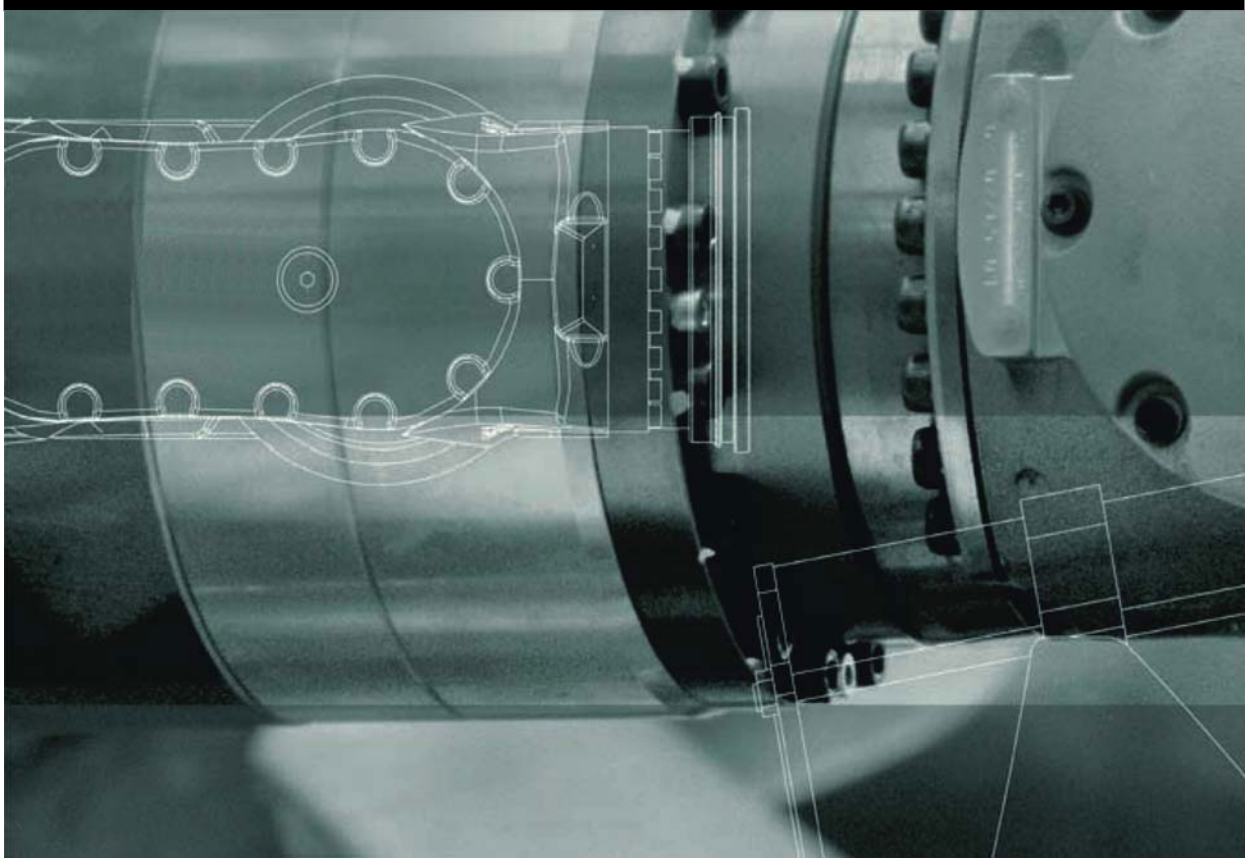
KUKA

Robots

KUKA Roboter GmbH

KR 16 arc HW, KR 16 L8 arc HW

Operating Instructions



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Germany

Other functions not described in this documentation may be operable in the controller. The user has no claims to these functions, however, in the case of a replacement or service work.

We have checked the content of this documentation for conformity with the hardware and software described. Nevertheless, discrepancies cannot be precluded, for which reason we are not able to guarantee total conformity. The information in this documentation is checked on a regular basis, however, and necessary corrections will be incorporated in the subsequent edition.

Subject to technical alterations without an effect on the function.

Translation of the original documentation

KIM-PS5-DOC

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Bookstructure:	BA KR 16 arc HW V5.1
Version:	BA KR 16 arc HW V6 en (PDF)

Contents

1 Introduction

1.1 Industrial robot documentation

The industrial robot documentation consists of the following parts:

- Documentation for the manipulator
- Documentation for the robot controller
- Operating and programming instructions for the KUKA System Software
- Documentation relating to options and accessories
- Parts catalog on storage medium

Each of these sets of instructions is a separate document.

1.2 Representation of warnings and notes

Safety

These warnings are relevant to safety and **must** be observed.

DANGER	These warnings mean that it is certain or highly probable that death or severe injuries **will** occur, if no precautions are taken.
WARNING	These warnings mean that death or severe injuries **may** occur, if no precautions are taken.
CAUTION	These warnings mean that minor injuries **may** occur, if no precautions are taken.
NOTICE	These warnings mean that damage to property **may** occur, if no precautions are taken.
	These warnings contain references to safety-relevant information or general safety measures. These warnings do not refer to individual hazards or individual precautionary measures.

This warning draws attention to procedures which serve to prevent or remedy emergencies or malfunctions:

SAFETY INSTRUCTIONS	Procedures marked with this warning **must** be followed exactly.

Notes

These hints serve to make your work easier or contain references to further information.

	Tip to make your work easier or reference to further information.

2 Purpose

2.1 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.

2.2 Intended use

Use

The industrial robot is intended for handling tools and fixtures, or for processing or transferring components or products. Use is only permitted under the specified environmental conditions.

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
- Use in underground mining

NOTICE 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.

The robot system is an integral part of a complete system and may only be operated in a CE-compliant system.

3 Product description

3.1 Overview of the robot system

A robot system (>>> Fig. 3-1) comprises all the assemblies of an industrial robot, including the manipulator (mechanical system and electrical installations), control cabinet, connecting cables, end effector (tool) and other equipment. The industrial robots KR 16 arc HW and KR 16 L8 arc HW comprise the following components:

- Manipulator
- Robot controller
- Connecting cables
- KCP teach pendant
- Software
- Options, accessories

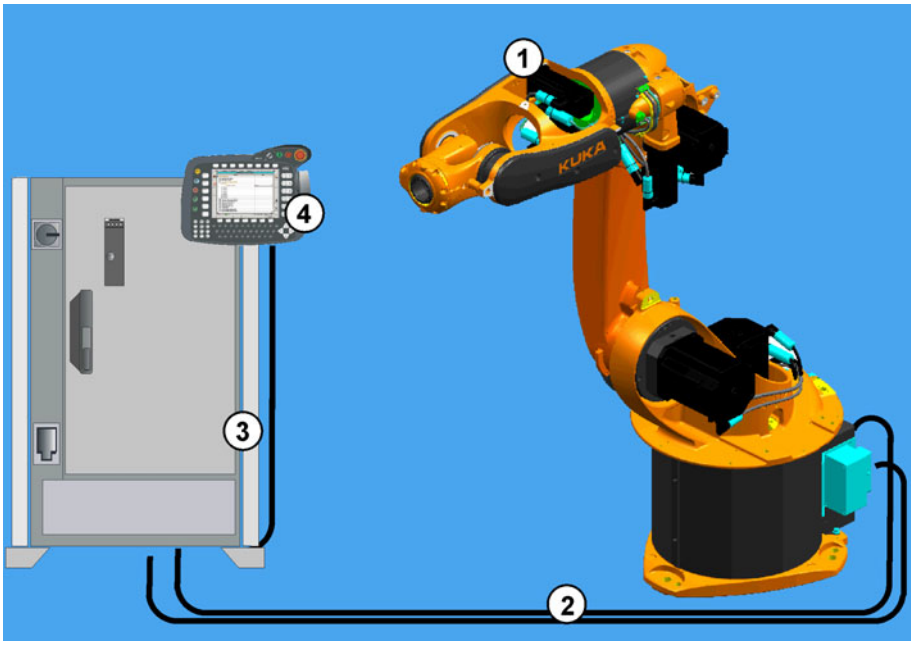


Fig. 3-1: Example of a robot system

1	Manipulator	3	Robot controller
2	Connecting cables	4	Teach pendant (KCP)

SafeRobot

The SafeRobot option is available for this robot.

In this case the robot moves within limits that have been configured. The actual position is continuously calculated and monitored by the SafeRDC. If the robot violates a monitoring limit or a safety parameter, it is stopped.

RoboTeam

The RoboTeam option is available for this robot.

RoboTeam allows the operation of cooperating robot systems. In the RoboTeam, up to 15 robots can work together in a group. One robot in the group always takes on the role of “master”, while the remaining robots work as “slaves”.

