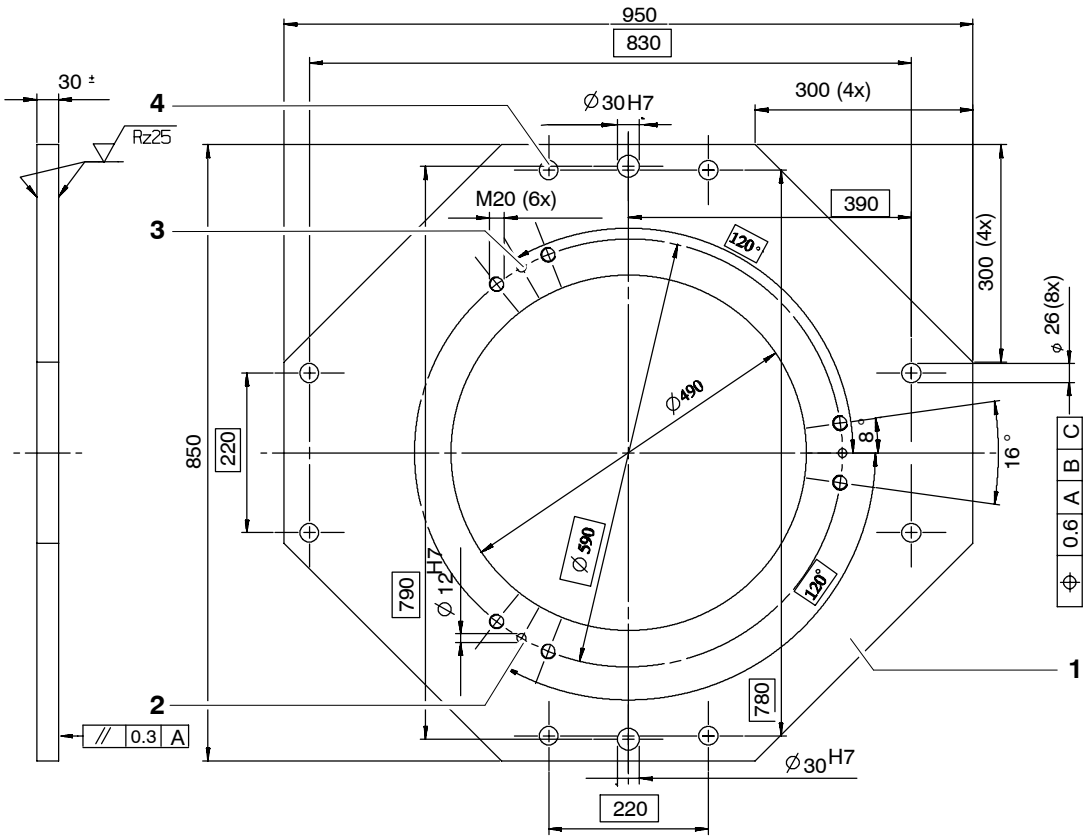


Fig. 45 Adapter plate, connecting dimensions

(4) Insert the locating pins (2, 3).

The steel foundation is now ready for the installation and connection of the manipulator. This is carried out in accordance with the procedures given in Section 7.6.1.

7.6 Installation

7.6.1 Installation

This description applies to all mounting variants for floor-mounted manipulators only. If the robot is to be installed on the floor in an inclined position, KUKA must be consulted beforehand.

The procedure for carrying out the work (whether for the first time or as an exchange) is as follows:

(1) Check that the locating pins (Fig. 46/1) are undamaged and fitted securely.

Damaged locating pins must be replaced by new ones.

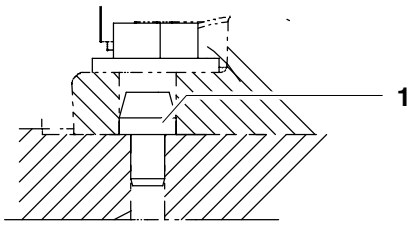


Fig. 46 Locating pins

(2) Move the manipulator into its transport position.

A1	A2	A3	A6
0°	−120°	+145°	0°

All angles are specified relative to the electrical "zero position" or to the KCP display.

G = 695 kg

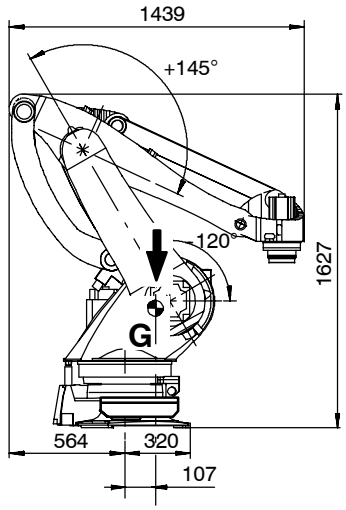


Fig. 47 Transport position

(3) Lift the manipulator with fork lift truck or lifting tackle.

For reasons of safety, it is imperative for the lifting tackle to be attached to the manipulator at the specified points. Risk of injury!
The transport instructions in chapter 6, “Transportation” must be observed.

If the manipulator is transported by fork lift truck, the forks must be placed in the slots in the base frame. It is forbidden to pick up the manipulator in any other way using a fork lift truck!

(4) Lower the manipulator (Fig. 48/5) vertically onto bedplates (4) or steel structure. If lifting tackle is used, particular care must be taken to ensure exact vertical positioning in order to avoid damaging the pins during this operation.

As the manipulator is lowered, the boreholes (2) must be aligned as accurately as possible with the two pins (3). If this operation is carried out inaccurately, it is more likely that parts will be damaged.

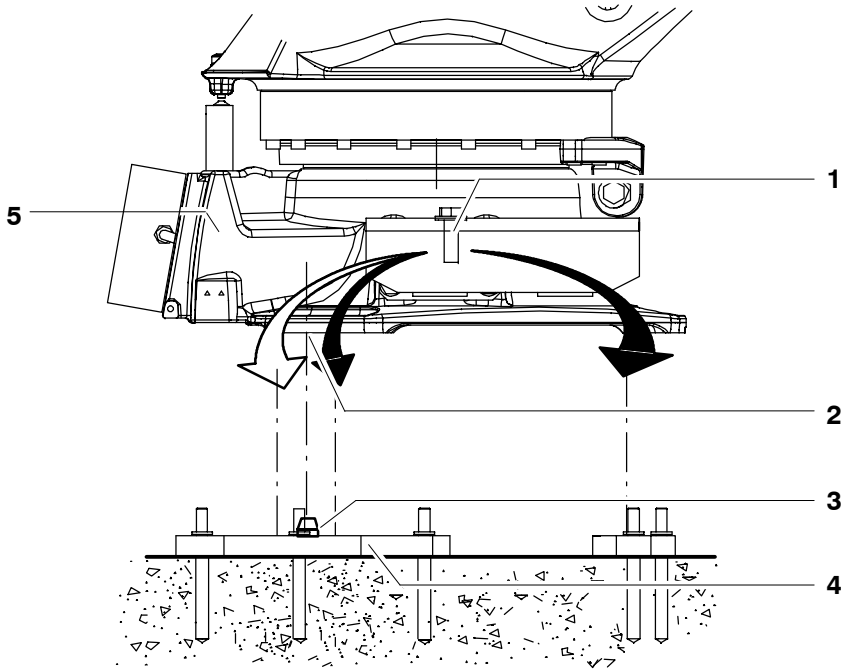


Fig. 48 Installing the manipulator

(5) Insert six M20x55 ISO 4017 hexagon bolts (1) together with washers and tighten them with a torque wrench in diagonally opposite sequence, increasing the tightening torque M_A to the specified value in several stages (M_A = 370 Nm).

Retighten the hexagon bolts after 100 hours of operation.

(6) Remove the lifting tackle if necessary.

(7) Connect the connecting cables and ground conductors (see Chapter 9, “Connecting cables”).

**Before performing the next step, it must be ensured that it is not possible for anyone to be injured within the range of the slowly moving manipulator.
The manipulator may only be moved at jog speed, with all applicable safety rules and regulations being observed.**

(8) Put the manipulator into operation and move it into a suitable position to install the end-effector and additional equipment.

Turn main switch on the manipulator control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

(9) Install the end-effector and additional equipment.

(10) Connect the electric cables and hose lines to the interfaces of the energy supply system A1 and all other peripheral supply lines to the manipulator, where necessary.

(11) Put the manipulator into operation.

The relevant documentation must be observed when putting the manipulator and the attached peripheral equipment into operation.

7.7 Exchange

To avoid the need for any major reprogramming after an exchange, the instructions given in the Operating Handbook, Software KR C4, Chapter “Start-up”, Section “Robot Mastering/ Unmastering” must be accurately carried out every time a robot is exchanged.

- **Removal**

Turn the main switch on the robot control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

(1) Remove the end-effector (tool) and additional equipment.

The end-effector and additional equipment have to be removed if the robot is to be replaced by another one or if they would otherwise impede the exchange work.

**Before performing the next step, it must be ensured that it is not possible for anyone to be injured within the range of the slowly moving robot.
The robot may only be moved at jog speed, with all applicable safety rules and regulations being observed.**

If the end-effector and additional equipment remain on the robot, this is liable to lead to adverse centers of gravity and collisions. The user is deemed responsible for any damage resulting in this respect.

(2) Put the manipulator into operation and move it into the transport position (Fig. 49).

A 1	A 2	A 3	A 6
0°	−120°	+145°	0°

All angles are specified relative to the electrical "zero position" or to the KCP display.

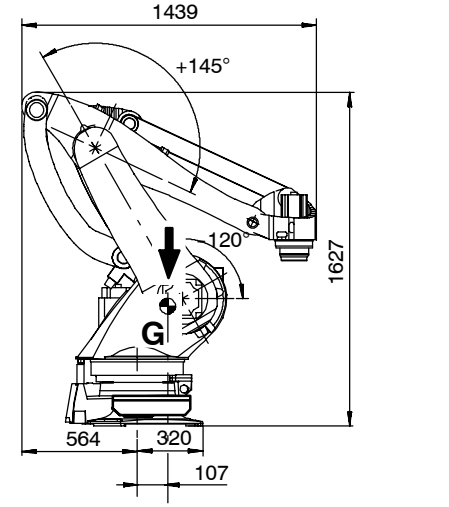


Fig. 49 Transport position

Turn the main switch on the robot control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

(3) Release and unplug all connectors of the connecting cables (Fig. 50/3).

(4) Remove the ground conductor.

(5) Remove electric cables and hose lines from the interfaces of energy supply system A1 and all other peripheral supply lines to the robot, where necessary.

Depressurize and drain hose lines beforehand.

(6) Remove six M20x55 hexagon bolts (2) and lock washers.

(7) Lift robot (1) with lifting tackle.

For reasons of safety, it is imperative for the lifting tackle to be attached to the manipulator at the specified points. Risk of injury!
The transport instructions in chapter 6, “Transportation” must be observed.

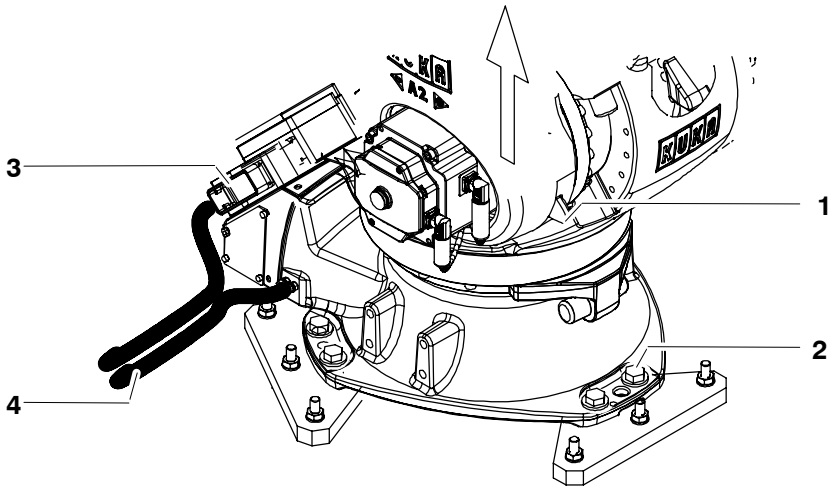


Fig. 50 Removal

The robot can also be lifted off and transported using the fork lift truck.

The robot must be lifted as vertically as possible until the locating pins are free.

(8) Lower the robot onto a suitable support.

If the robot is not to be reinstalled for some time, it must be protected against corrosion before being put into storage.

- **Installation**

  See Section 7.6.1.

8 Electrical installations

This description applies analogously to all of the industrial robots listed in Chapter 1, regardless of the variant or model shown in the illustrations.

The electrical installations of the manipulator form a separate assembly. It includes the “cable set” (Fig. 51), containing all the electric cables (Fig. 53 to Fig. 61). The cable set has plug-and-socket connections so that exchanges can be quickly carried out. This dispenses with the need for wiring work.

The arrangement, designation and allocation of the cables may be noted from the various diagrams. The connectors are provided with identification labels. The ground conductors are fastened with cable lugs to threaded bolts.

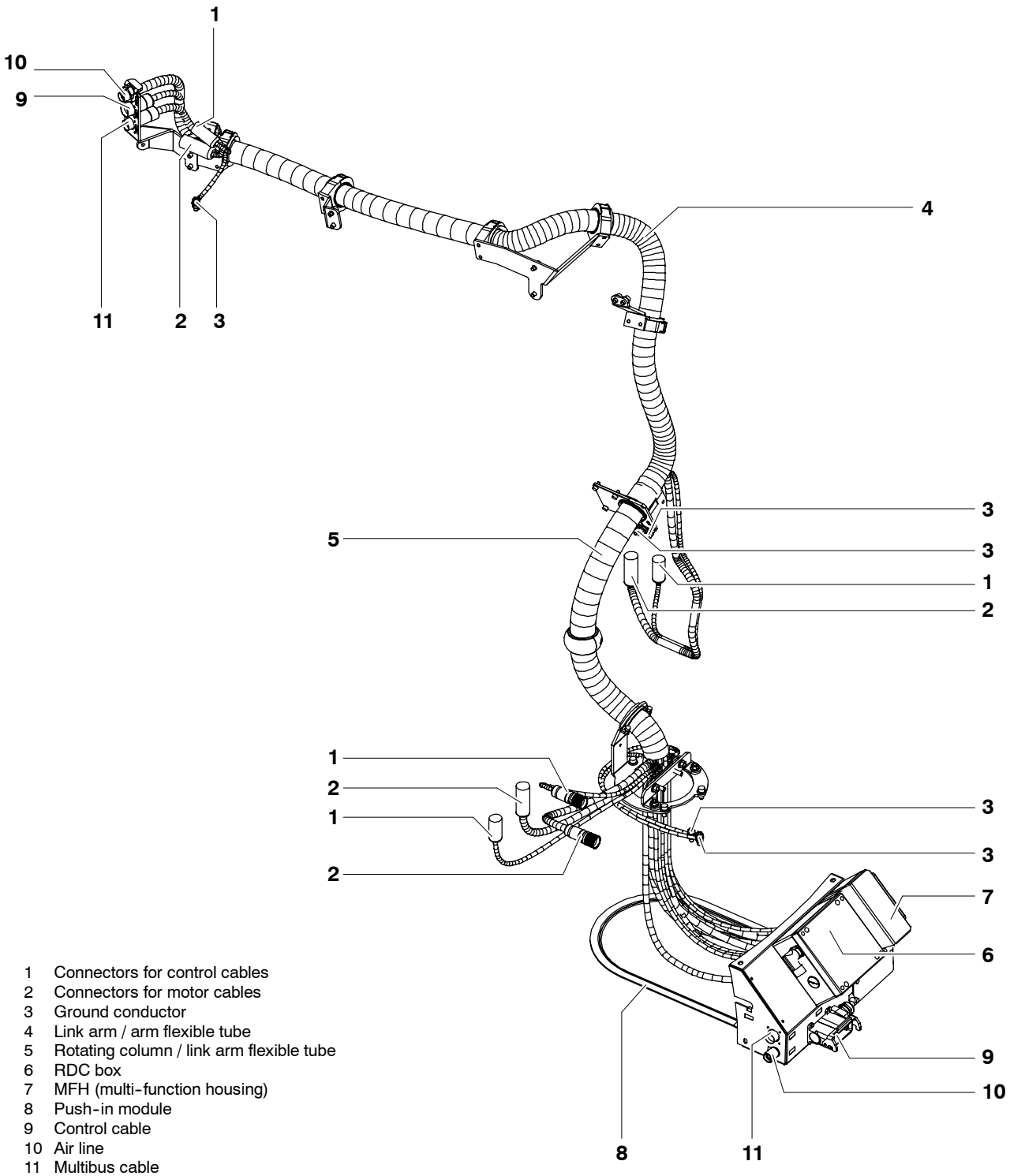
8.1 Description

Installed on the base frame are the push-in module (Fig. 51/8) with the RDC box (6) and the MFH (multi-function housing) (7). The motor cables for axes 1, 2, 3 and 6 are grouped together in the MFH and are wired up to a rectangular flange-mounted connector. This connector is at the same time the connector on the manipulator for the connecting cable (“motor cable”) between the manipulator and the control cabinet. The connector consists of four separate connector modules. The connector modules are each assigned a particular motor connector (e.g. XM1). The ground conductors (3) are connected to a ground conductor rail (Fig. 59) in the junction box (7).