3.2 Description of the robot

Overview

These manipulators (robots) (>>> Fig. 3-2) are designed as a 6-axis jointed-arm kinematic system. They consist of the following principal components:

- Hollow-shaft wrist
- Arm
- Link arm
- Rotating column
- Base frame
- Electrical installations

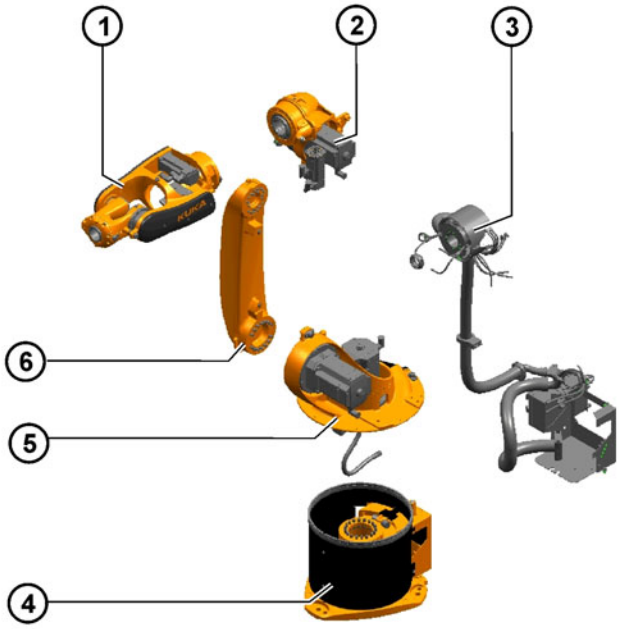


Fig. 3-2: Main assemblies of the manipulator

1	Hollow-shaft wrist	4	Base frame
2	Arm	5	Rotating column
3	Electrical installations	6	Link arm

Hollow-shaft wrist

The robot variants KR 16 arc HW and KR 16 L8 arc HW are equipped with a 2-axis hollow-shaft wrist. The wrist contains axes 5 and 6. The motors of axes 5 and 6 are incorporated in this assembly. Both axes are driven via toothed belts and gear units. The design enables the fluid supply to be routed directly through the center of axis 6 to the application.

For attaching end effectors (tools), the in-line wrist has a mounting flange.

Arm

The arm is the link between the hollow-shaft wrist and the link arm. It houses the motors of wrist axes 3 and 4. The arm is driven by the motor of axis 3. The maximum permissible swivel angle is mechanically limited by a stop for each direction, plus and minus. The associated buffers are attached to the link arm. The entire drive unit of axis 4 is also integrated inside the arm. In addition, the cable harness for the wrist axes A 5 and A 6 is installed under a cover. Fastening facilities are provided for the welding application equipment on the rear of the arm. The fluid supply to the tool is routed axially through the arm.

Link arm

The link arm is the assembly located between the arm and the rotating column. It consists of the link arm body with the buffers.

Rotating column

The rotating column houses the motors of axes 1 and 2. The rotational motion of axis 1 is performed by the rotating column. This is screwed to the base frame via the gear unit of axis 1 and is driven by a motor in the rotating column. The link arm is also mounted in the rotating column.

Base frame

The base frame is the base of the robot. It is screwed to the mounting base. The flexible tube for the electrical installations is fastened to the base frame. Also located on the base frame is the multi-function housing (MFH) and the data cable junction box.

Electrical installations

The electrical installations include all the motor and control cables for the motors of axes 1 to 6. All connections are implemented as connectors in order to enable the motors to be exchanged quickly and reliably. The electrical installations also include the RDC box and the multi-function housing (MFH), both of which are mounted on the robot base frame. The connecting cables from the robot controller are connected to these junction boxes by means of connectors. The electrical installations also include a protective circuit.

For the supply to the wrist axis drives, an additional cable harness is integrated into the arm, which ensures that the cables are guided without kinking throughout the motion range of axis 4.

4 Technical data

4.1 Basic data

Basic data

Type	KR 16 arc HW KR 16 L8 arc HW
Number of axes	6
Volume of working envelope	KR 16 arc HW: 15.44 m^3 KR 16 L8 arc HW: 29.22 m^3
Pose repeatability (ISO 9283)	KR 16 arc HW: ±0.04 mm KR 16 L8 arc HW: ±0.04 mm
Working envelope reference point	Intersection of axes 4 and 5
Weight	KR 16 arc HW: 245 kg KR 16 L8 arc HW: 240 kg
Principal dynamic loads	See “Loads acting on the mounting base”
Protection classification of the robot	IP 54 ready for operation, with connecting cables plugged in (according to EN 60529)
Protection classification of the in-line wrist	IP 54
Sound level	< 75 dB (A) outside the working envelope
Mounting position	Floor, ceiling
Surface finish, paintwork	Base frame, covers on hollow-shaft wrist and arm: black (RAL 9005); moving parts: KUKA orange 2567

Ambient temperature

Operation	283 K to 328 K (+10 °C to +55 °C)
Operation with Safe RDC	283 K to 323 K (+10 °C to +50 °C)
Storage and transportation	233 K to 333 K (-40 °C to +60 °C)
Start-up	283 K to 288 K (+10 °C to +15 °C) At these temperatures the robot may have to be warmed up before normal operation. Other temperature limits available on request.
Humidity rating	DIN EN 60721-3-3, Class 3K3

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.

Connecting cables

Cable designation	Connector designation robot controller - robot	Interface with robot
Motor cable	X20 - X30	Harting connectors at both ends
Data cable	X21 - X31	Harting connectors at both ends
Data cable, SafeRobot	X21.1 - X41	Harting connectors at both ends

Cable lengths	
Standard	7 m, 15 m, 25 m, 35 m, 50 m
With RoboTeam*	7 m, 15 m, 25 m, 35 m
With SafeRobot*	7 m, 15 m, 25 m, 35 m

* Only with KR C2.

For detailed specifications of the connecting cables, see “Description of the connecting cables” (>>> 6.4 "Connecting cables and interfaces" Page 63).

4.2 Axis data

Axis data

The following data are valid for the robot KR 16 arc HW:

Axis	Range of motion, software-limited	Speed with rated payload
1	+/-185°	200 °/s
2	+35° to -155°	200 °/s
3	+154° to -120°	195 °/s
4	+/-165°	370 °/s
5	+/-130°	310 °/s
6	Infinitely rotating	610 °/s

The following data are valid for the robot KR 16 L8 arc HW:

Axis	Range of motion, software-limited	Speed with rated payload
1	+/-185°	127 °/s
2	+35° to -155°	130 °/s
3	+154° to -120°	125 °/s
4	+/-165°	315 °/s
5	+/-140°	320 °/s
6	Infinitely rotating	680 °/s

The direction of motion and the arrangement of the individual axes may be noted from the following diagram.

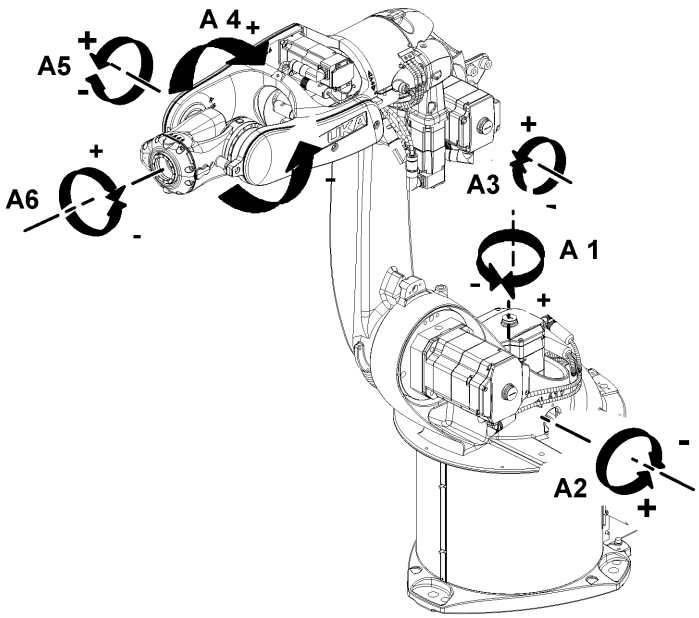


Fig. 4-1: Direction of rotation of the axes

Working envelope

The following diagrams show the shape and size of the working envelopes for the robots KR 16 arc HW (>>> Fig. 4-2) and KR 16 L8 arc HW (>>> Fig. 4-3).

The reference point for the working envelope is the intersection of axes 4 and 5.