The control cables for axes 1, 2, 3 and 6 are grouped together in the RDC box (Fig. 51/6) and are connected to the RDC board. Each control cable has a separate connector and can therefore be exchanged individually. The interface in the RDC box (6) with the connecting cable (data cable) between the manipulator and the control cabinet is formed by a 13-pole externally mounted socket.

The cables for the energy supply system (9, 10, 11) are mounted on the push-in module. The energy supply system cables and the electric cables are grouped together with a square clamping piece to form a cable harness and routed centrally through the rotating column. After the clamping piece, the drive cables for A1 and A3 branch off from the cable harness and are routed through the opening in the rotating column to motors A1 and A3. The remainder of the cable harness runs via the rotating column / link arm flexible tube (5) to the link arm. In the link arm the drive cables for A2 branch off downwards. The drive cables for A6 and the cables of the energy supply system are routed upwards through the link arm / arm flexible tube (4).

The cables installed in the manipulator are summarized in tabular form in Fig. 52.



1 Connectors for control cables
2 Connectors for motor cables
3 Ground conductor
4 Link arm / arm flexible tube
5 Rotating column / link arm flexible tube
6 RDC box
7 MFH (multi-function housing)
8 Push-in module
9 Control cable
10 Air line
11 Multibus cable

Fig. 51 Cable set assembly

Cable	from	to	Cable	from	to
Ground conductor 00-187-442	Bolt Push-in module	Bolt Base frame Rotating column Link arm Arm Wrist			
Motor cable A1 00-187-226	Connector X30	XM1	Control cable A1 00-187-230	Connector X1	XP1
Motor cable A2 00-187-227	Connector X30	XM2	Control cable A2 00-187-232	Connector X2	XP2
Motor cable A3 00-187-354	Connector X30	XM3	Control cable A3 00-187-356	Connector X3	XP3-L
Motor cable A6 00-187-355	Connector X30	XM6	Control cable A6 00-187-357	Connector X4	XP6
Multibus cable A1-A5 00-130-609	Connector X71	X91			
Air line 1/2", blue 00-130-655	Axis 1	Axis 5	Control cable A1-A5 00-131-963	Connector X76	X96

Fig. 52 Table of cables installed, KR 40 PA

8.2 Cabling plans and wiring diagrams

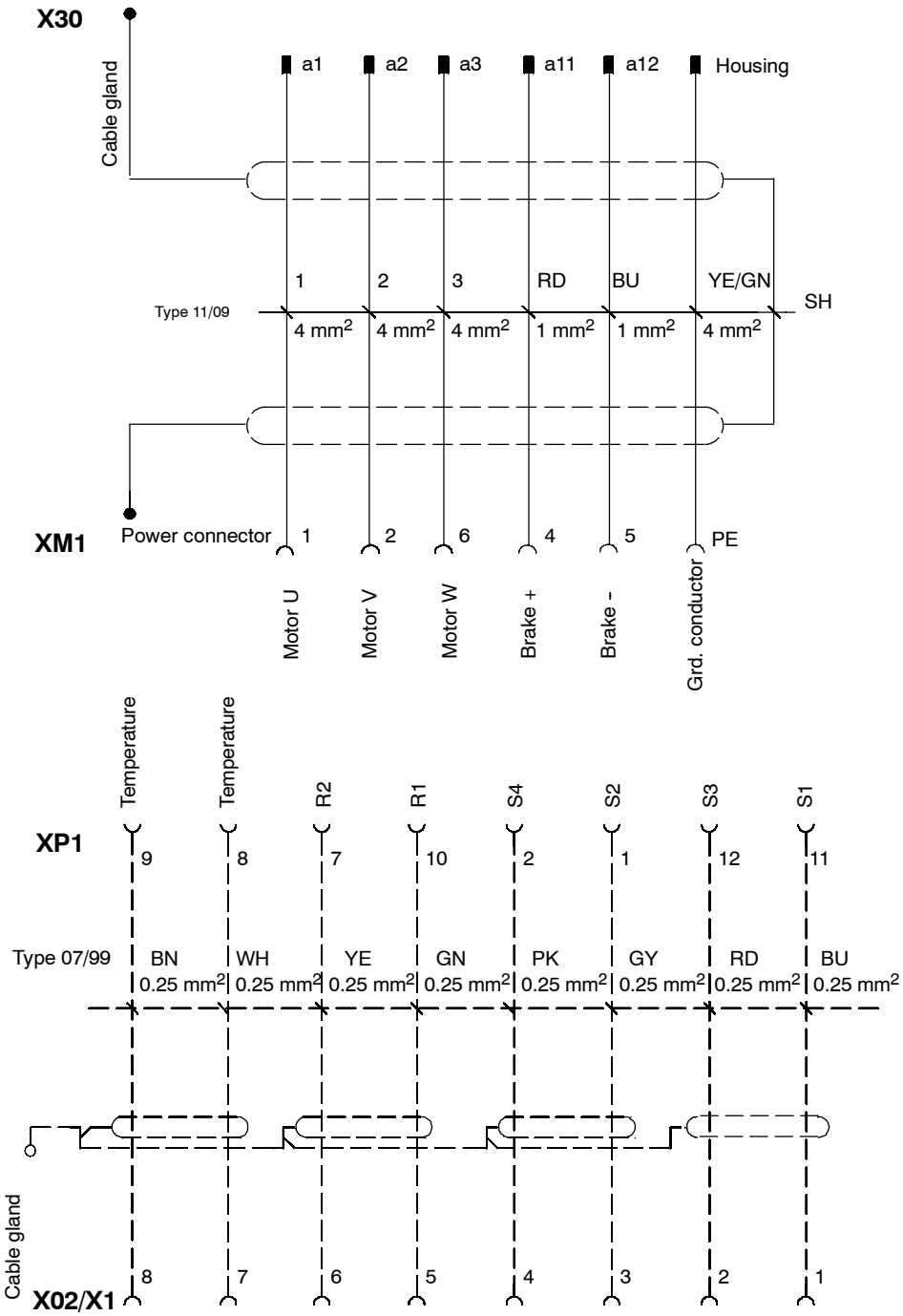


Fig. 53 Wiring diagram for drive A1

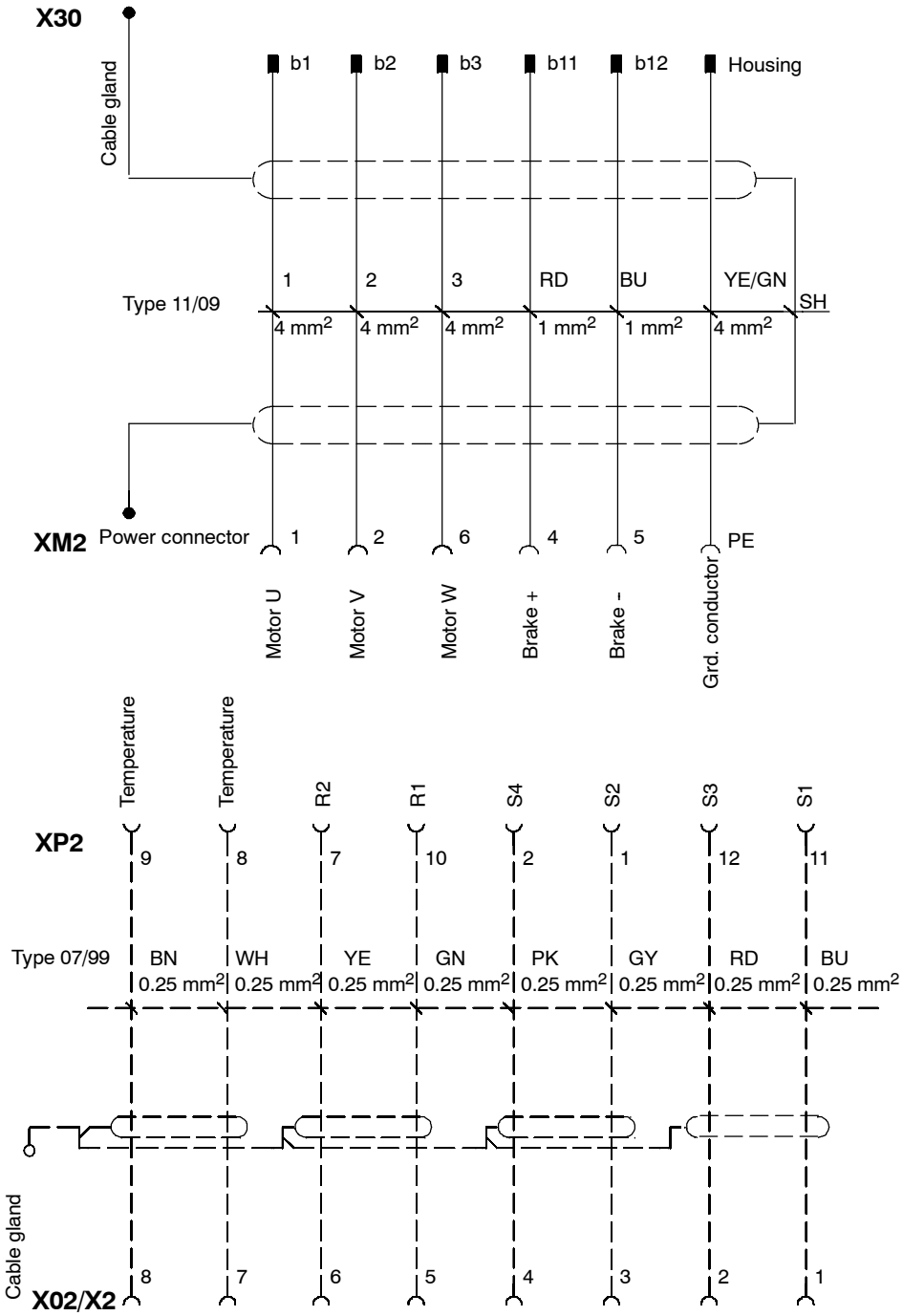


Fig. 54 Wiring diagram for drive A2

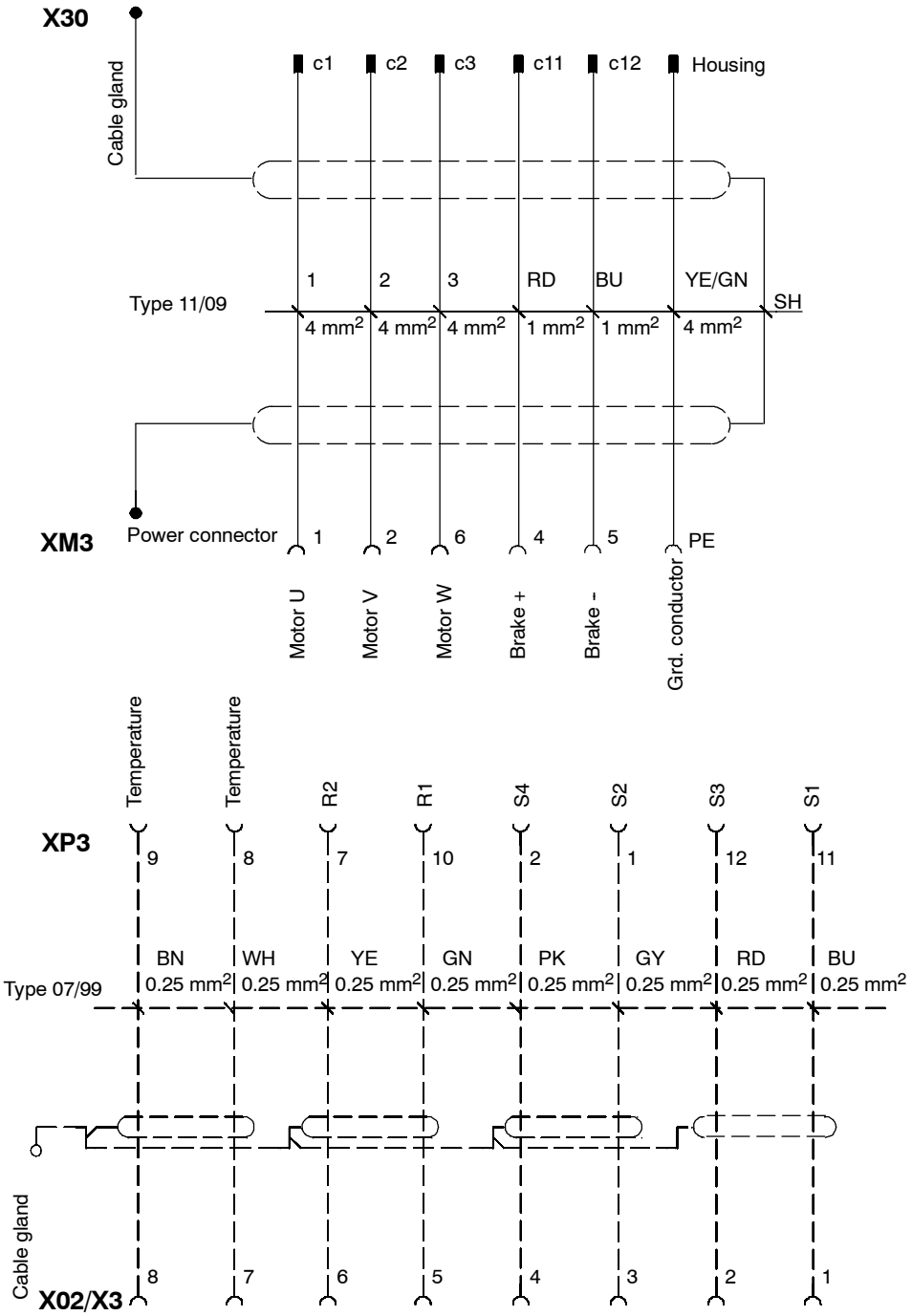


Fig. 55 Wiring diagram for drive A3

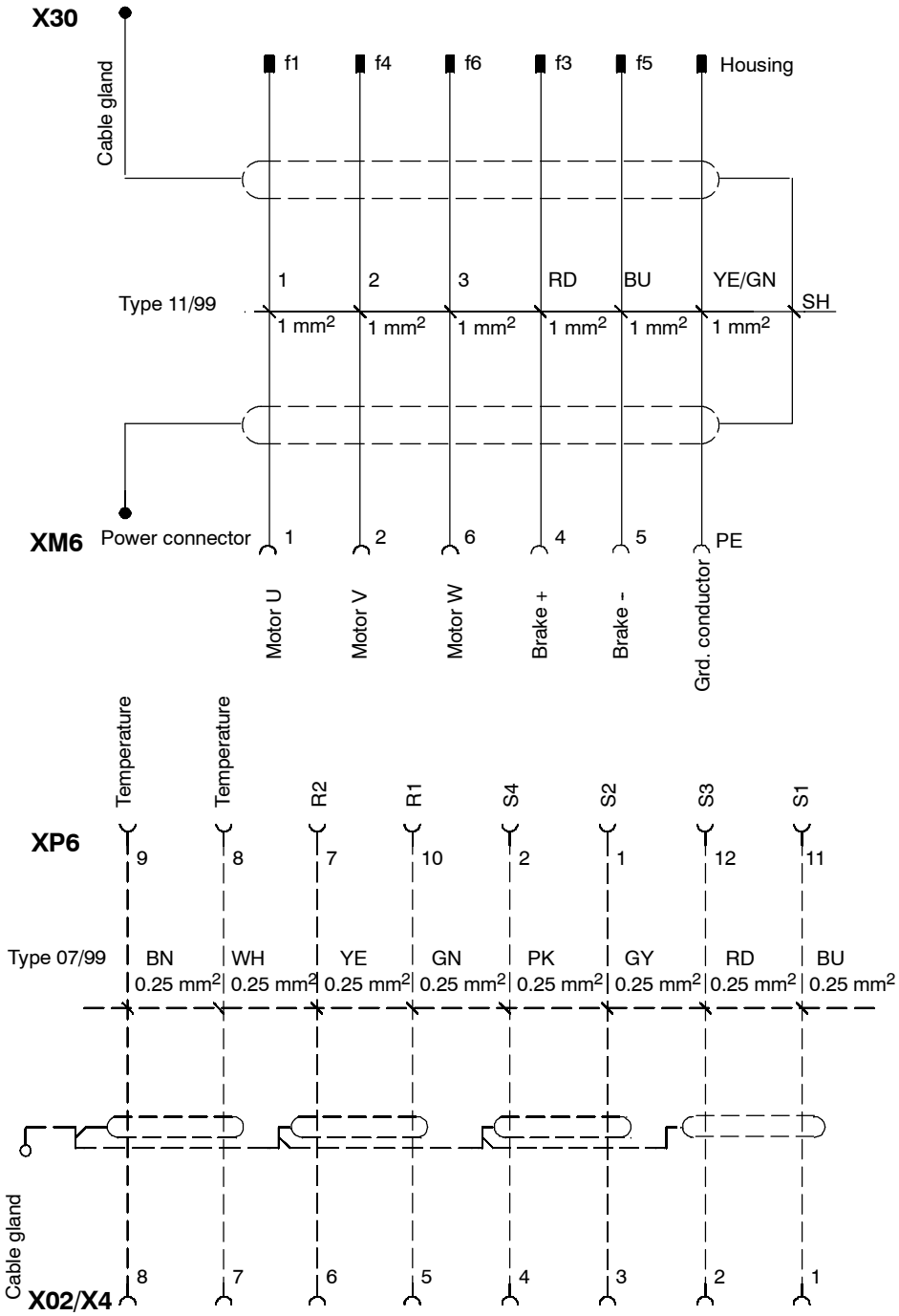


Fig. 56 Wiring diagram for drive A6

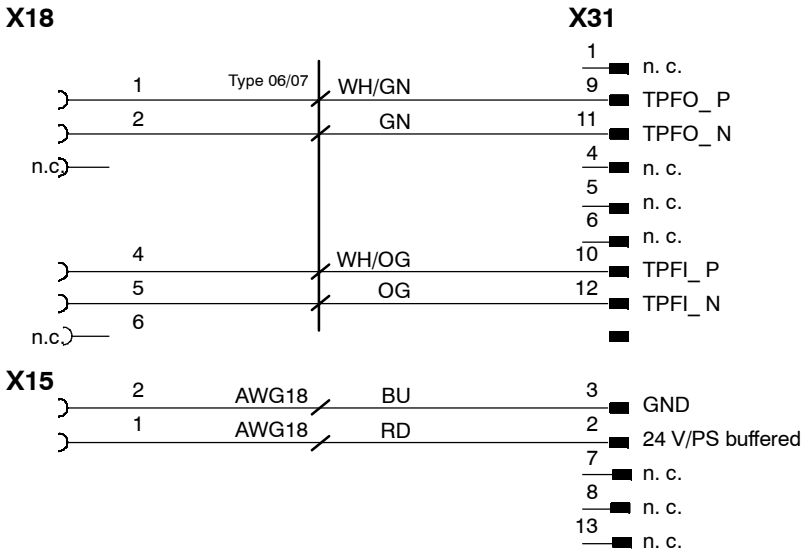


Fig. 57 Wiring diagram, RDC internal X31

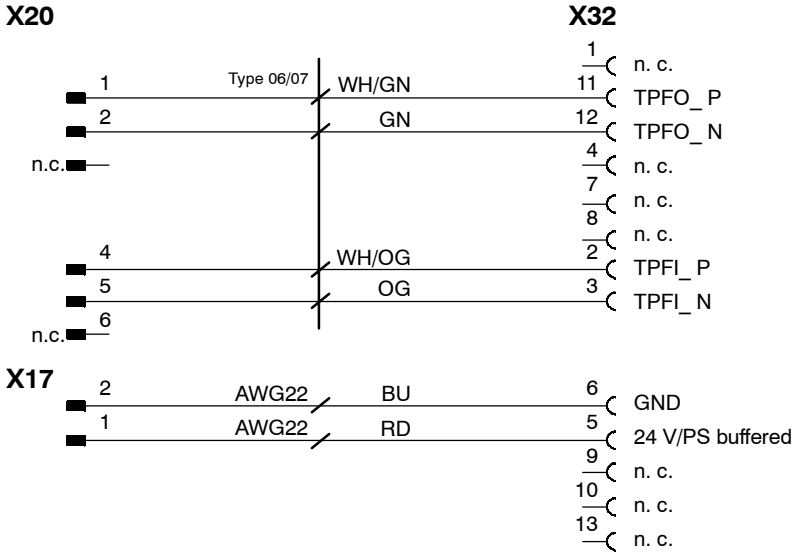


Fig. 58 Wiring diagram, RDC internal X32

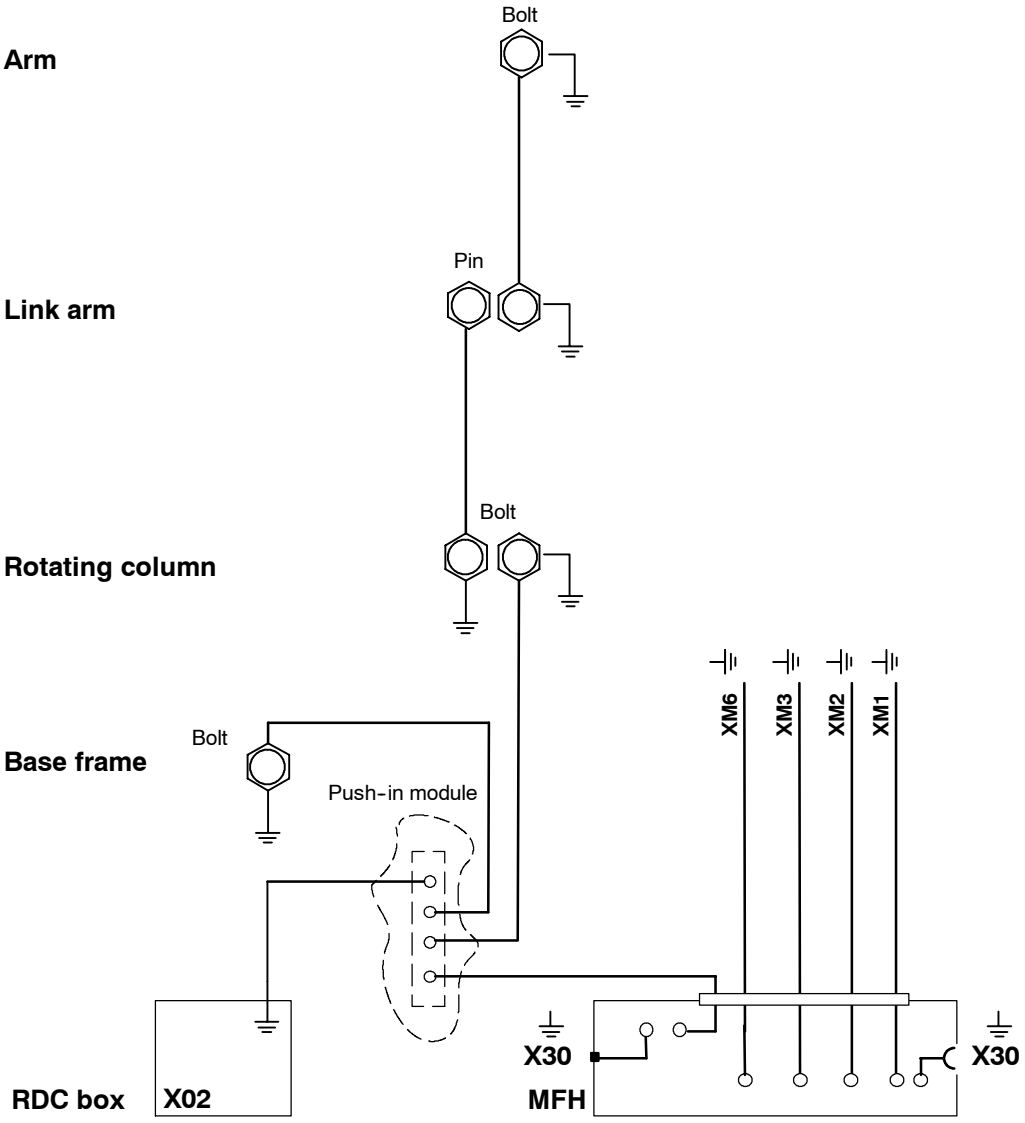


Fig. 59 Ground conductor installation, protective circuit

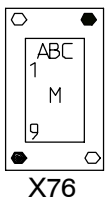
Wiring diagram

Plug	Pin	Shield Multibus a	Shield Multibus b	Wire a	Wire b	Shield Multibus a	Shield Multibus b	Pin	Plug	Signal name
X71									X91	
	7			YE	YE			7		IBS D0
	8			GN	GN			8		IBS $\overline{D0}$
	9			GY	GY			9		IBS D1
	10			PK	PK			10		IBS $\overline{D1}$
	11			GN	GN			11		Profi A
	6			RD	RD			6		Profi B
	17			RD	YE			17		CAN
	12			BU	GN			12		CAN
	13			WH	WH			13		CAN high
	14			BU	BN			14		CAN low
	2			BU	BU			2		US2 0V
	3			BN	BN			3		US2 24V
	1			BK	BK			1		US1 0V
	4			RD	RD			4		US1 24V
	5			GNYE	GNYE			5		PE
	15							15		free
	16							16		free
Housing										Connector housing

Fig. 60 Wiring diagram Multibus cable

Wiring diagram

Plug	Pin	Wire	Strip	Wire	Plug	Pin	Signal name
X76	PE	YE/GN			X96	26	Grd. conductor
	A1	1				1	Control signal
	C1	2				2	
	A2					n.c.	
	B2	3				3	
	C2	4				4	
	A3	5				5	
	B3	6				6	
	C3	7				7	
	A4	8				8	
	B4	9				9	
	C4	10				10	
	A5	11				11	
	B5	12				12	
	C5	13				13	
	A6	14				14	
	B6	15				15	
	C6	16				16	
	A7	17				17	
	B7	18				18	
	C7	19				19	
	A8	20				20	
	B8	21				21	
	C8	22				22	
	A9	23				23	
	C9	24				24	



X76

Fig. 61 Wiring diagram for control cable

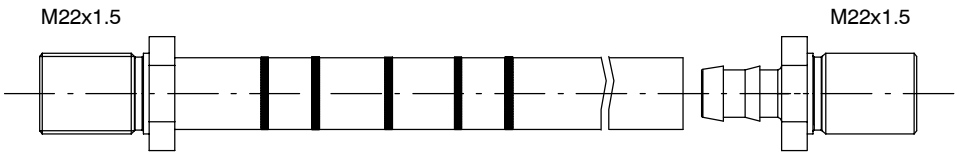


Fig. 62 Hose line

9 Connecting cables

This description applies analogously to all of the industrial robots listed in Chapter 1, regardless of the variant or model shown in the illustrations.

9.1 Description

Connecting cables are all the cables running between the robot (= manipulator) and the control cabinet (Fig. 63). They have plug-in connections at both ends. The terminal allocation of the connectors is given in Section9.6. In order to avoid the connectors being mixed up, the ends of each cable are provided with a designation label, which must match the corresponding connection point on the robot or on the control cabinet. The cable connections on the manipulator and the control cabinet are shown in Fig. 63.

The interfaces of the connecting cables are the RDC box for the data cable and the MFH (multi-function housing) for the motor cable on the robot (Fig. 65) and the connector panel on the control cabinet (Fig. 66).

The connectors must be inserted carefully to avoid damaging the contacts.

The ground conductors are fastened with cable lugs to threaded bolts. The threaded bolts are included in the scope of supply.
The ground conductors are **not** included in the scope of supply for the connecting cables, but can be ordered separately as an option.

Before the manipulator is put into operation, the continuity of the ground conductor connection between the control cabinet and the manipulator must be tested with a ground conductor measurement in accordance with DIN EN 60204-18.2 and the relevant national regulations.

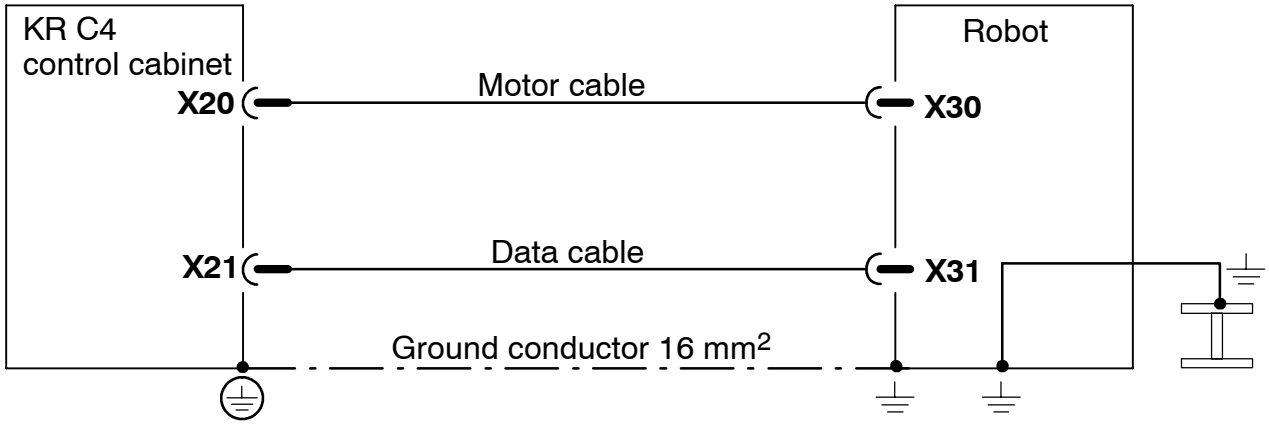


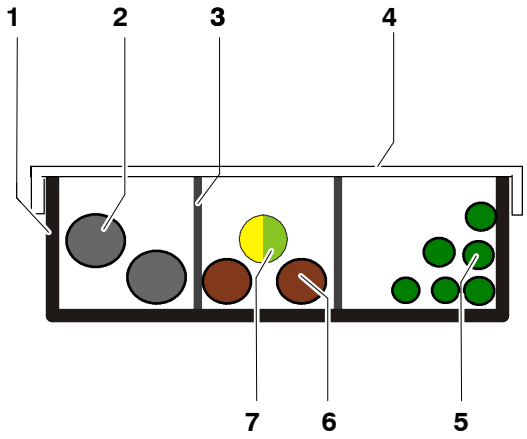
Fig. 63 Connecting cables (diagram)

9.2 Routing of cables

The following points must be observed when routing the cables:

- Bending radius of the cables for fixed installation
  - Motor cable 150 mm
  - Control cable 60 mm

  must be observed
- Protect cables against exposure to mechanical stress.
- Route the cables without tension (no tensile forces on the connectors).
- Cables are only to be installed indoors.
- Observe permissible temperature range (fixed installation) 263 K (–10 °C) to 328 K (+55 °C).
- Route the motor cables and the control cables separately in metal ducts (Fig. 64); if necessary, additional measures must be taken to ensure electromagnetic compatibility (EMC).



1 Cable duct
2 Welding cables
3 Separating web
4 Cover
5 Data cables
6 Motor cables
7 Equipotential bonding conductor 16 mm²

Fig. 64 Routing of cables in cable ducts

9.3 Junction boxes on the manipulator

The plug-in connections on the robot are located on the multi-function housing on the base frame for the motor cable, and on the RDC box for the data cable. The allocation of the junction boxes to the respective connectors for the different manipulators may be noted from Fig. 65.