Maße / Dimensions: mm

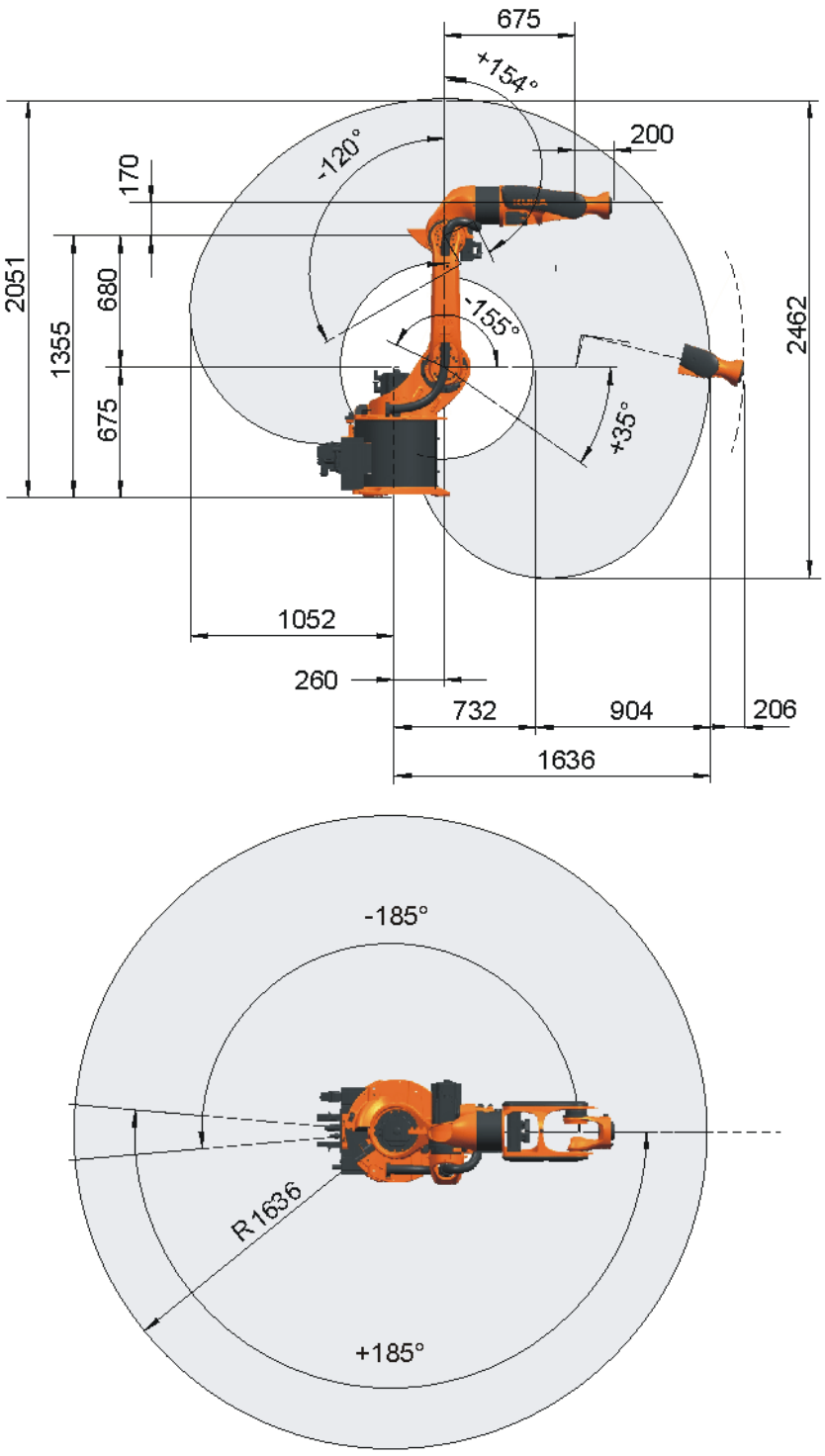


Fig. 4-2: Working envelope, KR 16 arc HW

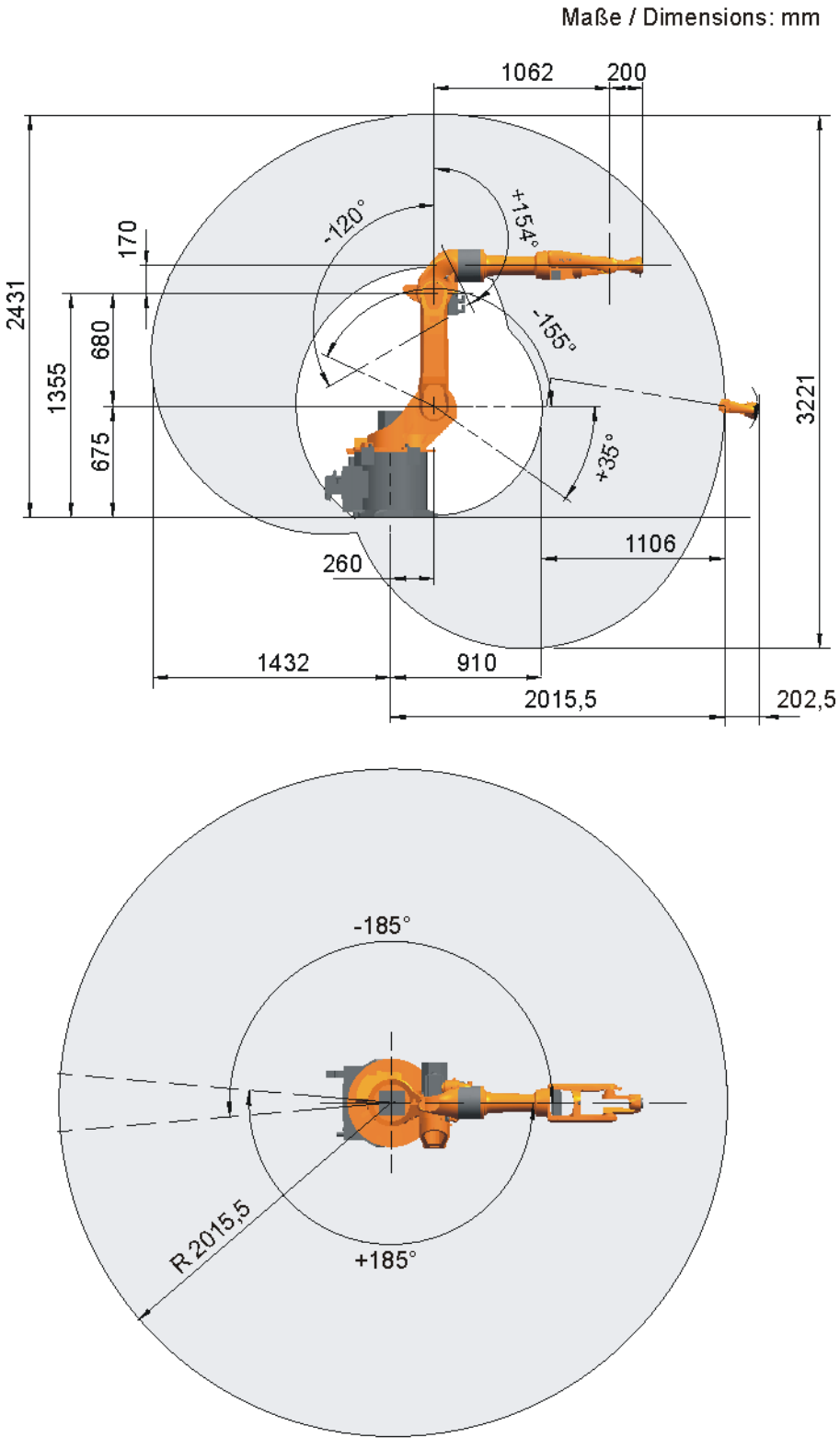


Fig. 4-3: Working envelope for KR 16 L8 arc HW

4.3 Payloads

Payloads KR 16 arc HW

Robot	KR 16 arc HW
In-line wrist	IW 16 arc HW
Rated payload	16 kg
Distance of the load center of gravity L_z (horizontal)	120 mm

Robot	KR 16 arc HW
Distance of the load center of gravity L_{xy} (vertical)	80 mm
Permissible mass moment of inertia	0.36 kgm^2
Max. total load	48 kg
Supplementary load, arm	12 kg
Supplementary load, link arm	None
Supplementary load, rotating column	20 kg
Supplementary load, base frame	None

Payloads KR 16 L8 arc HW

Robot	KR 16 L8 arc HW
In-line wrist	IW 5 arc HW
Rated payload	8 kg
Distance of the load center of gravity L_z (horizontal)	70 mm
Distance of the load center of gravity L_{xy} (vertical)	50 mm
Permissible mass moment of inertia	0.10 kgm^2
Max. total load	40 kg
Supplementary load, arm	12 kg
Supplementary load, link arm	None
Supplementary load, rotating column	20 kg
Supplementary load, base frame	None

Load center of gravity P

For all payloads, the load center of gravity refers to the distance from the face of the mounting flange on axis 6. Refer to the payload diagram for the nominal distance.