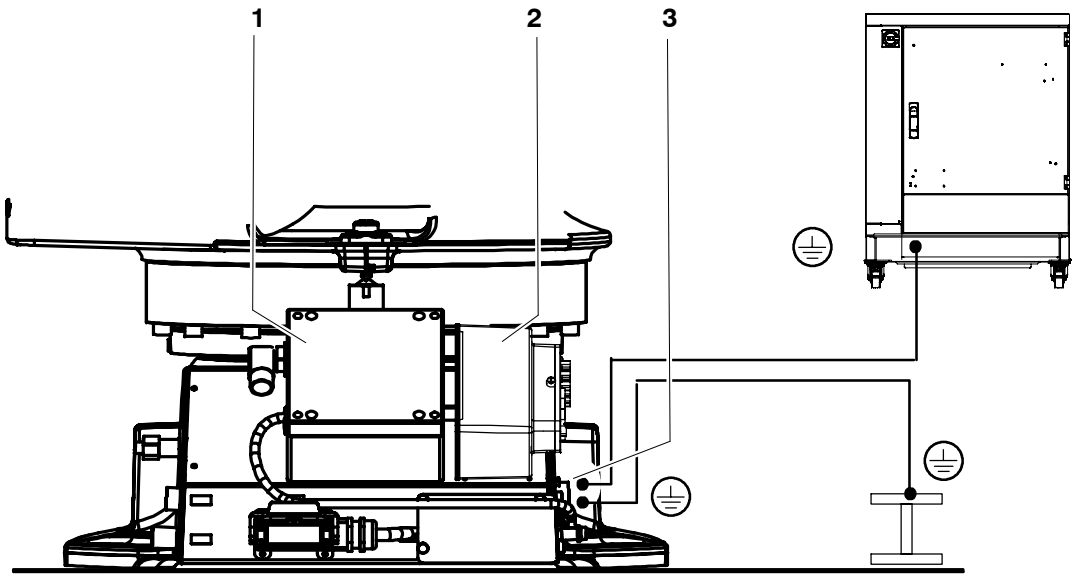
Equipotential bonding (ground conductor) between control cabinet and manipulator must be established using M8 PE bolts. The user of the robot is responsible for ensuring that this is implemented correctly.

The ground conductor is **not** part of the connecting cable set assembly, but can be ordered as an option.

9.3.1 Coding

Motor cable:
Connectors X20 and X30 are each fitted with two coding pins, which prevent them from being used incorrectly.

Data cables:
In the case of the data cable, coding is achieved by the shape of the connector and the pin configuration.



1 RDC box
2 MFH, multi-function housing
3 Ground conductor connection

Fig. 65 RDC box and multi-function housing

9.4 Connector panel on the control cabinet

The connector panel (Fig. 66) is accessed by opening the door to the cabinet.

The connected cables are routed under the control cabinet to the rear.

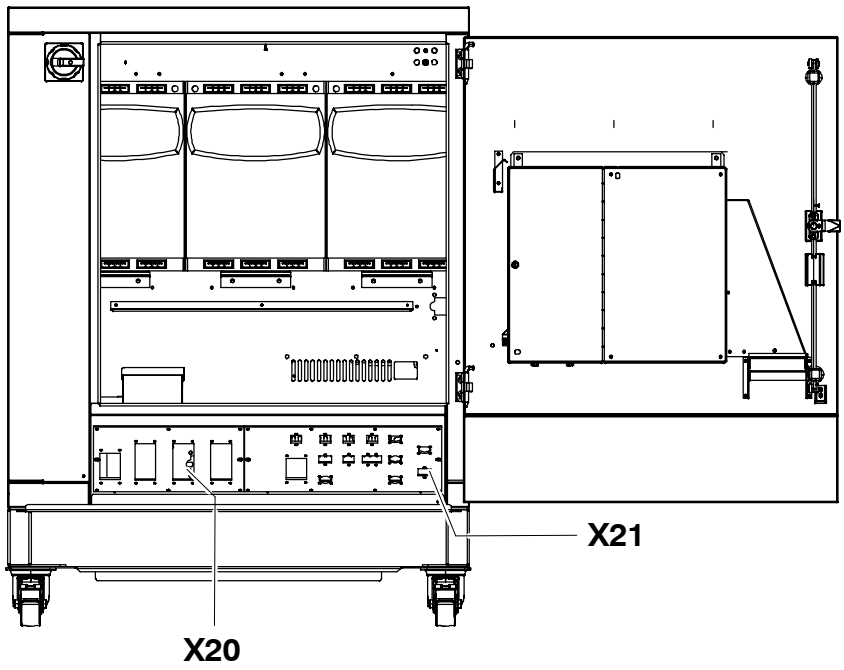


Fig. 66 Connector panel on the control cabinet

9.5 Configuration of the connecting cables

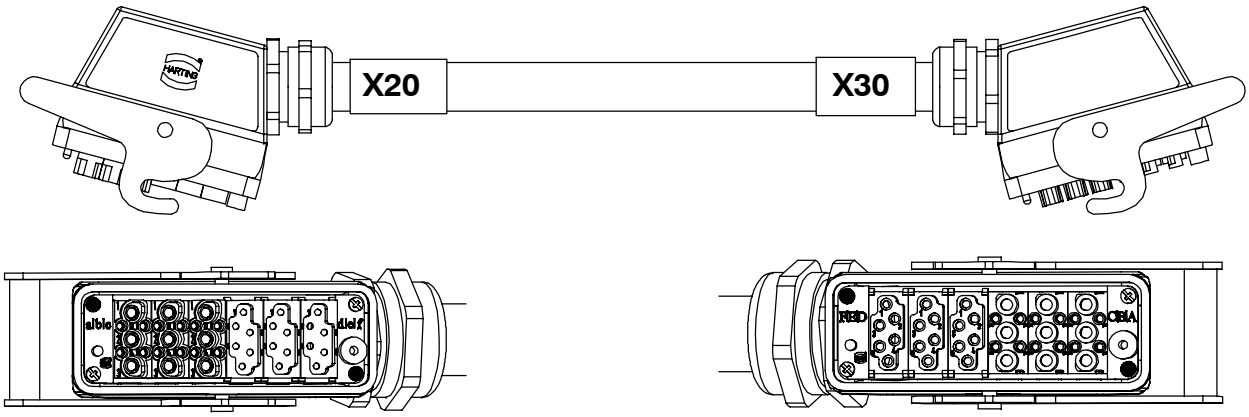


Fig. 67 Motor cable

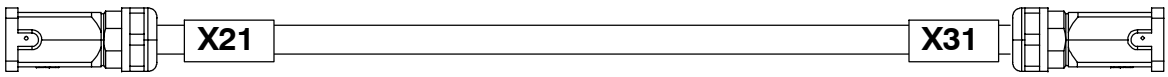
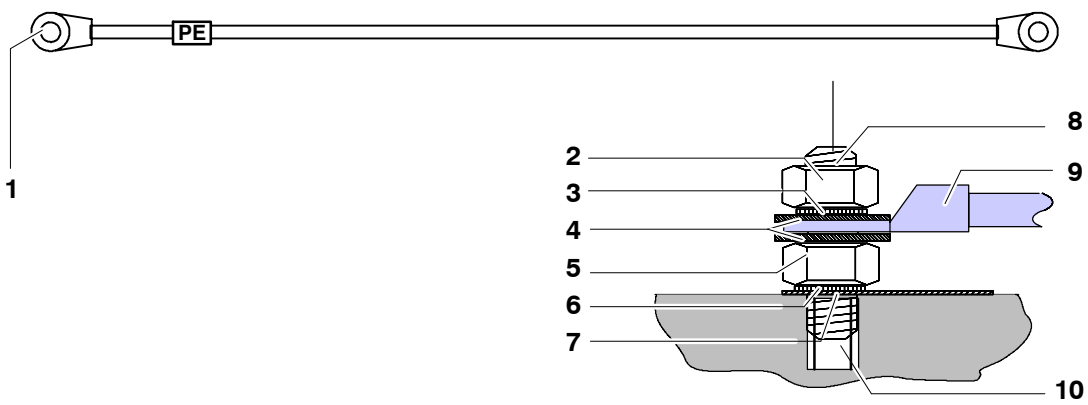


Fig. 68 Data cable



1	M8 ring cable lug	6	Conical spring washer
2	M8 nut	7	Ground plate
3	Conical spring washer	8	PE bolt
4	8.4 washer	9	Cable lug
5	M8 nut	10	M8 tapped hole

Fig. 69 Ground conductor

9.6 Wiring diagrams

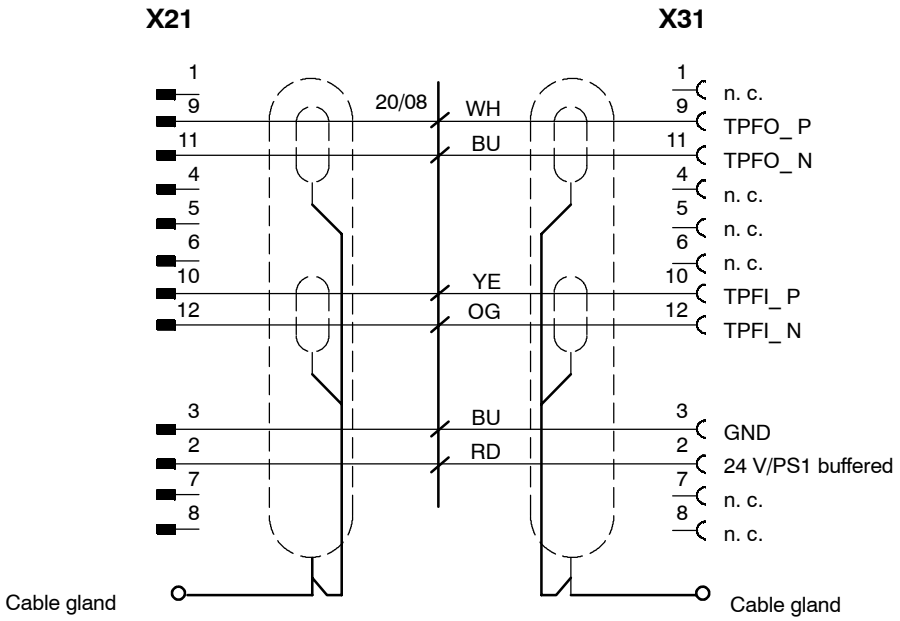


Fig. 70 Data cable X21

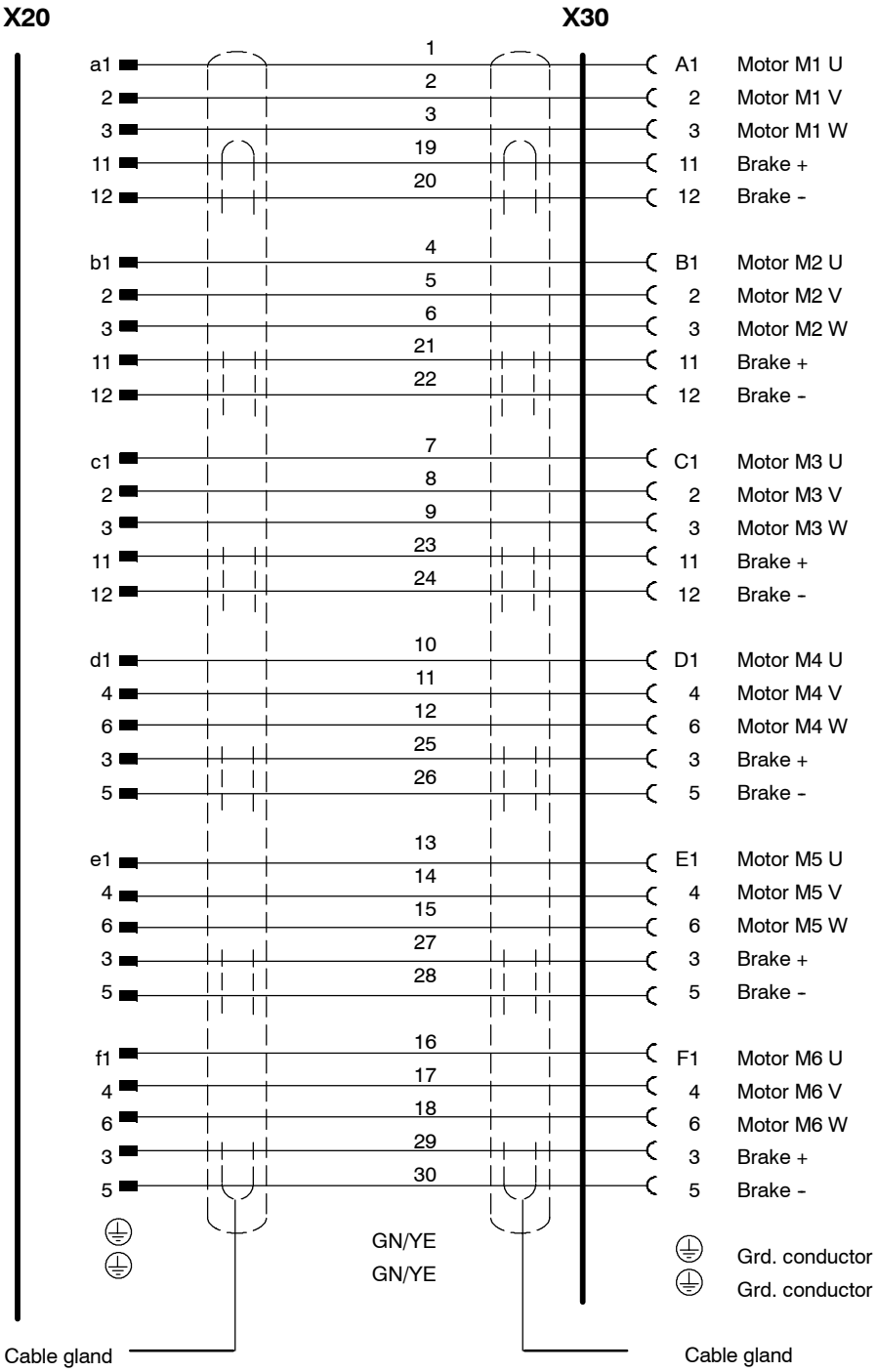


Fig. 71 Motor cable X20

10 Maintenance work

This description applies analogously to all of the industrial robots listed in Chapter 1, regardless of the variant or model shown in the illustrations.

10.1 General

Observe Chapter 5, “Safety”!

Turn the main switch on the robot control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again. This also applies to any cleaning work which, though not performed directly on the robot, is carried out within or close to its working range.

Before any maintenance work is started, any attached tools or additional equipment that would hinder maintenance must be dismounted.

Explanation of the symbols used in connection with maintenance intervals in the “Lubrication” and “Other maintenance”.

● means: maintenance interval

□ means: recommended maintenance

Lubrication is performed either at the specified maintenance intervals or every 5 years after commissioning by the customer – whichever is reached first.

With maintenance intervals of 20,000 hours, the first maintenance (oil change) is performed either after 20,000 operating hours or 5 years after commissioning by the customer – whichever is reached first.

It is imperative that lubrication is carried out every 5 years, as prescribed (oil ageing!).

With F-variant robots, this maintenance interval is reduced to 10,000 hours.

It is imperative that lubrication is carried out every 5 years, as prescribed (oil ageing!).

The maintenance intervals specified in the tables are valid for normal operating conditions. In case of variations from normal conditions (e.g. increased dust or water content in the environment of the robot, abnormal temperatures), KUKA Roboter GmbH must be consulted.

Explanation of symbols:

● Normal maintenance interval

① Maintenance point

Maintenance point, visible on drawing

Maintenance point, hidden on drawing

Oil change, to be repeated at specific intervals;

with indication of oil capacity

Tighten screw (nut)

Check and replace toothed belts

Visual inspection

The description of maintenance operations is subdivided into job steps with numbers in brackets appearing before them. The text which immediately follows these steps must also be read if it is specially marked by a **warning triangle** or either of the **hand symbols**. This is because many of these marked texts refer to the preceding job step.

Example:

(9) Pour the specified amount of oil into the filler hole.

Only KUKA-approved lubricants may be used.

Some of the specially marked texts refer exclusively to everything that follows – until the instruction is expressly revoked or the work is completed at the end of a section.

Example:

Turn the main switch on the robot control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

10.2 Maintenance work, robot

Please observe Section 10.1.

Turn the main switch on the robot control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

Utmost caution must be exercised when handling cable grease. The use of protective clothing (at least protective gloves, for example) is strongly recommended.
All accident prevention regulations and Chapter 5, “Safety” must be observed.

Store used oil and grease in accordance with regulations and dispose of them with minimum environmental impact.