Payload diagram

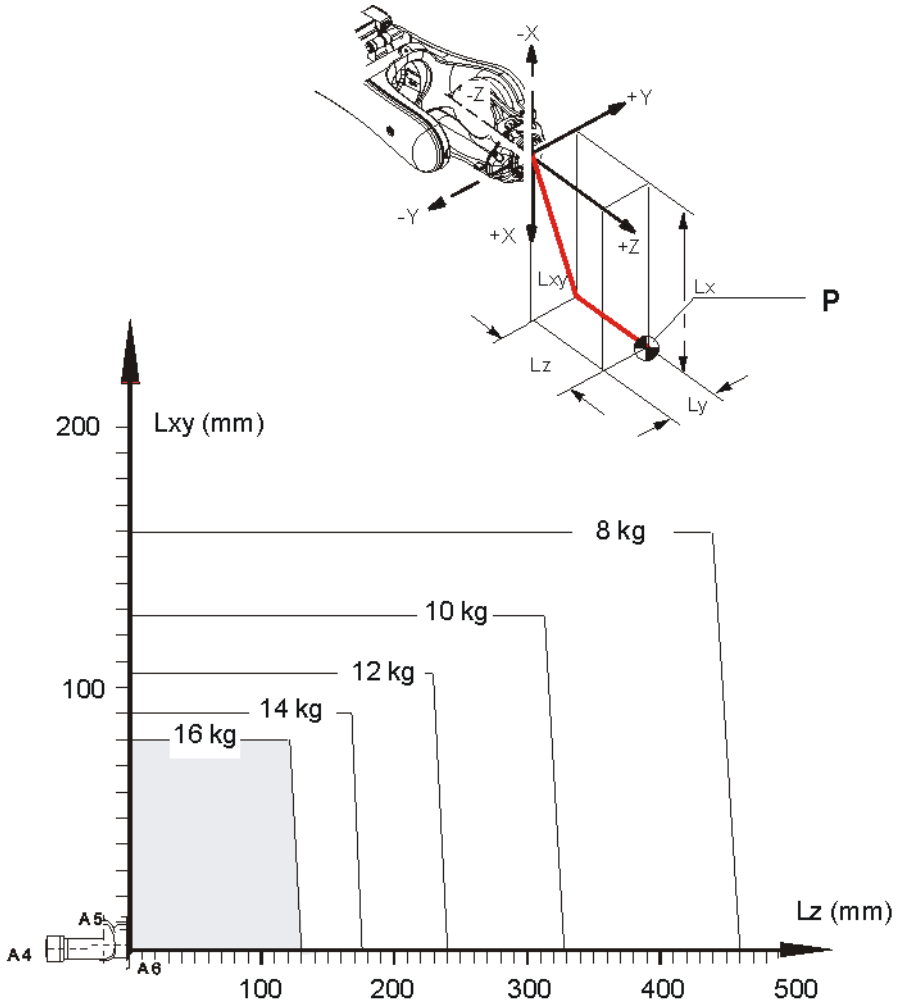


Fig. 4-4: Payload diagram, KR 16 arc HW

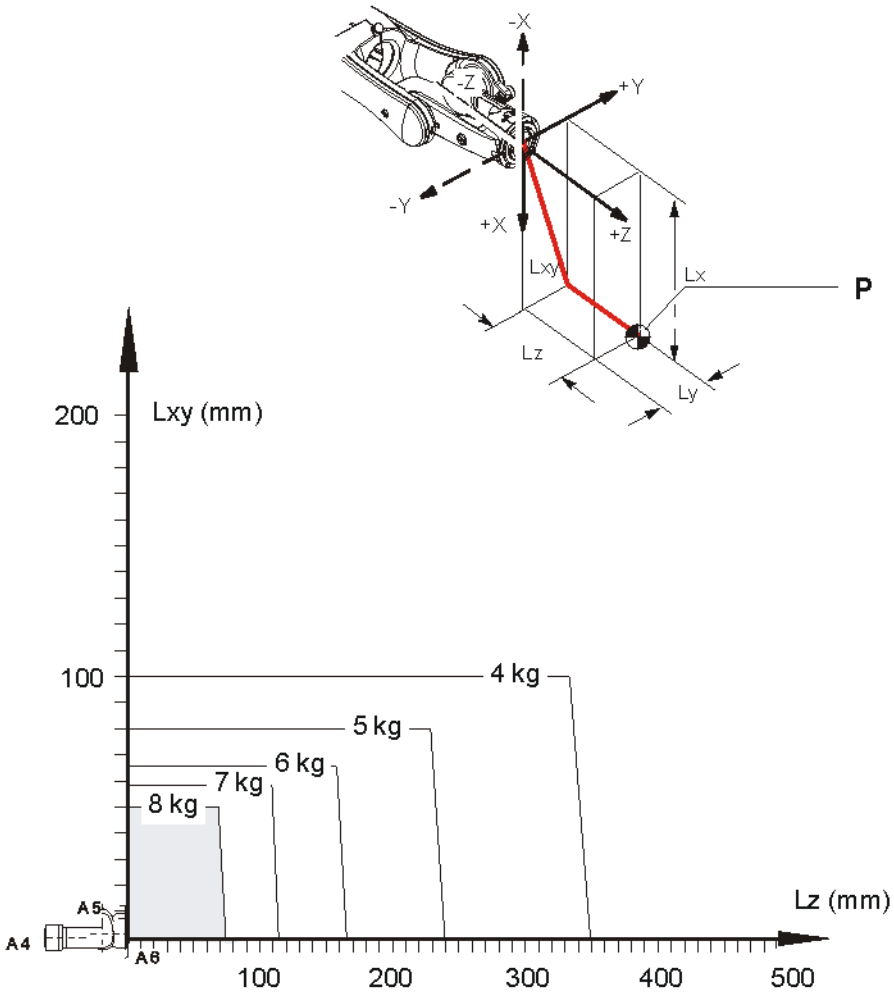


Fig. 4-5: Payload diagram, KR 16 L8 arc HW

NOTICE This loading curve corresponds to the maximum load capacity. Both values (payload and mass moment of inertia) must be checked in all cases. Exceeding this capacity will reduce the service life of the robot and overload the motors and the gears; in any such case the KUKA Roboter GmbH must be consulted beforehand.
The values determined here are necessary for planning the robot application. For commissioning the robot, additional input data are required in accordance with operating and programming instructions of the KUKA System Software.
The mass inertia must be verified using KUKA.Load. It is imperative for the load data to be entered in the robot controller!

Mounting flange

Robot	KR 16 arc HW	KR 16 L8 arc HW
Wrist	IW 16 arc HW	IW 5 arc HW
Mounting flange (hole circle)	66 mm	58 mm
Screw grade	10.9	10.9
Screw size	M5	M4
Grip length	1.5 x nominal diameter	1.5 x nominal diameter
Depth of engagement	min. 7 mm, max. 8 mm	min. 6 mm, max. 7 mm
Locating element	5 ^{H7}	4 ^{H7}

The mounting flange is depicted with axes 4 and 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