- **“Lubrication and other maintenance work” table**

Maintenance point (see Fig. 72)		Maintenance interval (hours) 10000	20000	Activity Lubricant Manufacturer Amount KUKA Art. no.	Note
①	Gear unit with bearings A1		●	Oil change Optigear Synthetic RO 150 Optimol approx. 6.3 l [1)] KUKA Art. no. 00-144-898	Change oil as described in Section 2.2.1.
②	Bearings, swing frame, parallel kinematic system	●		Lubricate SKF LGEM2 SFK, 10 g per nipple KUKA Art. no. 00-130-761	Pump grease into nine nipples until clean grease emerges. Remove old grease. 2x on swing frame 2x on parallel arm 2x on parallel link arm 1x on coupler 2x on coupling rod
③	Bearing of the arm	●		Lubricate SKF LGEM2 SFK, approx. 10 g per nipple KUKA Art. no. 00-130-761	Pump grease into one nipple until clean grease emerges. Remove old grease.
④	Gear unit with bearings A2		●	Oil change Optigear Synthetic RO 150 Optimol approx. 1.5 l [1)] KUKA Art. no. 00-144-898	Change oil as described in Section 2.2.2.
⑤	Gear unit with bearings A3		●	Oil change Optigear Synthetic RO 150 Optimol approx. 1.5 l [1)] KUKA Art. no. 00-144-898	Change oil as described in Section 2.2.3.
⑥	Gear block A6	●		Oil change Optigear Synthetic RO 150 Optimol approx. 0.3 l [1)] KUKA Art. no. 00-144-898	Change oil as described in Section 2.1.
⑦	Robot mounting base	●		Check tightening torques for bolts and anchor nuts.	See Doc. Module “Installation, Connection, Exchange”.

● Maintenance interval

1) The oil quantities specified are the actual amounts of oil in the gear unit at first filling

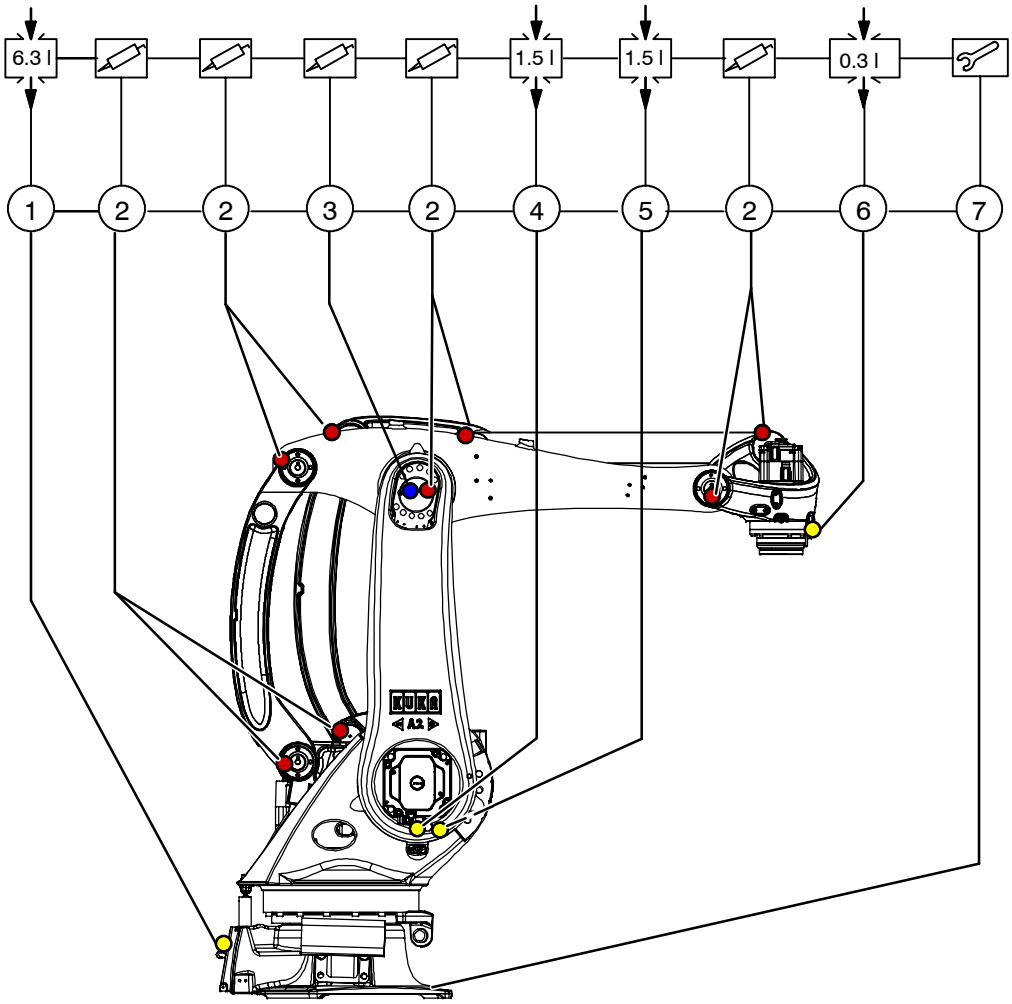


Fig. 72 Lubrication and other maintenance work

When draining the oil, it is important to remember that the quantity drained is dependent on time and temperature.
The quantity of oil drained must be measured, as only this quantity may be used when refilling. If less than 70% of the specified oil quantity flows out, flush the gear unit with the measured quantity of drained oil once, then pour in the amount of oil that was drained. During the flushing procedure, move the axis at jog velocity throughout the entire axis range.

The gear unit of axis 1 must always be flushed with the quantity of oil drained.

10.3 Oil change on wrist

Please observe Section 10.2.

The oil is to be changed only at operating temperature.

If the oil change is carried out immediately after the robot has stopped operating, the oil temperature is liable to be high, in which case appropriate safety measures must be taken.

- **Draining the oil**

Before performing the next step, it must be ensured that it is not possible for anyone to be injured within the range of the slowly rotating arm.
The robot may only be moved at jog speed, with all applicable safety rules and regulations being observed.

(1) Put robot into operation and move arm into a horizontal position (Fig. 73).

Turn the main switch on the robot control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

(2) Remove the screw plug (1).

(3) Remove screw plug (2) and catch oil as it drains out.

(4) Store used oil in accordance with the regulations and dispose of it with minimum environmental impact.

- **Filling with oil**

Turn the main switch on the robot control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

(1) Using a syringe, pump, or hose, fill the specified amount of oil upwards into the oil filler hole at (Fig. 73/2).

(2) Check sealing element of screw plug (1), insert and tighten screw plug (tightening torque M_A = 10 Nm).

(3) Check sealing element of screw plug (2), insert and tighten screw plug (tightening torque M_A = 10 Nm).

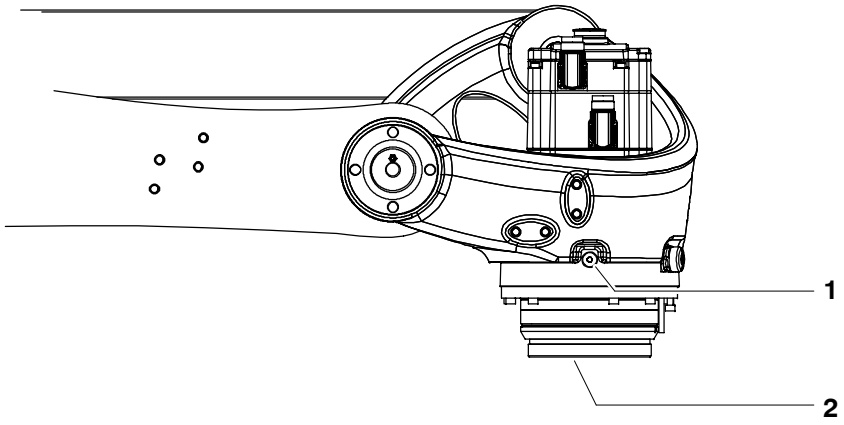


Fig. 73 Oil change on wrist

10.4 Changing the oil on main axis gear units

Please observe Section 10.2.

The oil is to be changed only at operating temperature.

If the oil change is carried out immediately after the robot has stopped operating, the oil temperature is liable to be high, in which case appropriate safety measures must be taken.

Before work is started, turn main switch on the robot control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

10.4.1 Changing the oil on axis 1 gear unit

Please observe Section 10.4.

- **Draining the oil**

(1) Remove sealing cap (Fig. 74/2) and place a suitable receptacle (3) under the oil drain hose.

(2) Remove screw plug (1) and catch the oil as it drains out.

The oil takes about 5 minutes to drain completely.

(3) Store used oil in accordance with the regulations and dispose of it with minimum environmental impact.

(4) Check sealing element of sealing cap (2), insert and tighten sealing cap (tightening torque M_A = 10 Nm).

- **Filling with oil**

(1) Pour specified amount of oil into filler hole (5). The oil level can be checked at the sight-glass (4).

Use a hose approx. 1 m long with a straight union (2) together with a funnel which fits into the free end of the hose.

(2) Check screw plug (1), insert and tighten screw plug (tightening torque M_A = 10 Nm).

(3) Check the sealing cap for leaks.

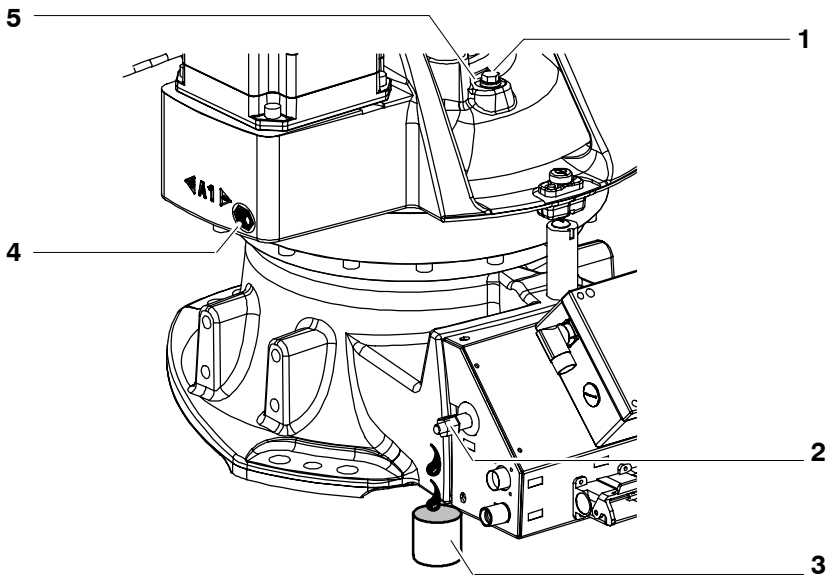


Fig. 74 Oil change on main axis A1

10.4.2 Changing the oil on axis 2 gear unit

Please observe Section 10.4.

- **Draining the oil**

(1) Remove screw plug (Fig. 75/1) and place a suitable receptacle (3) under the oil drain hose (2).

It is easier to collect the drained oil if a hose with an M10x1 connecting nipple is used at the position of the screw plug (1).

(2) Catch the oil as it drains out.

(3) Remove the screw plug (4).

The oil takes about 5 minutes to drain completely.

(4) Store used oil in accordance with the regulations and dispose of it with minimum environmental impact.

(5) Check sealing element of screw plug (1), insert and tighten screw plug (tightening torque M_A = 10 Nm).

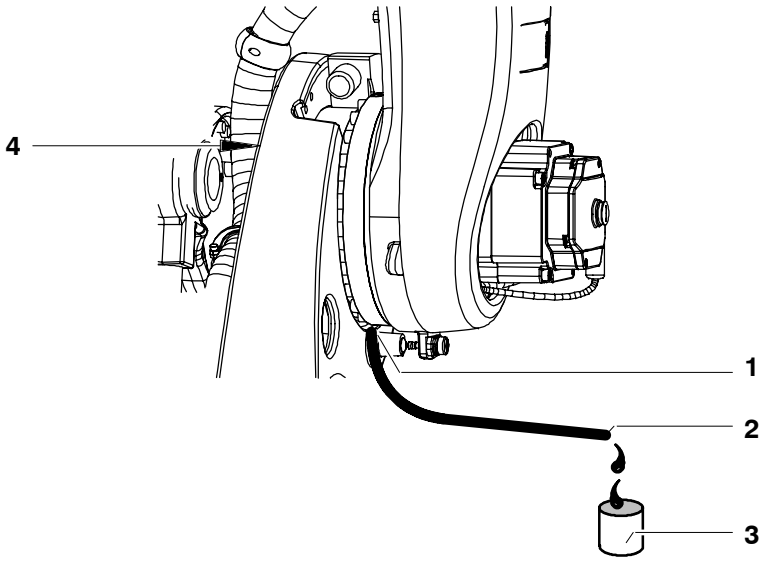


Fig. 75 Oil change on main axis A2

- **Filling with oil**

(1) Pour in specified amount of oil at (4).

Use a hose approx. 1 m long with a straight M18x1.5 union (4) together with a funnel which fits into the free end of the hose.

(2) Check sealing element of screw plug (4), insert and tighten M18x1.5 screw plug (tightening torque M_A = 20 Nm)

(3) Check the screw plug (1) for leaks.

10.4.3 Changing the oil on axis 3 gear unit

Please observe Section 10.4.

- **Draining the oil**

(1) Remove screw plug (Fig. 76/1) and place a suitable receptacle (4) under the oil drain hose (2).

It is easier to collect the drained oil if a hose with an M10x1 connecting nipple is used at the position of the screw plug (1).

(2) Catch the oil as it drains out.

(3) Remove the screw plug (4).

The oil takes about 5 minutes to drain completely.

(4) Store used oil in accordance with the regulations and dispose of it with minimum environmental impact.

(5) Check sealing element of screw plug (1), insert and tighten screw plug (tightening torque M_A = 10 Nm).

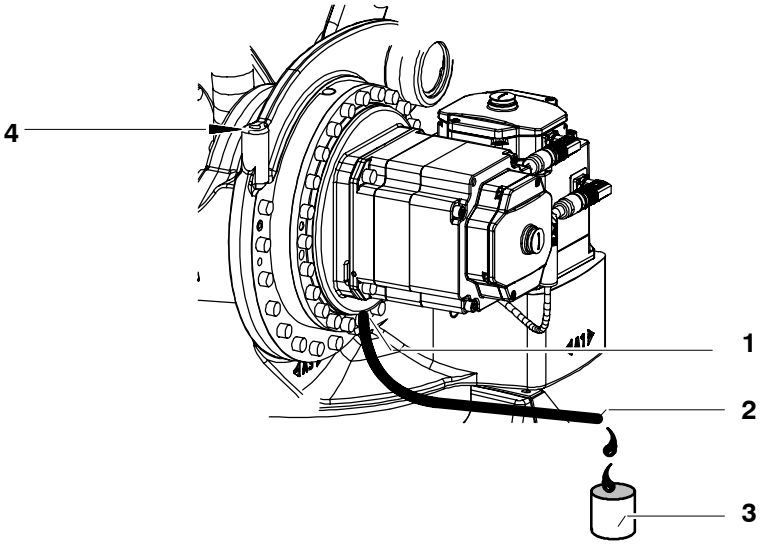


Fig. 76 Oil change on main axis A3

- **Filling with oil**

(1) Pour in specified amount of oil at (4).

Use a hose approx. 1 m long with a straight M18x1.5 union (4) together with a funnel which fits into the free end of the hose.

(2) Check sealing element of screw plug (4), insert and tighten M18x1.5 screw plug (tightening torque M_A = 20 Nm).

(3) Check the screw plug (1) for leaks.

10.5 Cleaning and preventive maintenance

Turn the main switch on the robot control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again. This also applies to any cleaning work which, though not performed directly on the robot, is carried out within or close to its working range.

Cleaning and preventive maintenance work is to be carried out in accordance with the following instructions:

- Clean robot with a cloth soaked with washing agent.
- Clean cables, plastic parts and hoses with solvent-free washing agents.
- The manufacturer’s instructions are to be observed when using washing agents.
- If washing agent does enter bearings, these must be re-greased or re-oiled.
- Remove any lubricant that has escaped using washing agent. If a large amount of lubricant has emerged, trace and remedy the cause.
- It must be ensured that no washing fluid enters bearings, seals or electrical equipment.
- Remove any corrosion and – where permissible – protect the affected areas with paint, grease or oil.
- Apply a thin coat of oil to bare metal parts.
- Replace damaged, illegible or missing inscriptions, labels and plates.

Do not use compressed air to clean the system, as this could cause dirt to penetrate and damage seals, bearings and electrical components.
Used cleaning agents and lubricants must be stored and disposed of in accordance with all pertinent regulations and with minimum environmental impact.

10.6 Safety precautions when handling lubricants

The information contained in the safety data sheet according to 91/155 EEC must be observed when handling lubricants. An excerpt from this data sheet is included in the robot Doc. Module “Consumables, Safety Data Sheet”.

The following safety procedures must be observed at all times:

- Avoid prolonged intensive contact with the skin; wear protective gloves and aprons if necessary (especially when working with cable grease).

All accident prevention regulations must be observed when handling lubricants.