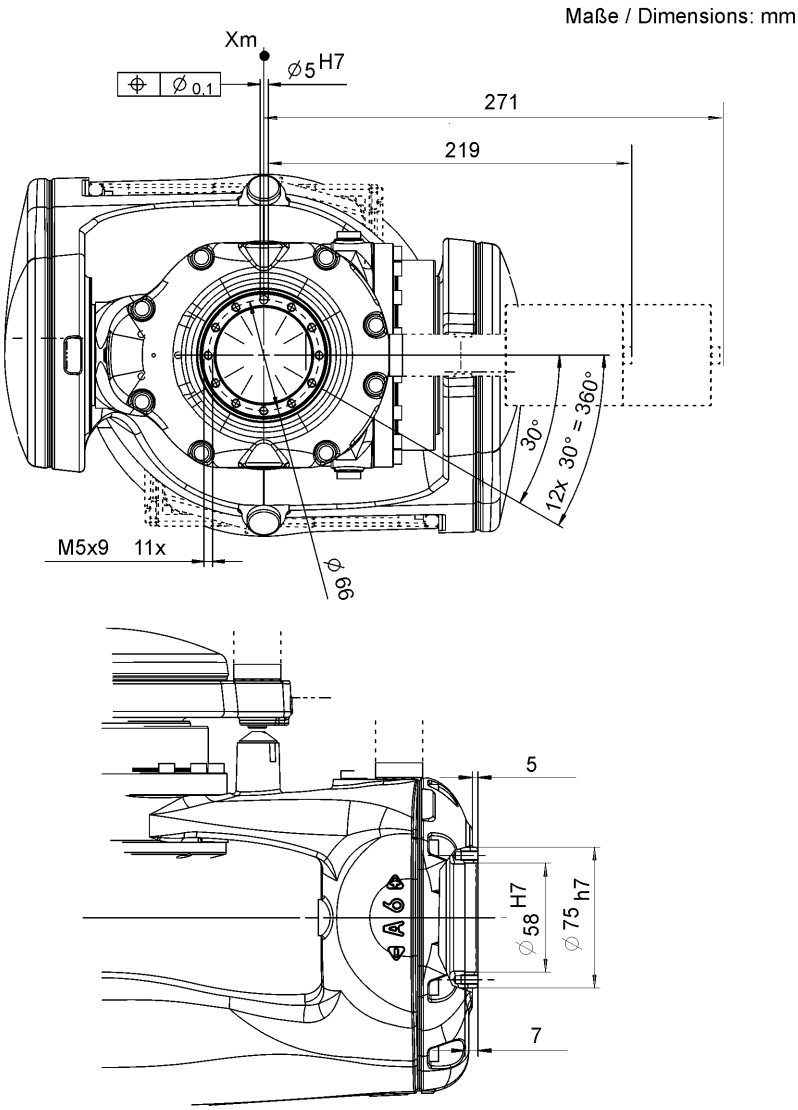


Fig. 4-6: Mounting flange, KR 16 arc HW

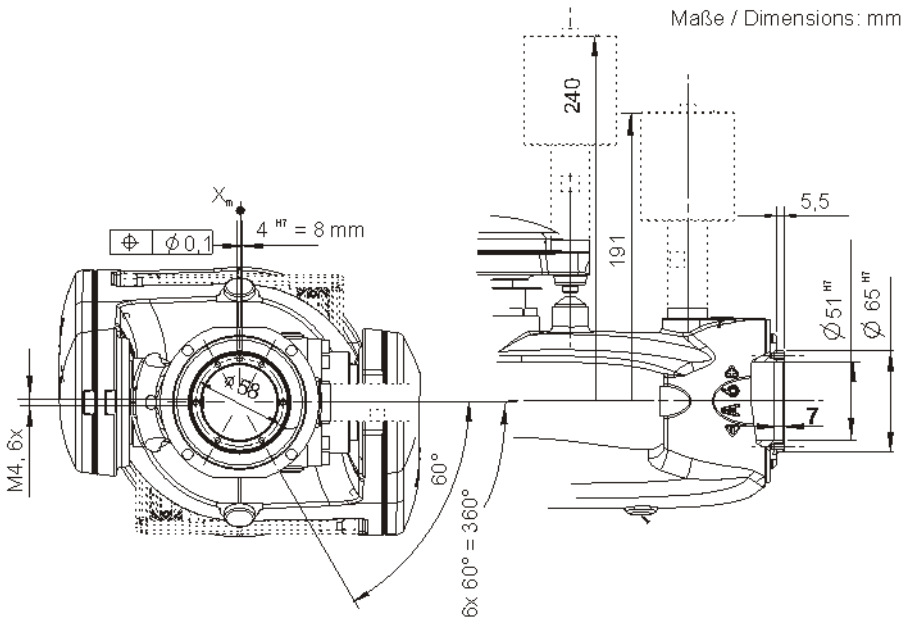


Fig. 4-7: Mounting flange, KR 16 L8 arc HW

Interface A6

The hollow-shaft wrists are provided with a special interface, interface A6, which allows welding equipment to be connected to the swivel housing. The dimensions and designs of this interface can be seen in the following illustrations.

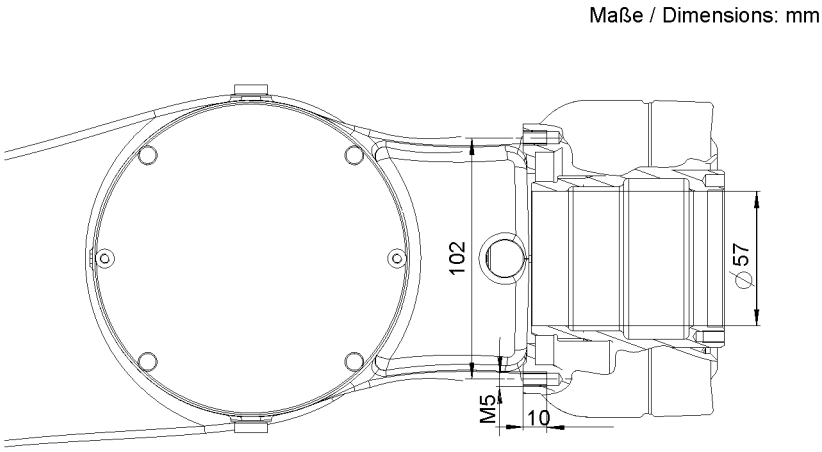


Fig. 4-8: Interface A6, IW 16 arc HW

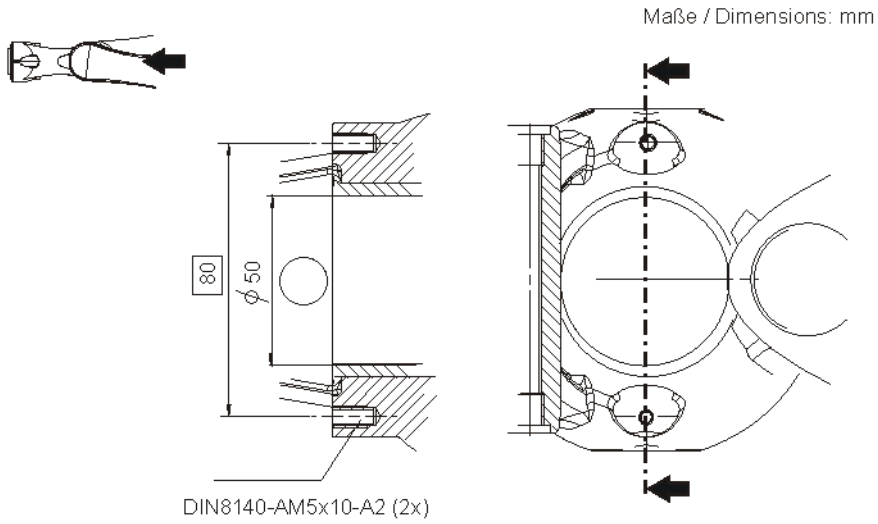


Fig. 4-9: Interface A6, IW 5 (8 kg) arc HW

Supplementary load

The robot can carry supplementary loads on the arm. When mounting the supplementary loads, be careful to observe the maximum permissible total load. The dimensions and positions of the installation options can be seen in the following diagram. These dimensions and positions are valid for KR 16 arc HW and KR 16 L8 arc HW.

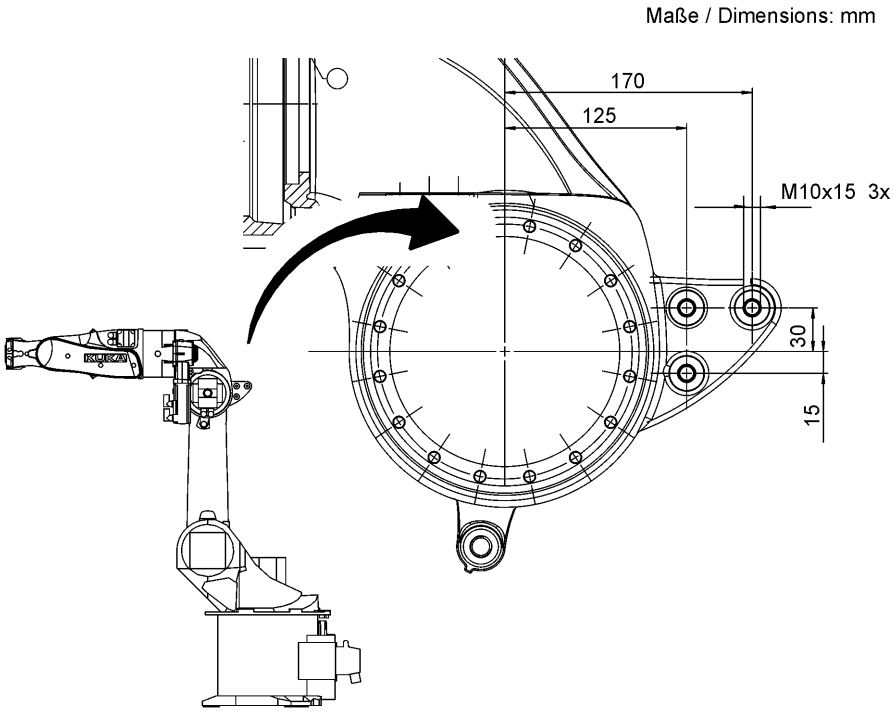


Fig. 4-10: Supplementary load on arm (example: KR 16 arc HW)

4.4 Loads acting on the mounting base

Loads acting on the mounting base

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

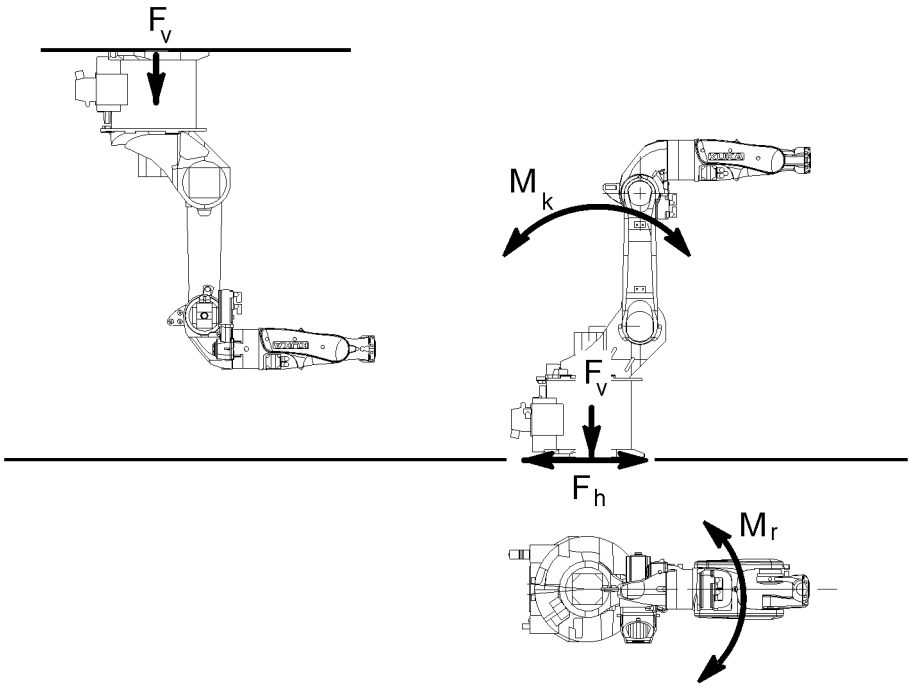


Fig. 4-11: Loads acting on the mounting base

Type of load	Force/torque/mass
F_v = vertical force	F_{vmax} = 4,600 N
F_h = horizontal force	F_{hmax} = 5,000 N
M_k = tilting moment	M_{kmax} = 5,200 Nm
M_r = torque	M_{rmax} = 4,200 Nm
Total mass for load acting on the mounting base	KR 16 arc HW: 273 kg KR 16 L8 arc HW: 258 kg
Robot	KR 16 arc HW: 245 kg KR 16 L8 arc HW: 240 kg
Total load (suppl. load on arm + rated payload)	KR 16 arc HW: 28 kg KR 16 L8 arc HW: 20 kg

The supplementary loads on the base frame and rotating column are not taken into consideration in the calculation of the mounting base load. These supplementary loads must be taken into consideration for F_v.

4.5 Transport dimensions

The transport dimensions (>>> Fig. 4-12) for the robot can be noted from the following diagram. The position of the center of mass and the weight vary according to the specific configuration. The specified dimensions refer to the robot without equipment. The following diagram shows the dimensions of the robot when it stands on the floor without wooden transport blocks.

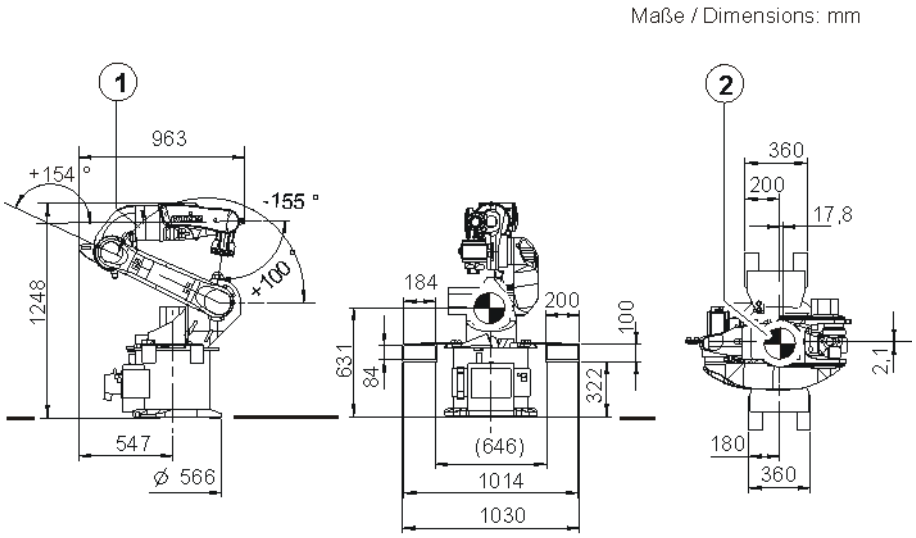


Fig. 4-12: Transport dimensions, floor-mounted robot KR 16 arc HW

1 Robot 2 Center of gravity

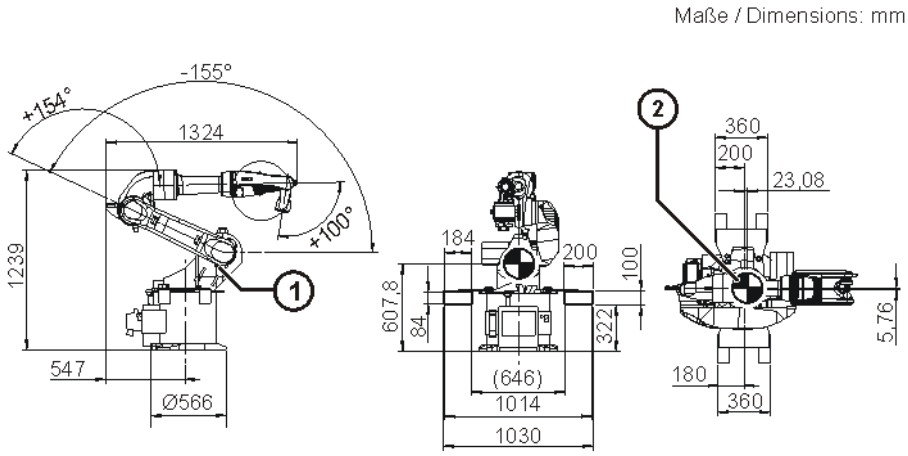


Fig. 4-13: Transport dimensions, floor-mounted robot KR 16 L8 arc HW

1 Robot 2 Center of gravity

For transporting ceiling-mounted robots in the mounting position, a transport frame is provided (>>> Fig. 4-14), which can be picked up using a crane attached to 4 eyebolts, or with a fork lift truck.

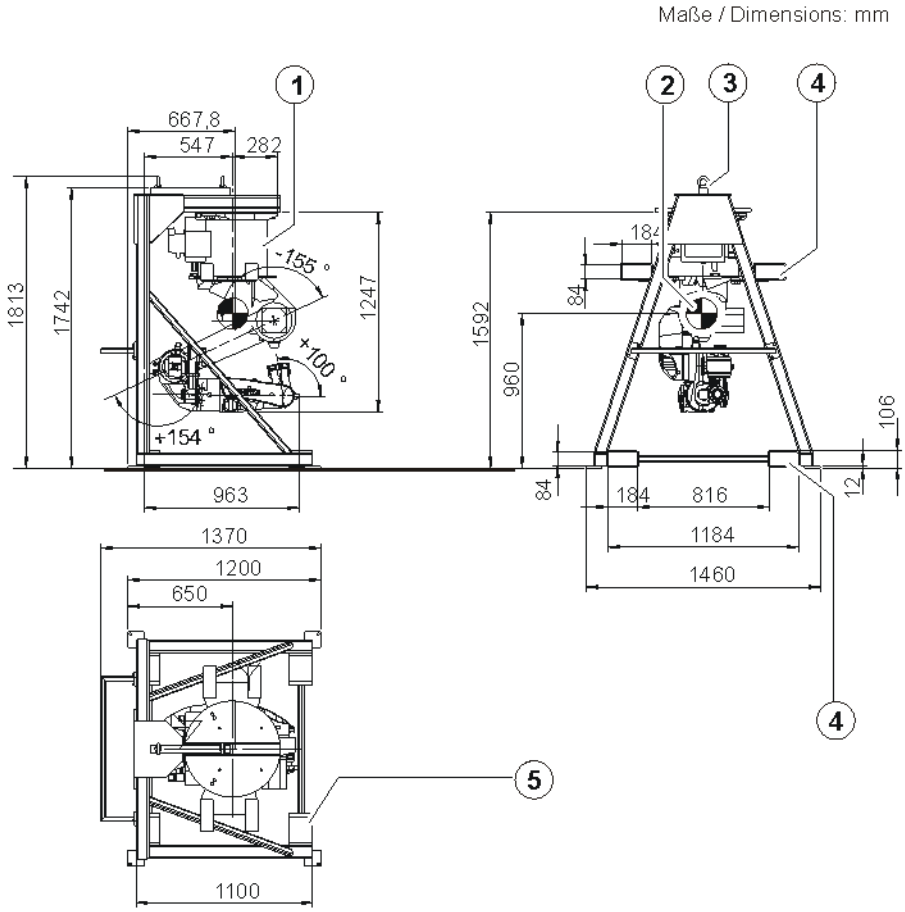


Fig. 4-14: Transport dimensions, ceiling-mounted robot KR 16 arc HW

1 Robot
2 Center of gravity
3 Eyebolts
4 Fork slots
5 Transport frame for ceiling-mounted robot

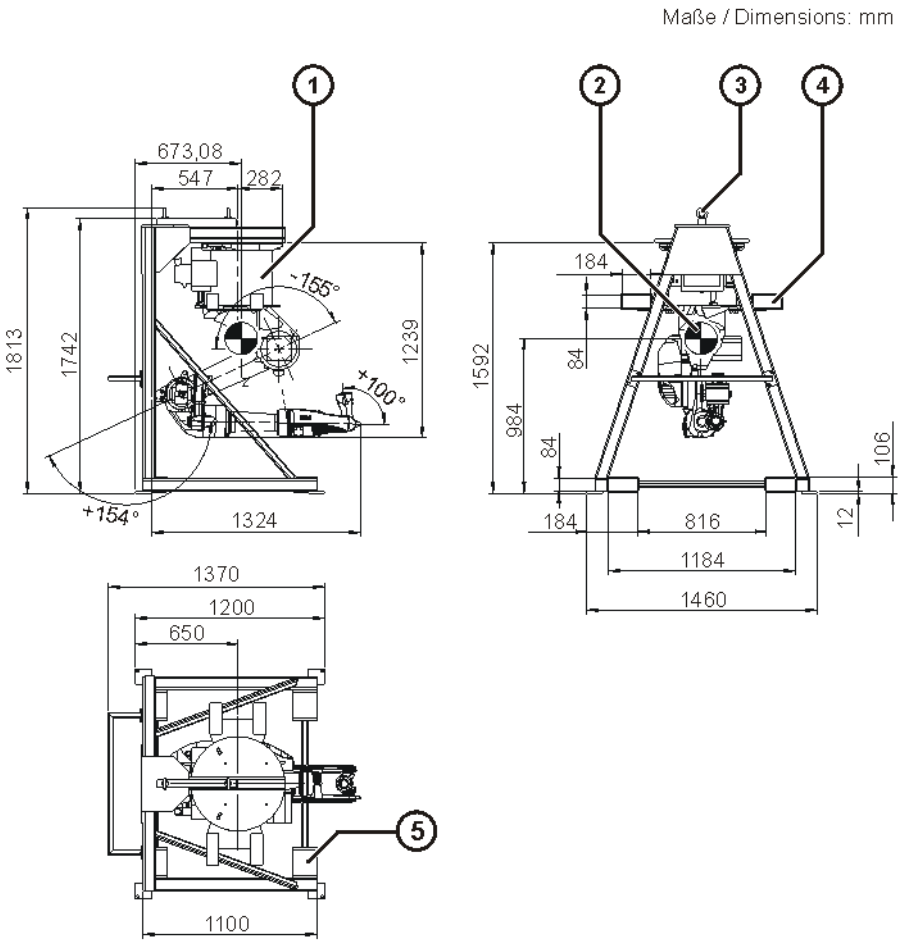


Fig. 4-15: Transport dimensions, ceiling-mounted robot KR 16 L8 arc HW

1 Robot
2 Center of gravity
3 Eyebolts
4 Fork slots
5 Transport frame for ceiling-mounted robot

4.6 Plates and labels

Plates and labels The following plates and labels are attached to the robot. They must not be removed or rendered illegible. Illegible plates and labels must be replaced.