- If lubricant is likely to come into contact with the skin, e.g. with the hands, suitable barrier creams must be applied before work is started.
- On completion of work and before smoking breaks or meal breaks (before any intake of food), clean oil-contaminated skin thoroughly with water and skin-friendly cleansing agents or soap. After cleaning, replace lost skin grease with appropriate skin creams containing grease.
- Change oil-soaked clothing immediately. Do not carry oily rags or any cloths soaked with solvents, mineral oil mixtures or cable grease in your pockets.
- Avoid breathing in oil spray or vapors wherever possible.

11 Adjustment

When employed for its intended purpose, this robot does not require any adjustment work on the robot arm.

12 Repair

This description applies analogously to all of the industrial robots listed in Chapter 1, regardless of the variant or model shown in the illustrations.

12.1 General

Observe Chapter 5, “Safety”!

Important repair operations for assemblies to be repaired are described in the sections. This work comprises the removal and installation of assemblies. The user’s personnel may not carry out dismantling work going beyond the scope of these operations unless they have been trained by KUKA for that particular purpose and have the necessary measuring and testing equipment at their disposal as well as the appropriate documentation.

The description of the repair work is based on the assumption that the work is carried out by skilled and appropriately trained personnel. Deviations from the specified removal and dismantling procedures are permitted, provided they are not of a fundamental nature and endanger neither equipment nor persons. No particular reference is made to safety regulations or trade association regulations; these are always to be observed and are supplemented in this manual where necessary by remarks introduced by a **warning triangle** or a **hand symbol**.

When any work is being carried out in the manipulator’s danger area, the robot must be switched off and the main switch secured with a padlock to prevent unauthorized persons from starting it up again. If this is not possible in the opinion of the user, it must be ensured that an EMERGENCY STOP pushbutton can be immediately actuated at all times.
When assemblies are removed or work is carried out on an installed manipulator, it must be ensured that the manipulator is not able to move on its own.

The description of the repair work only covers those operations that do not necessitate subsequent calibration of the manipulator.

The screw sizes and strength classes (standard strength class 8.8) specified in the sections for assemblies to be repaired are valid at the copy deadline. The specifications contained in the Parts Catalog are, however, always to be taken as the most up-to-date information.

Screws of grade 10.9 and higher may only be tightened once with the rated tightening torque. When the screws are next slackened they must be replaced with new ones.

The description of the repair operations is subdivided into job steps with numbers in brackets appearing before them. The text which immediately follows these steps must also be read if it is specially marked by a **warning triangle** or either of the **hand symbols**. Many of these marked texts refer to the preceding job step.

Example:
(5) Unscrew four hexagon screws and remove main axis motor unit.

The main axis motor unit must not be tilted while it is being lifted off.

When removing the main axis motor unit, care must be taken to avoid any injury by crushing!

Some of the specially marked texts refer exclusively to everything that follows – until the instruction is expressly revoked or the work is completed at the end of a section.

Example:

Turn the main switch on the robot control cabinet to “OFF” and secure it with a padlock to prevent unauthorized persons from switching it on again.

If it is necessary to carry out work in the area beneath a manipulator, the latter must be secured to guard against the risk of unintended motion into this area. This can be done by supporting it from below or by securing it with a rope from above.

Never work or stand under suspended loads!

12.2 Bonding instructions

When sealants, adhesives and locking agents are used, the manufacturer's directions must be strictly observed. This also applies to the cleaning of open sealing, locking and adhesion joints where the parts to be joined are to be used again.

- **Instructions for bonding components**

  (1) Wash the components with cleaning agent and blow them dry.

  (2) Wash the components with cleaning agent again and dry them with a lint-free cloth.

  (3) Apply a thin layer of adhesive to one side of the joint, assemble the components and insert the screws.

Lightly grease the screw threads in order to prevent the screws from becoming stuck.

  (4) Tighten the screws with the specified torque.

  (5) Remove any excess adhesive which has emerged from the joint.

12.3 Unbraked impact against limit stops

If the manipulator hits an obstruction or a buffer on the mechanical end stop or axis range limitation, this can result in material damage to the manipulator. KUKA Roboter GmbH must be consulted before the manipulator is put back into operation. The affected buffer must immediately be replaced with a new one.

If a manipulator collides with a buffer at more than 250 mm/s, the manipulator must be exchanged or recommissioning must be carried out by KUKA Roboter GmbH.

12.4 Removal, installation of wrist

Please observe Section 12.1.

The wrist cannot be removed and installed as a complete assembly.
In the following description, only the removal and installation of the servomotor will be described.
The wrist may not be further dismantled.

- **Removal**

If the servomotor is removed immediately after the robot has stopped operating, it is liable to have an elevated surface temperature.

(6) Release and unplug connectors XM6 (Fig. 77/4) and XP6 (3).

(7) Remove four M8x20 Allen screws (4).

(8) Lift off AC servomotor (3).

The servomotor weighs approx. 8 kg.
When lifting off the servomotor, care must be taken to avoid any injury by crushing!

The servomotor must not be tilted while it is being lifted off. The orientation of the servomotor is identified from the position of the sockets. When the motor unit is subsequently installed, these sockets must be positioned in the same way as before removal.

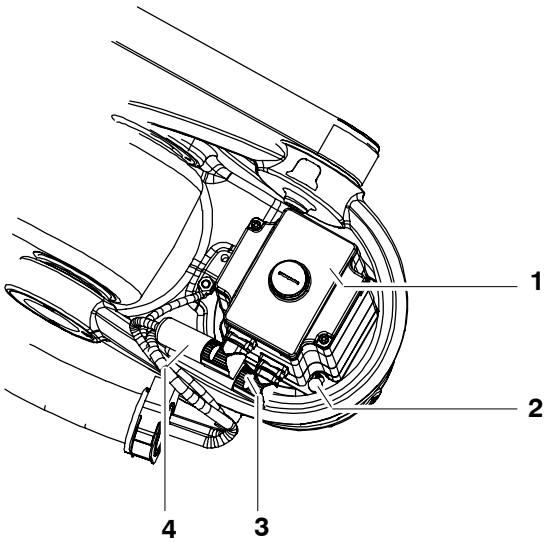


Fig. 77 Removal of AC servomotor

If the AC servomotor is not to be reinstalled, it must be protected against corrosion before being put into storage.

- **Installation**

When exchanging AC servomotors, care must be taken to ensure that AC servomotors are replaced only with those bearing the same article numbers. If the incorrect motors are installed, an error message is generated.

AC servomotors may only be installed in gear units if the toothing is undamaged on both sides of the connection.

(1) Remove all protective coatings and oil from new AC servomotor, if applicable.

(2) Clean mounting surface of AC servomotor.

(3) Clean spline shaft connection (Fig. 78/6) on gear unit and AC servomotor and apply a thin but continuous coat of Microlube GL 261.

The servomotor weighs approx. 8 kg.
When inserting the servomotor, care must be taken to avoid any injury by crushing!

(4) Insert AC servomotor (2) into swing frame (5).

When inserting the AC servomotor, it must be ensured that the spline shaft connection of the servomotor and gear unit meshes properly.
This can be facilitated by gently turning the servomotor during insertion.

The motor shaft must not be subjected to any axial loads or tilted during installation.

(5) Insert and lightly tighten the four M8x20 Allen screws (1).

(6) Tighten Allen screws (1) with a torque wrench in diagonally opposite sequence, increasing the tightening torque to the specified value in several stages (M_A= 23.9 Nm).

(7) Insert connectors XM6 (4) and XP6 (3).

(8) Carry out zero adjustment (see Operating Handbook, Software KR C4, Chapter “Start-up”, Section “Robot Mastering/Unmastering”).

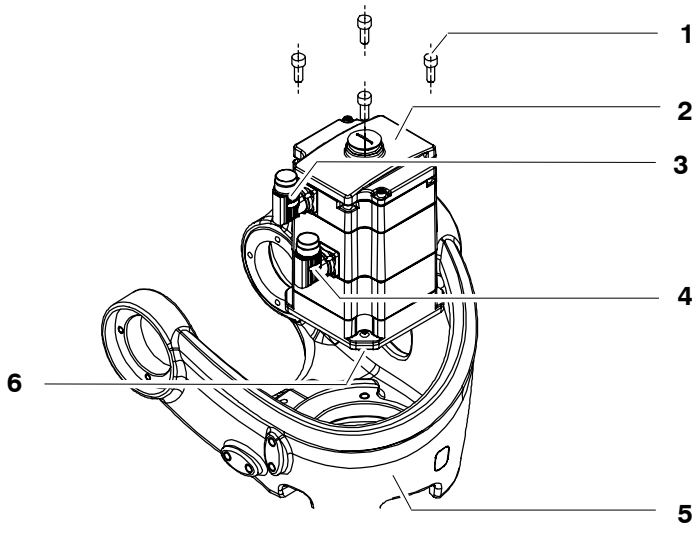


Fig. 78 Installation of servomotor

12.5 Removal, installation of servomotors

When exchanging servomotors, care must be taken to ensure that servomotors are replaced only with those bearing the same article numbers. If the incorrect motors are installed, an error message is generated.

Servomotors may only be installed in gear units if the toothing is undamaged on both sides of the connection.

12.5.1 Removal, installation of servomotor A1

Please observe Section 12.1.

- **Removal**

If the servomotor is removed immediately after the robot has stopped operating, it is liable to have an elevated surface temperature.

(9) Release and unplug connectors XM1 (Fig. 79/1) and XP1 (2).
(10) Unscrew four M12x25 Allen screws (3).
(11) Lift out servomotor A1 (4).

The servomotor weighs approx. 23 kg.
When lifting off servomotor A1, care must be taken to avoid any injury by crushing!

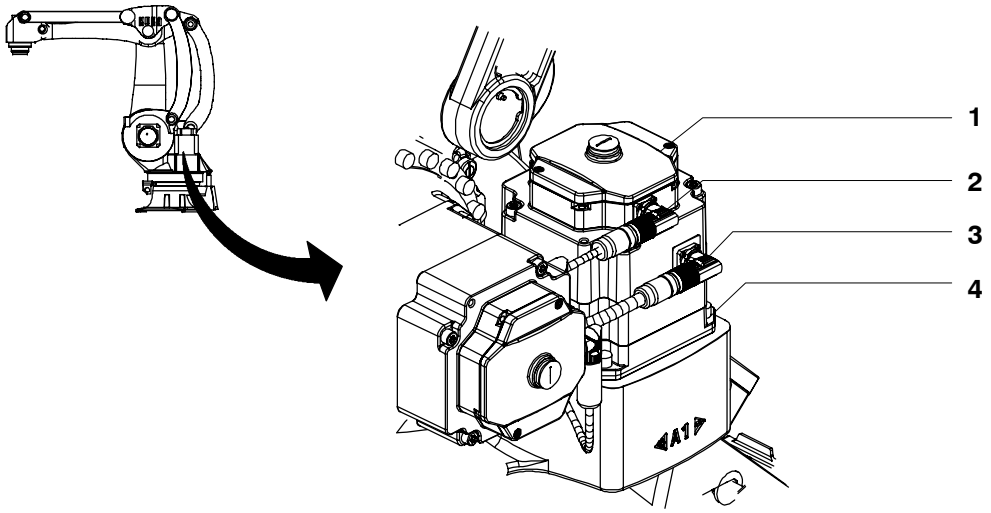


Fig. 79 Removal of servomotor A1

If servomotor A1 is not to be reinstalled, it must be protected against corrosion before being put into storage.

- **Installation**

(1) Remove all protective coatings and oil from new servomotor, if applicable.

(2) Clean mounting surface (Fig. 80/4).

(3) Clean spline shaft connection (3) on gear unit and servomotor and apply a thin but continuous coat of Microlube GL 261.

(4) Install servomotor (Fig. 80/4).

The servomotor weighs approx. 23 kg. When installing the servomotor, care must be taken to avoid any injury by crushing!

When inserting the servomotor, it must be ensured that the spline shaft connection of the servomotor and gear unit meshes properly. This can be facilitated by gently turning the servomotor during insertion.

The motor shaft must not be subjected to any axial loads or tilted during installation.

Servomotors may only be installed in gear units if the toothing is undamaged on both sides of the connection.

(5) Insert four M12x25 Allen screws (1).

(6) Tighten Allen screws (1) with a torque wrench in diagonally opposite sequence, increasing the tightening torque to the specified value in several stages (M_A= 78 Nm).

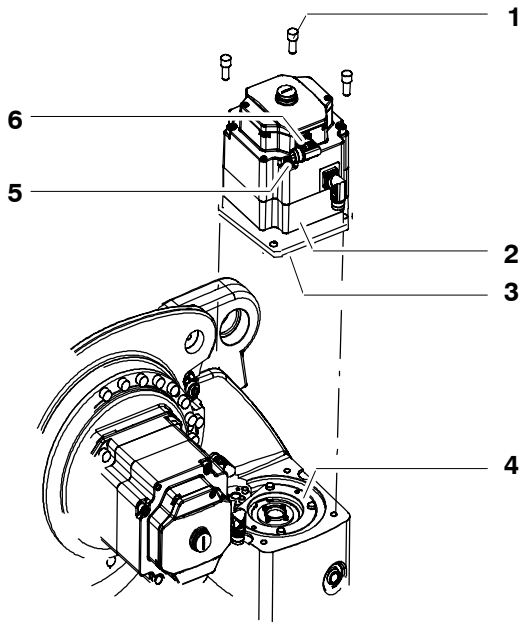


Fig. 80 Installation of servomotor A1

(7) Insert connectors XM1 (5) and XP1 (6).

(8) Carry out zero adjustment (see Operating Handbook, Software KR C4, Chapter “Start-up”, Section “Robot Mastering/Unmastering”).

12.5.2 Removal, installation of servomotor A2

Please observe Section 12.1.

- **Removal**

If the servomotor is removed immediately after the robot has stopped operating, it is liable to have an elevated surface temperature.

(1) Secure link arm by suitable means, e.g. with lifting tackle (Fig. 81) or propped from below.

When securing the robot, the lifting tackle must be attached in such a way that the arm and parallel arm are not damaged.
The link arm must not be able to move either during or after removal of the servomotor.

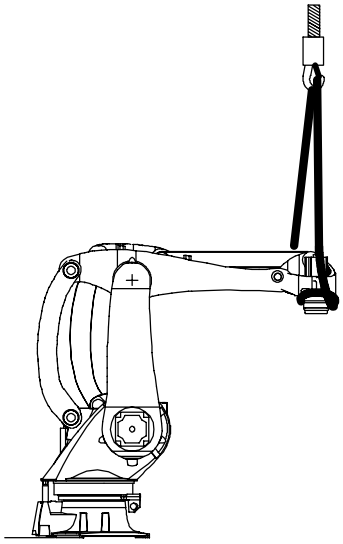


Fig. 81 Securing the link arm

(2) Release and unplug connectors XM2 (Fig. 82/3) and XP2 (4).

(3) Slacken four M12x25 Allen screws (1) but do not remove them.

(4) Secure servomotor (2) using lifting tackle.

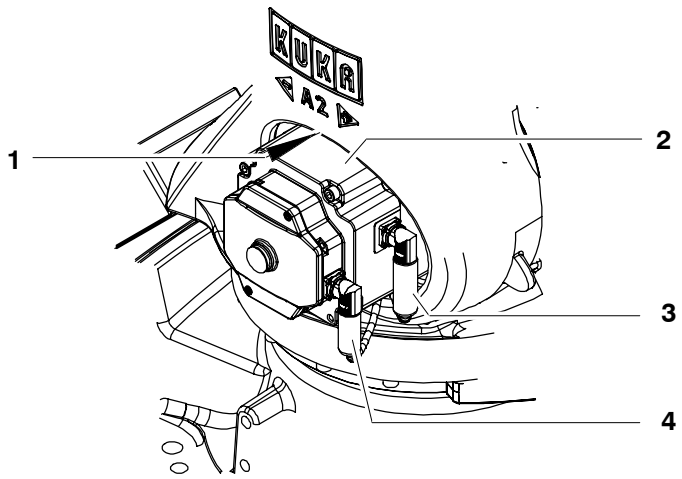


Fig. 82 Removal of servomotor A2

(5) Unscrew four M12x25 Allen screws (1).

(6) Take off servomotor (2).

The servomotor weighs approx. 23 kg.
When removing the servomotor, care must be taken to avoid any injury by crushing!

The servomotor must not be tilted while it is being removed.
The orientation of the servomotor is identified from the position of the sockets. When the motor unit is subsequently installed, these sockets must be positioned in the same way as before removal.

If the servomotor is not to be reinstalled, it must be protected against corrosion before being put into storage.

- **Installation**

(1) Remove all protective coatings and oil from new servomotor (Fig. 83/2), if applicable.