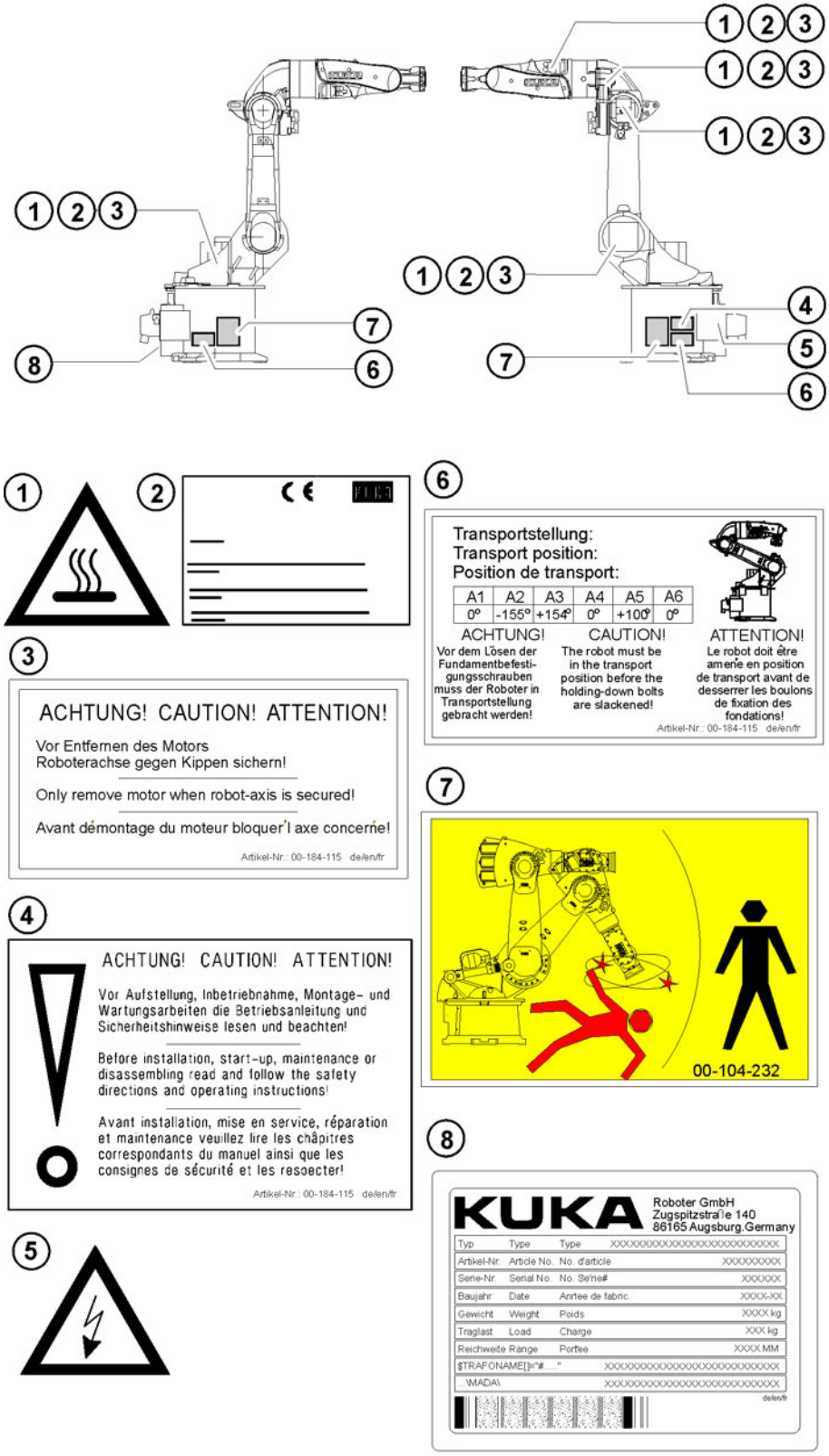


Fig. 4-16: Plates and labels

4.7 Stopping distances and times, KR 16 arc HW

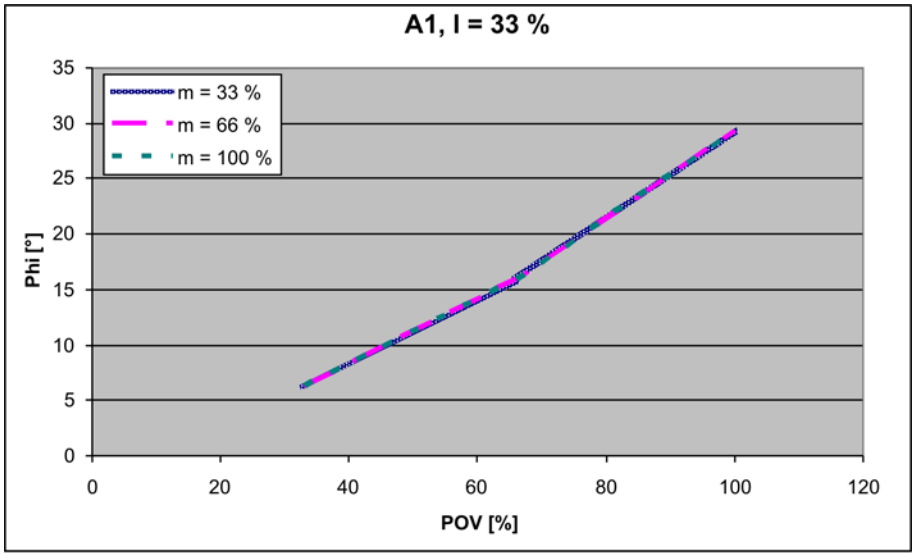
4.7.1 Stopping distances and stopping times for STOP 0, axis 1 to axis 3

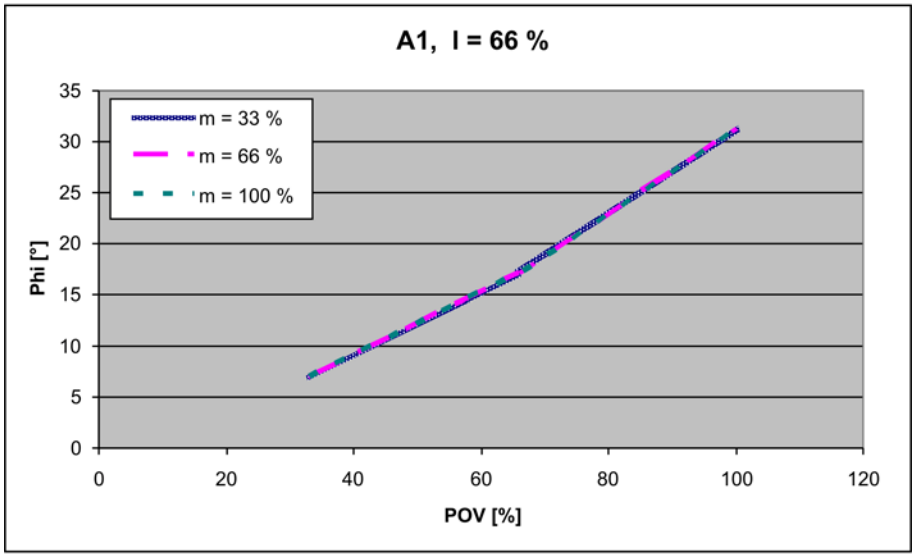
The table shows the stopping distances and stopping times after a STOP 0 (category 0 stop) is triggered. The values refer to the following configuration:

- Extension l = 100%
- Program override POV = 100%
- Mass m = maximum load (rated load + supplementary load on arm)

	Stopping distance (°)	Stopping time (s)
Axis 1	42.16	0.387
Axis 2	41.35	0.385
Axis 3	33.51	0.266