(2) Clean the mounting surface (4).

(3) Clean spline shaft connection (3) on gear unit and servomotor and apply a thin but continuous coat of Microlube GL 261.

(4) Install servomotor (2).

The servomotor weighs approx. 23 kg.
When inserting the servomotor, great care must be taken to avoid any injury by crushing!

When inserting the servomotor, it must be ensured that the spline shaft connection of the servomotor and gear unit meshes properly. This can be facilitated by gently turning the servomotor during insertion.

The motor shaft must not be subjected to any axial loads or tilted during installation.

Servomotors may only be installed in gear units if the toothing is undamaged on both sides of the connection.

(5) Fasten servomotor (2) with four M12x25 Allen screws (1).

(6) Tighten Allen screws (1) with a torque wrench in diagonally opposite sequence, increasing the tightening torque to the specified value in several stages (M_A= 78 Nm).

(7) Insert connectors XM2 (5) and XP2 (6).

(8) Remove devices securing the arm.

(9) Carry out zero adjustment (see Operating Handbook, Software KR C4, Chapter “Start-up”, Section “Robot Mastering/Unmastering”).

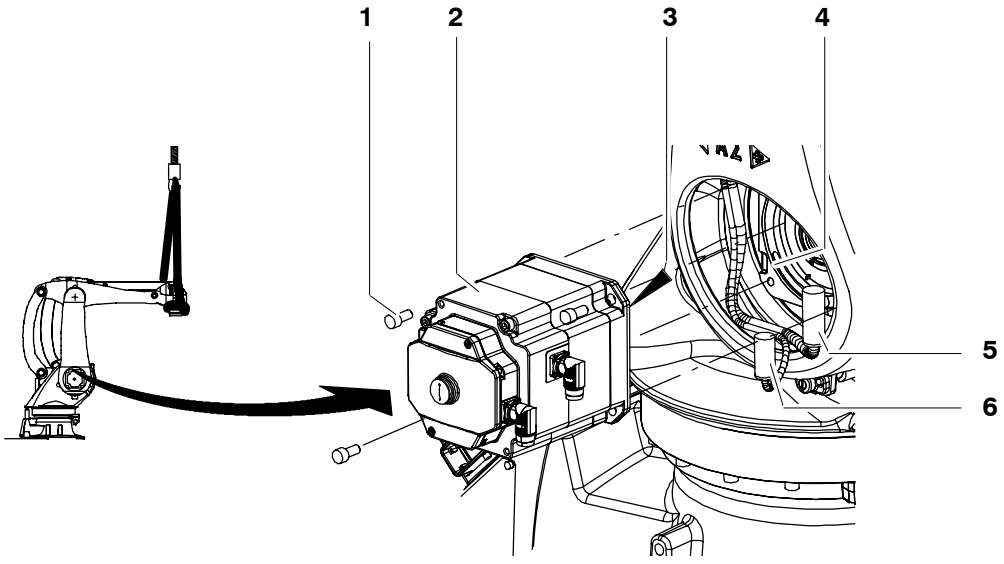


Fig. 83 Installation of servomotor A2

12.5.3 Removal, installation of servomotor A3

Please observe Section 12.1.

- **Removal**

If the servomotor is removed immediately after the robot has stopped operating, it is liable to have an elevated surface temperature.

(1) Secure link arm by suitable means, e.g. with lifting tackle (Fig. 84) or propped from below.

When securing the robot, the lifting tackle must be attached in such a way that the arm and parallel arm are not damaged.
The link arm must not be able to move either during or after removal of the servomotor.

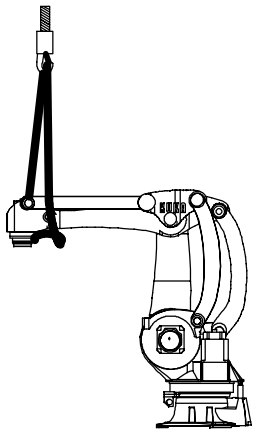


Fig. 84 Securing the link arm

(2) Release and unplug connectors XM3 (Fig. 85/4) and XP3 (3).

(3) Slacken four M12x25 Allen screws (2) but do not remove them.

(4) Secure servomotor (2) using lifting tackle.

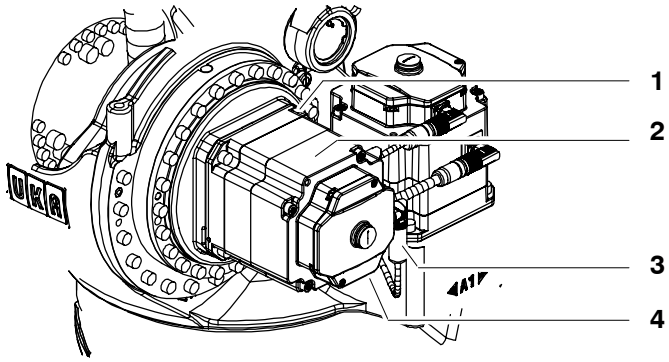


Fig. 85 Removal of servomotor A3

(5) Unscrew four M12x25 Allen screws (1).

(6) Take off servomotor (2).

The servomotor weighs approx. 23 kg.
When removing the servomotor, care must be taken to avoid any injury by crushing!

The servomotor must not be tilted while it is being removed.
The orientation of the servomotor is identified from the position of the sockets. When the motor unit is subsequently installed, these sockets must be positioned in the same way as before removal.

If the servomotor is not to be reinstalled, it must be protected against corrosion before being put into storage.

- **Installation**

  (1) Remove all protective coatings and oil from new servomotor (Fig. 86/4), if applicable.

  (2) Clean the mounting surface (6).

  (3) Clean spline shaft connection (1) on gear unit and servomotor and apply a thin but continuous coat of Microlube GL 261.

  (4) Insert servomotor (4).

The servomotor weighs approx. 23 kg.
When inserting the servomotor, great care must be taken to avoid any injury by crushing!

When inserting the servomotor, it must be ensured that the spline shaft connection of the servomotor and gear unit meshes properly. This can be facilitated by gently turning the servomotor during insertion.

The motor shaft must not be subjected to any axial loads or tilted during installation.

Servomotors may only be installed in gear units if the toothing is undamaged on both sides of the connection.

  (5) Fasten servomotor (4) with four M12x25 Allen screws (5).

  (6) Tighten Allen screws (5) with a torque wrench in diagonally opposite sequence, increasing the tightening torque to the specified value in several stages (M_A= 78 Nm).

  (7) Insert connectors XM3 (2) and XP3 (3).

  (8) Remove devices securing the arm.

  (9) Carry out zero adjustment (see Operating Handbook, Software KR C4, Chapter “Start-up”, Section “Robot Mastering/Unmastering”).

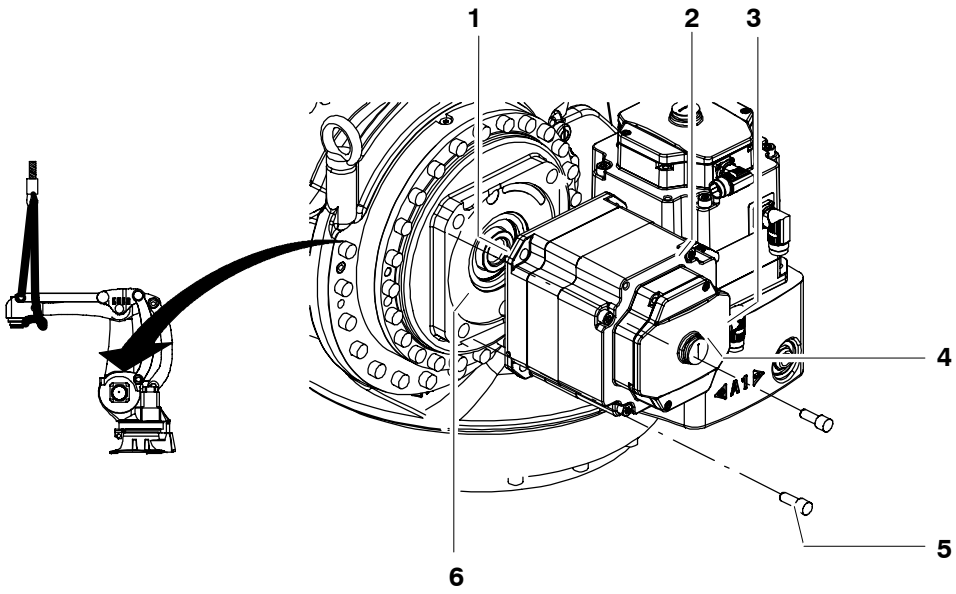


Fig. 86 Installation of servomotor A3

13 Consumables, safety data sheets

13.1 Safety data sheet for Optitemp RB1 cable grease

The following extract from the safety data sheet according to 91/155/EEC must be observed when handling Optitemp RB1.

1 Designation of substance/formulation and manufacturer		
Trade name:	**Optitemp RB1**	Art. no. **08020**
Use:	Lubrication	
Firm:	**Optimol Ölwerke Industrie GmbH**	
Address:	Postfach 80 13 49, D-81613 Munich	
Tel.:	+49 89 4183 116	
Fax:	+49 89 4183 192	

2 Composition / Information about the components
Chemical components: Synthetic oil based lubricating grease, lithium soap and additives.
Hazardous components: This product contains no substances requiring declaration as a hazardous substance.

3 Possible hazards
This product is NOT classified as hazardous according to the German Dangerous Substances Order.

4 First aid measures	
Eyes:	Immediately rinse thoroughly with plenty of water for several minutes.
Skin:	Wash thoroughly as soon as possible with soap and water or a suitable skin cleansing agent. If the skin has a tendency to dry out, apply suitable skin cream.
Inhalation:	Remove from zone of exposure – occurrence unlikely.
Ingestion:	Consult a doctor immediately. Do NOT induce vomiting.

5 Fire-fighting measures
Extinguishing agents
Suitable extinguishing agents: Not essential. Sufficient ventilation is recommended in industry, however.
Unsuitable extinguishing agents: Water jet.

6 Measures after unintended release
Personal safety precautions: Spilled product constitutes a considerable slip hazard.
Environmental protection measures: Prevent the product from entering the drainage system or surface waters.
Disposal information: Pick up in container. Dispose of as waste.

7 Handling and storage	
Handling:	No special measures required.
Storage:	Store product in original container only. Do not store in direct sunlight. Never leave the container open.
Technical Instructions on Air Quality Control / Annex E (Class):	III
Water hazard classification:	1 (manufacturer's classification based on the law of mixtures acc. to the German Administrative Regulation on the Classification of Substances Hazardous to Waters into Water Hazard Classes (VwVwS))

8 Personal protective equipment	
Personal protective equipment:	Avoid contact with skin and eyes. Wear oil-proof gloves if handling repeatedly or for prolonged periods. A high standard of personal hygiene is necessary.

9 Physical and chemical properties

10 Reactivity	
Conditions to be avoided:	Temperatures above 180 °C
Substances to be avoided:	Strong oxidizing agents.
Hazardous decomposition products:	None if used for designated purpose.

11 Toxicological information	
The following toxicological analysis is based on the known toxicity of the individual components. Expected LD_{50} oral (rat) > 2g/kg. Expected LD_{50} dermal (rabbit) > 2g/kg.	
Effects on health	
On eyes:	Can cause temporary irritation.
On skin:	Can make the skin dry. Can cause temporary irritation. With occasional contact of short duration, irritation is unlikely.
If inhaled	The low volatility of the product makes inhalation unlikely at room temperature.
If ingested:	Can cause nausea, vomiting and diarrhea.
Chronic effects:	Repeated or prolonged skin contact can cause long-term changes in the skin.

12 Ecological information	
General assessment:	If used for the designated purpose and disposed of correctly, no adverse effects are expected on the environment.
Mobility:	Non-volatile. Paste-like. Insoluble in water.
Persistence and degradability:	Not determined.
Bioaccumulation potential:	Bioaccumulation is unlikely due to the low water-solubility.
Ecotoxicity:	Ecotoxicity for fish, daphniae and algae is not assumed. An inhibitory effect on activated sludge bacteria is not assumed.

13 Disposal information		
This product must be disposed of in accordance with all pertinent regulations governing the disposal of waste and used lubricants.		
	Waste code:	Recommended means of disposal:
Unused product:	54 202	SAV
Used/contaminated product:	54 202	SAV
Packaging:	54 202	SAV, SAD Container reconditioning

14 Transport regulations
This product is NOT classified as a dangerous good for the purpose of transportation according to the German Law concerning the Conveyance of Dangerous Goods.

15 Regulations	
EC regulations:	EC Safety Data Sheet Directive 91/155/EEC EC Directive on Dangerous Preparations 88/379/EEC EC Framework Directive on Waste 91/156/EEC EC Directive on Hazardous Waste 91/689/EEC
National regulations (Germany):	Law concerning the Conveyance of Dangerous Goods Water Resources Law (WHG) Chemicals Law (ChemG) Dangerous Substances Order (GefStoffV) Law concerning Life-cycle Management and Waste (KrW-AbfG) Federal Immission Control Act (BImschG) Technical Guideline on Air (TA-Luft)

16 Other information
All information is based on the current state of our knowledge. It is intended only to describe our product with regard to the safety data. It is not intended to provide assurance of particular properties. The product may only be used for the scope of work specified above; any other use requires prior consultation with KUKA. Using the product for any purpose other than for its designated use could lead to risks which are not described in this document. Further information on the use of the product may be found in the relevant technical specifications.

13.2 Safety data sheet for Optimol Olit CLS lubricating grease

The following extract from the safety data sheet according to 91/155/EEC must be observed when handling Optimol Olit CLS.

1 Designation of substance/formulation and manufacturer		
Trade name:	**Optimol Olit CLS**	Art. no.: **08202**
Use:	Lubrication	
Firm:	**Optimol Ölwerke Industrie GmbH**	
Address:	Postfach 80 13 49, D-81613 Munich	
Tel.:	+49 89 4183 116	
Fax:	+49 89 4183 192	

2 Composition / Information about the components
Chemical components:
Lubricating grease based on mineral oil and lithium-calcium soap grease as thickener.
Hazardous components:
This product contains no substances requiring declaration as a hazardous substance.

3 Possible hazards
This product is NOT classified as hazardous according to the German Dangerous Substances Order.

4 First aid measures	
Eyes:	Rinse thoroughly with plenty of water for several minutes; consult a doctor if necessary.
Skin:	Wash thoroughly with soap and water; replace lost skin grease with skin cream.
Inhalation:	Not applicable.
Ingestion:	Do NOT induce vomiting; consult a doctor immediately.

5 Fire-fighting measures
Extinguishing agents
Suitable extinguishing agents:
Foam, dry powder, CO_2.
Unsuitable extinguishing agents:
Water.

6 Measures after unintended release
Personal safety precautions:
No special safety precautions required.
Environmental protection measures:
Contain polluted or extinguishing water. Prevent it from entering the drainage system or surface waters.
Disposal information:
Bind lubricant with a suitable binding agent and dispose of it in accordance with regulations.

7 Handling and storage	
Handling:	No special measures required if handled in accordance with specifications.
Storage:	Store in a dry, dust-free atmosphere in closed, original containers at temperatures between 10–20 °C. Avoid large variations in temperature! Do not store together with strong oxidizing agents. Do not leave container outdoors; protect from direct sunlight.
Technical Instructions on Air Quality Control / Annex E (Class):	Not applicable.
Water hazard classification:	Not applicable.

8 Personal protective equipment	
Personal protective equipment:	The usual precautions when handling lubricants must be observed. Avoid prolonged contact with the skin. Do not eat, drink, smoke or take snuff during work. Change contaminated working clothes. Clean skin and apply skin cream after work. Wear protective neoprene gloves.

9 Physical and chemical properties

10 Reactivity	
Conditions to be avoided:	The product is stable.
Substances to be avoided:	Strong acids and oxidizing agents.
Hazardous decomposition products:	Dependent on decomposition conditions: oxides of C, S, P.

11 Toxicological information	
Effects on health	
on eyes:	Contact with eyes can cause temporary irritation of the conjunctiva.
on skin:	Avoid prolonged or repeated contact with the skin, as mild irritation may occur.

12 Ecological information	
General assessment:	Prevent the lubricant from entering soil, surface waters and drainage system.

13 Disposal information

This product must be disposed of in accordance with all pertinent regulations governing the disposal of waste and used lubricants.

	Waste code:	Recommended means of disposal:
Unused product:	54 202	
Packaging:		Contaminated packaging should be emptied optimally; it can then be recycled after appropriate cleaning.

14 Transport regulations

This product is NOT classified as a dangerous good for the purpose of transportation according to the German Law concerning the Conveyance of Dangerous Goods.

15 Regulations	
EC regulations:	EC Safety Data Sheet Directive 91/155/EEC EC Directive on Dangerous Preparations 88/379/EEC EC Framework Directive on Waste 91/156/EEC EC Directive on Hazardous Waste 91/689/EEC
National regulations (Germany):	Law concerning the Conveyance of Dangerous Goods Water Resources Law (WHG) Chemicals Law (ChemG) Dangerous Substances Order (GefStoffV) Law concerning Life-cycle Management and Waste (KrW-AbfG) Federal Immission Control Act (BImschG) Technical Guideline on Air (TA-Luft)

16 Other information
All information is based on the current state of our knowledge. It is intended only to describe our product with regard to the safety data. It is not intended to provide assurance of particular properties.
The product may only be used for the scope of work specified above; any other use requires prior consultation with KUKA. Using the product for any purpose other than for its designated use could lead to risks which are not described in this document.
Further information on the use of the product may be found in the relevant technical specifications.

13.3 Safety data sheet for Optigear Synthetic RO 150 oil

1 Designation of substance/formulation and manufacturer		
Product name:	**Optigear Synthetic RO 150**	SDS no.: **465036**
Historical SDS no.:	**DE-05254, FR-465036, SK-5254**	
Use of substance or formulation:	Lubricant For specific instructions for use, see the corresponding technical data sheet or contact a company representative.	
Supplier:	Deutsche BP Aktiengesellschaft, Industrial Lubricants & Services	
Address:	Erkelenzer Strasse 20, D-41179 Mönchengladbach	
Country:	Germany	
Tel.:	+49 (0)2161 909 319	
Fax:	+49 (0)2161 909 392	
Emergency hotline:	Carechem: +44 (0)208 762 8322	
e-mail address:	MSDSadvice@bp.com	

2 Possible hazards

The preparation is classified as hazardous in accordance with Directive 1999/45/EC in its altered and adapted version.

Environmental hazards:

Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Sections 11 and 12 contain more detailed information on health hazards, symptoms and environmental risks.

3 Composition and information about the components

Chemical characterization:

Synthetic lubricant and additives.

Chemical description:

	CAS no.	%	EINECS/ELINCS.	Rating
Dithiocarbamic acid, dibutyl-, methylene ester	10254-57-6	1 - 5	233-593-1	R52/53
Tridecanamine, n-tridecyl, branched, compounds with molybdenum hydroxide oxide (1:1)	280130-32-7	0.1 - 1	442-990-0	Xi; R41, R38 N; R50/53

Refer to Section 16 for the full text of the above R-phrases.
The occupational exposure limit values, where available, are specified in Section 8.

4 First aid measures	
Eye contact:	In case of contact, rinse eyes immediately with plenty of water for at least 15 minutes. If irritation occurs, consult a doctor.
Skin contact:	Wash affected areas of skin with soap and water, or use suitable cleaning agent. Change clothing and shoes if they become contaminated with product. Wash clothing before reuse. Clean shoes thoroughly before reuse. If irritation occurs consult a doctor.
Inhalation:	Take affected person into fresh air. Consult a doctor if symptoms persist.
Ingestion:	Do NOT induce vomiting. If the person is unconscious, do not give anything by mouth. Consult a physician immediately.

5 Fire-fighting measures	
Suitable extinguishing agents	In the event of a fire: use water spray (mist), foam, dry chemicals or CO_2. This substance is harmful to aquatic organisms. Extinguishing water contaminated with this product must be contained and prevented from entering surface waters or the sewage or drainage system.
Unsuitable extinguishing agents:	Do NOT use water jets.
Hazardous decomposition products:	The decomposition products may include the following materials: Carbon oxides Nitrogen oxides Sulfur oxides
Unusual fire/explosion hazards:	This product is not inherently explosive in accordance with the applicable rules.
Special fire-fighting measures:	Not specified.
Protection of fire-fighters:	Fire-fighters must wear self-contained positive pressure breathing apparatus (SCBA) and full protective gear.

6 Measures after unintended release	
Personal safety precautions:	No measures should be taken that involve a risk to personnel or have not been adequately trained. Evacuate the environment. Refuse access to personnel who are not required or are unprotected. Do not touch or step on any spilled substance. Avoid breathing in any spray or vapors. Ensure adequate ventilation. Where there is insufficient ventilation, wear suitable respiratory equipment. Use suitable protective equipment (see Section 8).
Environmental protection measures:	Prevent released material from dispersing or flowing away and from coming into contact with soil, surface waters and drainage system. Notify the relevant authorities if the product has caused pollution (sewers, surface waters, ground or air). Substance is a water pollutant.
Large spills:	Stop the leak if you can do so without risk. Remove container from spill area. Approach the spill area only with a following wind. Prevent entry into drainage system, surface waters, basements or confined areas. Flush spilled material into a wastewater treatment plant, or proceed as follows. Contain spilled material using a non-combustible absorbent (e.g. sand, soil, vermiculite, diatomaceous earth) and collect it in the designated containers for disposal in accordance with the local regulations (see Section 13). Disposal should be entrusted to a recognized waste disposal company. Contaminated absorbents can be just as dangerous as spilled material. Note: See Section 1 for contact in emergencies and Section 13 for disposal information.
Small spills:	Stop the leak if you can do so without risk. Remove container from spill area. Absorb spill with inert material and place it in a suitable container for disposal. Disposal should be entrusted to a recognized waste disposal company.

7 Handling and storage	
Handling:	Spilled and leaked product must be prevented from coming into contact with soil and surface waters. Wash thoroughly after handling.
Storage:	Keep containers tightly sealed. Keep containers in a cool, well-ventilated area.
Germany - storage class:	10

8 Exposure limits and personal protective equipment	
Ingredient name ACGIH TLVs:	Base oil – unspecified
Limits to monitor:	**ACGIH (USA).** TWA: 5 mg/m^3 8 hour(s). Form: mineral oil mist STEL: 10 mg/m^3 15 minute(s). Form: mineral oil mist
The ACGIH values are enclosed for information and orientation purposes. Further information can be obtained from your supplier. While this section contains specific OELs for individual components, different components may be contained in any mists, vapors or dusts that are generated. The specific OELs may thus not necessarily be applicable to the product as a whole and are merely provided for general information purposes.	
Limitation and monitoring of exposure	
Limitation and monitoring of exposure in the workplace:	Provide exhaust ventilation or other engineering controls to keep the relevant airborne concentrations below their respective occupational exposure limits.
Hygiene measures:	Wash hands, forearms and face thoroughly after handling chemical products and before eating, smoking or using the toilet, as well as at the end of the working day.
Personal protective equipment	
Respiratory protection:	Not essential. Sufficient ventilation is recommended in industry, however.
Hand protection:	Wear protective gloves if prolonged or repeated contact is likely. Chemical-resistant protective gloves. Recommended: nitrile gloves The right choice of protective gloves is dependent on the chemicals to be handled, the working conditions, and the condition of the gloves themselves (even the best chemical-resistant protective gloves start to leak after repeated contact with chemicals). Most protective gloves only provide protection for a short period of time, after which they must be disposed of and replaced. As the specific working conditions and the chemicals concerned differ from case to case, appropriate safety measures must be developed for each individual application. Protective gloves should therefore be selected in consultation with the supplier/manufacturer, giving full consideration to the specific working conditions.
Eye protection:	Protective goggles with side shields to guard against splashing.
Skin and body:	Wear appropriate clothing to avoid prolonged skin contact.

9 Physical and chemical properties	
General information regarding appearance	
Physical state	Liquid.
Color:	Green.
Odor:	Slight.
Important information on health, safety and the environment	
Flash point:	Open cup: 230 °C (446 °F) [Cleveland]
Vapor pressure:	<0.01 kPa (<0.075 mm Hg) at 20°C
Viscosity:	Kinematic: 150 mm^2/s (150 cSt) at 40°C
Pour point:	-36°C
Density:	< 1000 kg/m^3 (< 1 g/cm^3) at 20 °C
Solubility:	Insoluble in water.

10 Stability and reactivity	
Stability:	The product is stable. No hazardous polymerization occurs under normal storage conditions and in normal use.
Conditions to be avoided:	No specific data.
Substances to be avoided:	Reactive or incompatible with the following substances: oxidizing materials.
Hazardous decomposition products:	The combustion products may include the following compounds: Carbon oxides Nitrogen oxides Sulfur oxides No hazardous decomposition products should be formed under normal conditions of storage and use.

11 Toxicological information

12 Ecological information	
Persistence / degradability:	Inherently biodegradable.
Mobility:	Non-volatile. Liquid. Insoluble in water.
Environmental hazards:	Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

13 Disposal information	
Disposal information	
Disposal information / waste specifications:	Generation of waste should be avoided or minimized if at all possible. Disposal of surplus material and products not suitable for recycling must be entrusted to a recognized waste disposal company. Disposal of this product and of its solutions and by-products must at all times comply with the environmental protection requirements, waste disposal legislation and the requirements of local authorities. Prevent released material from dispersing or flowing away and from coming into contact with soil, surface waters and drainage system.
Unused product	
European Waste Catalog (EWC):	13 02 08* Synthetic machine oils, gear oils and lubricating oils Use of the product for purposes other than those specified and/or the presence of impurities can necessitate the use of a different waste code number by the waste producer.
Packaging	
European Waste Catalog (EWC):	15 01 10* Packaging containing the residue of hazardous materials or contaminated by hazardous materials.

14 Transport information
Not hazardous as defined by the transport regulations (ADR/RID, ADNR, IMDG, ICAO/IATA).

15 Regulations
Classification and labeling have been performed according to EU directives 1999/45/EC and 67/548/EEC as amended and adapted.

Labeling requirements	
Risk (R) phrases:	R52/53 – Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
Safety (S) phrases:	S61 – Avoid release to the environment. Refer to special instructions/safety data sheet.
Miscellaneous provisions	
Inventories:	**European inventory:** All components are listed or exempted. **US inventory (TSCA 8b):** All components are listed or exempted. **Australian inventory (AICS):** All components are listed or exempted. **Canadian inventory:** At least one component is not listed. **Inventory of Existing Chemical Substances in China (IECSC):** All components are listed or exempted. **Japanese inventory of Existing and New Chemical Substances (ENCS):** At least one component is not listed. **Korean Existing Chemicals Inventory (KECI):** All components are listed or exempted. **Philippine Inventory of Chemicals and Chemical Substances (PICCS):** All components are listed or exempted.
Water hazard classification (WGK), **classification acc. to the German Administrative Regulation on the Classification of Substances Hazardous to Water into Water Hazard Classes (VwVwS):**	1, Annex no. 4

16 Other information	
Full text of R-phrases referred to in Sections 2 and 3:	R41 - Risk of serious damage to eyes. R38 - Irritating to skin. R50/53 - Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment. R52/53 - Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
History:	
Date of issue:	23/11/2007.
Date of previous issue:	31/08/2007.
Prepared by:	Product Stewardship Group
Notes for the reader:	

All reasonably practicable steps have been taken to ensure this data sheet and the health, safety and environmental information contained in it is accurate as at the date of issue specified below. No warranty or representation, express or implied, is made as to the accuracy or completeness of the data and information in this data sheet.
The data and advice issued are valid if the product is sold for the application(s) specified. The product should not be used for purposes other than the applications specified without prior consultation with us.
It is the responsibility of the user to check this product and to use it with care, while observing all the relevant laws and regulations in force.
The BP Group accepts no responsibility for any damage or injury resulting from uses other than the stated product use of the material, from any failure to adhere to recommendations, or from hazards inherent in the nature of the material. Those purchasing the product for supply to third parties for use at work have a duty to take all necessary steps to ensure that any person handling or using the product is provided with the information on this data sheet. Employers have a duty to tell employees and others who may be affected of any hazards described in this sheet and of any precautions that should be taken.

13.4 Safety data sheet for Microlube GL 261 lubricant

The following extract from the safety data sheet according to 91/155/EEC must be observed when handling Microlube GL 261.

1 Designation of substance/formulation and manufacturer		
Trade name:	**Microlube GL 261**	Article no.: **020195**
Use:	Lubricant	
Firm:	**KLÜBER LUBRICATION MÜNCHEN KG**	
Address:	Geisenhausenerstr. 7, D-81379 Munich	
Tel.:	+49 89 7876 0	
Fax:	+49 89 7876 333	

2 Composition / Information about the components

Chemical characterization:

- Mineral oil
- Lithium special soap
- UV indicator

Hazardous components:

This product contains no substances requiring declaration as a hazardous substance.

3 Possible hazards

This product is NOT classified as hazardous according to the German Dangerous Substances Order.

4 First aid measures	
Eyes:	Rinse thoroughly with plenty of water for several minutes; consult a doctor if necessary.
Skin:	Wash thoroughly with soap and water; replace lost skin grease with skin cream.
Inhalation:	If oil vapor has been inhaled, ensure plentiful supply of fresh air and consult a doctor if necessary.
Ingestion:	Consult a doctor if symptoms persist.

5 Fire-fighting measures

Extinguishing agents

Suitable extinguishing agents:

Foam, fine water spray, dry powder, CO_2.

Unsuitable extinguishing agents:

Full water jet.

Special fire-fighting measures:

Cool containers at risk from fire with water spray.
Residue from after a fire and contaminated fire-extinguishing water must be disposed of in accordance with the applicable regulations.

In the event of fire, the following can be released:

Carbon monoxide (CO), hydrocarbons.

Special protective equipment:

Do not inhale gases from explosions and combustion.
Usual measures for fires involving chemicals.

6 Measures after unintended release
Personal safety precautions: No special safety precautions required.
Environmental protection measures: Contain polluted or extinguishing water. Prevent it from entering the drainage system, surface waters or other waterways.
Procedure for cleaning/removing: Bind lubricant with a suitable binding agent and dispose of it in accordance with regulations.
Additional instructions: No hazardous materials are released.

7 Handling and storage	
Handling:	No special measures required.
Storage:	Store in well sealed containers in a cool and dry place. Do not store together with oxidizing agents or food.
Storage class in accordance with VCI:	11

8 Exposure limits and personal protective equipment
Additional information for the design of technical systems: No further information.
Components with applicable occupational exposure limit values: The product contains no relevant amounts of materials that are subject to monitoring of limit values in the workplace.
Additional instructions: These values are based on the lists valid at the time of issue.
Personal protective equipment
General protective and hygiene measures: Immediately take off any contaminated, soaked clothing. Avoid prolonged and intensive contact with the skin. Thoroughly clean the skin after work and before taking breaks.
Respiratory protection and eye protection: Not essential.
Hand protection: Appropriate measures for precautionary skin protection are recommended.

9 Physical and chemical properties	
State:	Paste
Color:	Tawny
Odor:	Product-specific
Pour point:	>220 °C (DIN ISO 2176)
Flash point:	Not applicable.
Risk of explosion:	The product presents no danger of explosion.
Density (20 °C):	~ 0.89 g/cm^3
Solubility:	Insoluble in water.

10 Stability and reactivity
Thermal decomposition / conditions to be avoided: No decomposition if handled and stored correctly.
Substances to be avoided: Oxidizing agents.
Hazardous reactions: No hazardous reactions known.
Hazardous decomposition products: None if used for designated purpose.

11 Toxicological information
Prolonged contact with the skin can cause irritation and/or dermatitis.

12 Ecological information
Measures at wastewater treatment facilities: The product can be separated by mechanical means.
General information: Prevent from entering groundwater, surface waters or the drainage system. Water hazard classification 1 (manufacturer's classification): low hazard to waters

13 Disposal information
Waste code number: No waste code number for this product can be defined in accordance with the European Waste Catalog (EWC) until the purpose of use has been assigned by the customer. The waste code number should be determined in consultation with the regional disposal service.
Contaminated packaging:
Recommendation: Contaminated packaging should be emptied optimally; it can then be recycled after appropriate cleaning.

14 Transport regulations
This product is NOT classified as a dangerous good for the purpose of transportation according to the German Law concerning the Conveyance of Dangerous Goods.

15 Regulations
EC regulations: The product is not subject to labeling obligations due to the method of calculation in the latest version of the "EC General Classification Directive for Preparations".
Water hazard classification: WGK 1 (manufacturer's classification): low hazard to waters in accordance with the German Administrative Regulation on the Classification of Substances Hazardous to Water into Water Hazard Classes (VwVwS) 17.5.99 Annex 4

16 Other information
All information is based on the current state of our knowledge. The information does not represent any assurance of product characteristics, however, and does not establish a legally valid contractual relationship.