4.7.2 Stopping distances and stopping times for STOP 1, axis 1





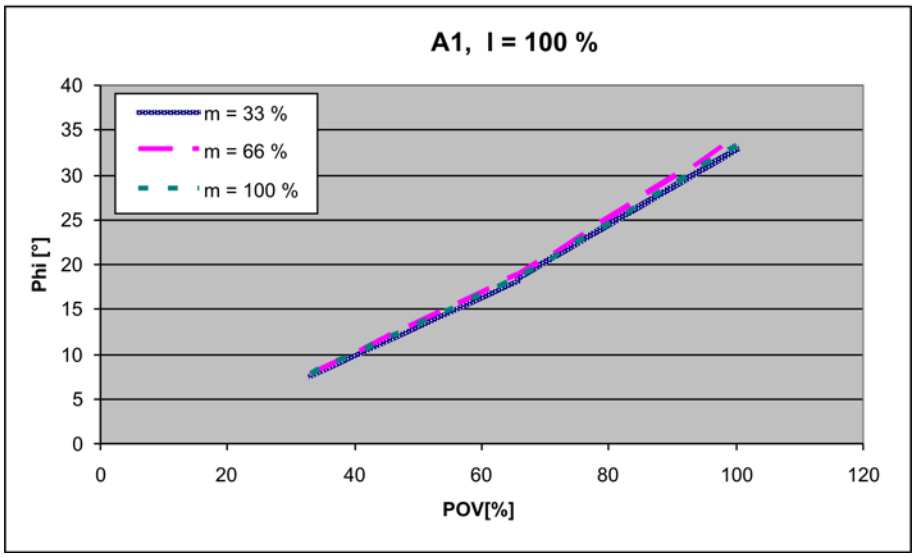


Fig. 4-17: Stopping distances for STOP 1, axis 1

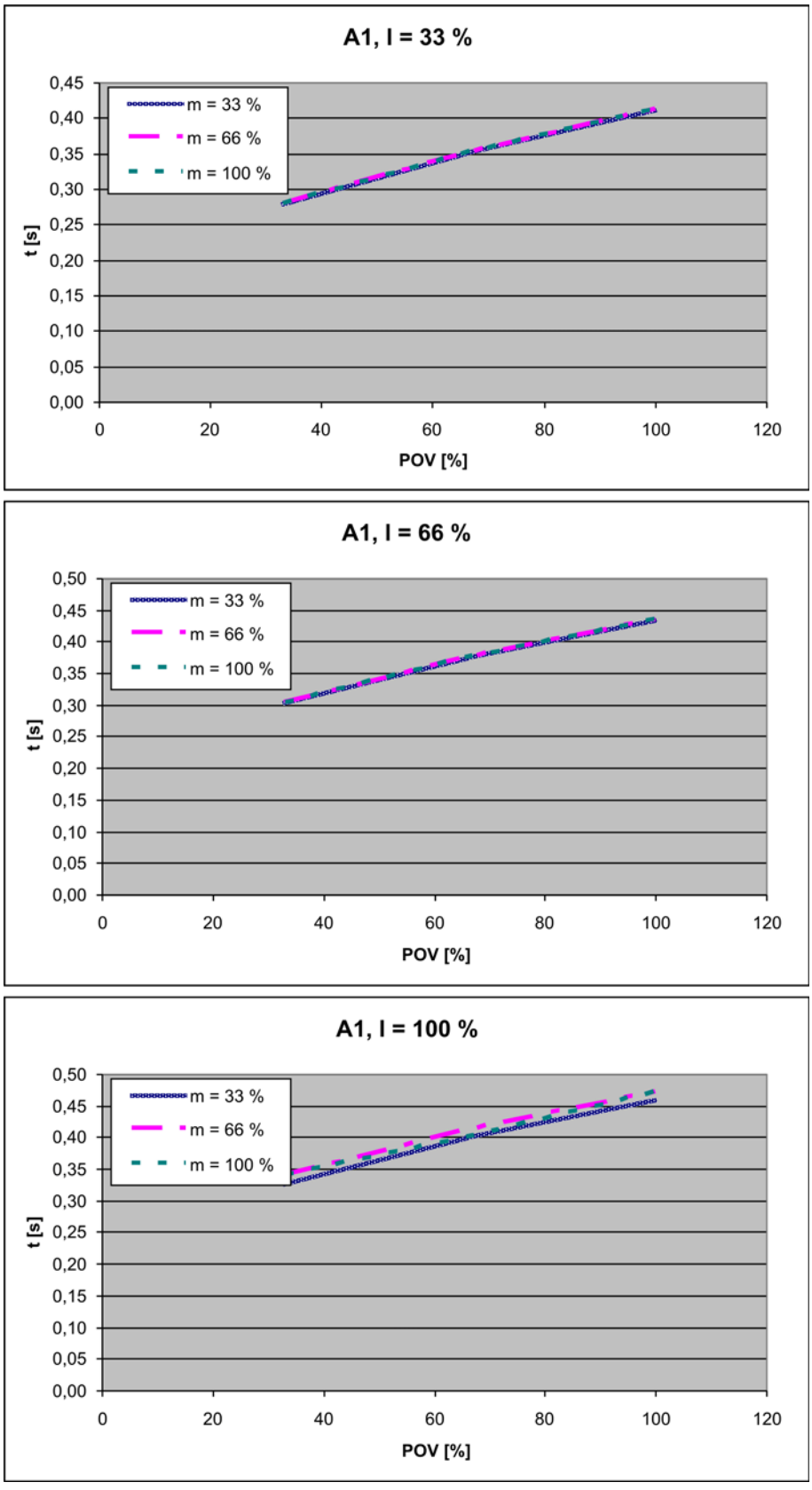


Fig. 4-18: Stopping times for STOP 1, axis 1

4.7.3 Stopping distances and stopping times for STOP 1, axis 2

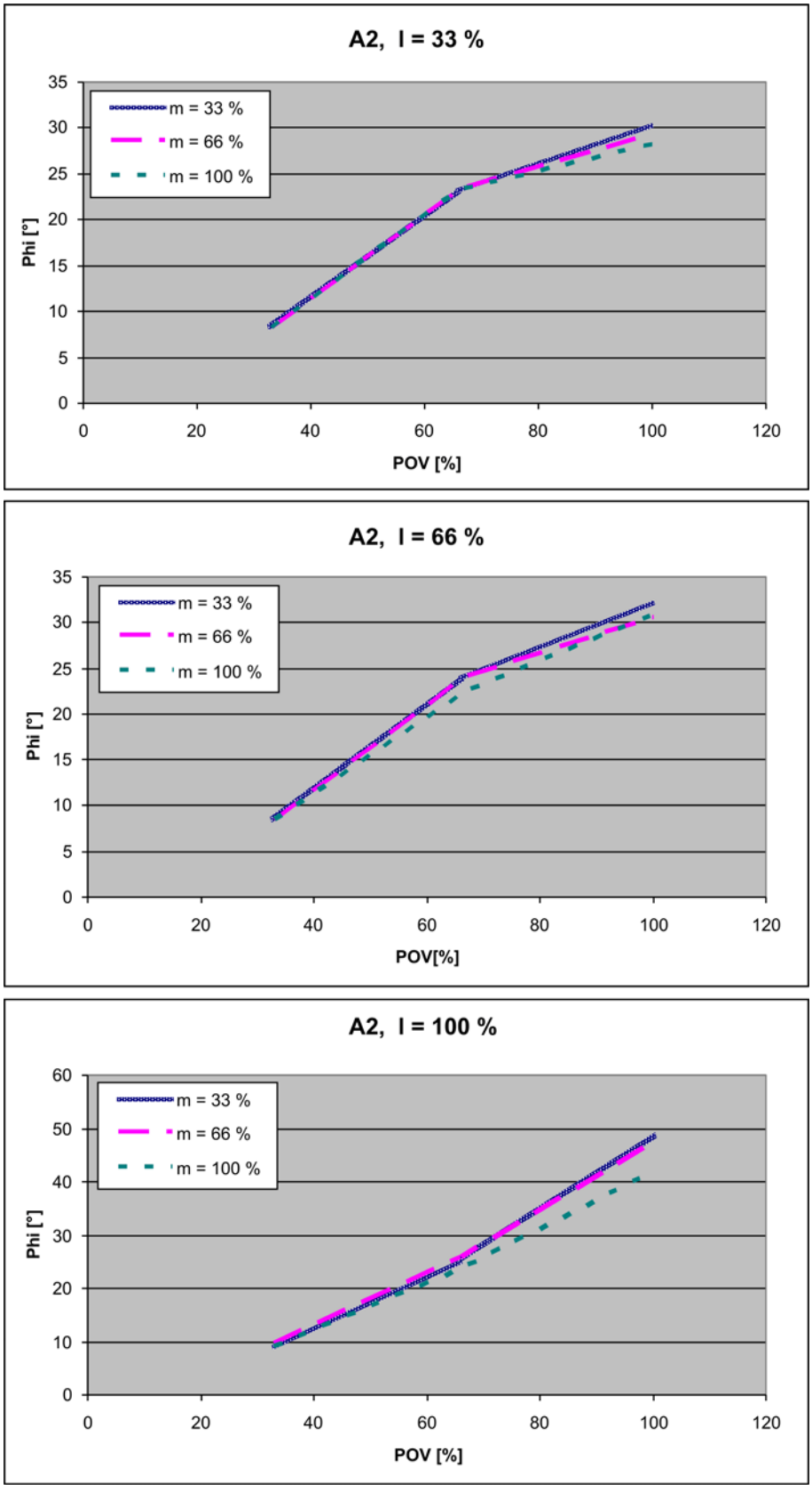


Fig. 4-19: Stopping distances for STOP 1, axis 2

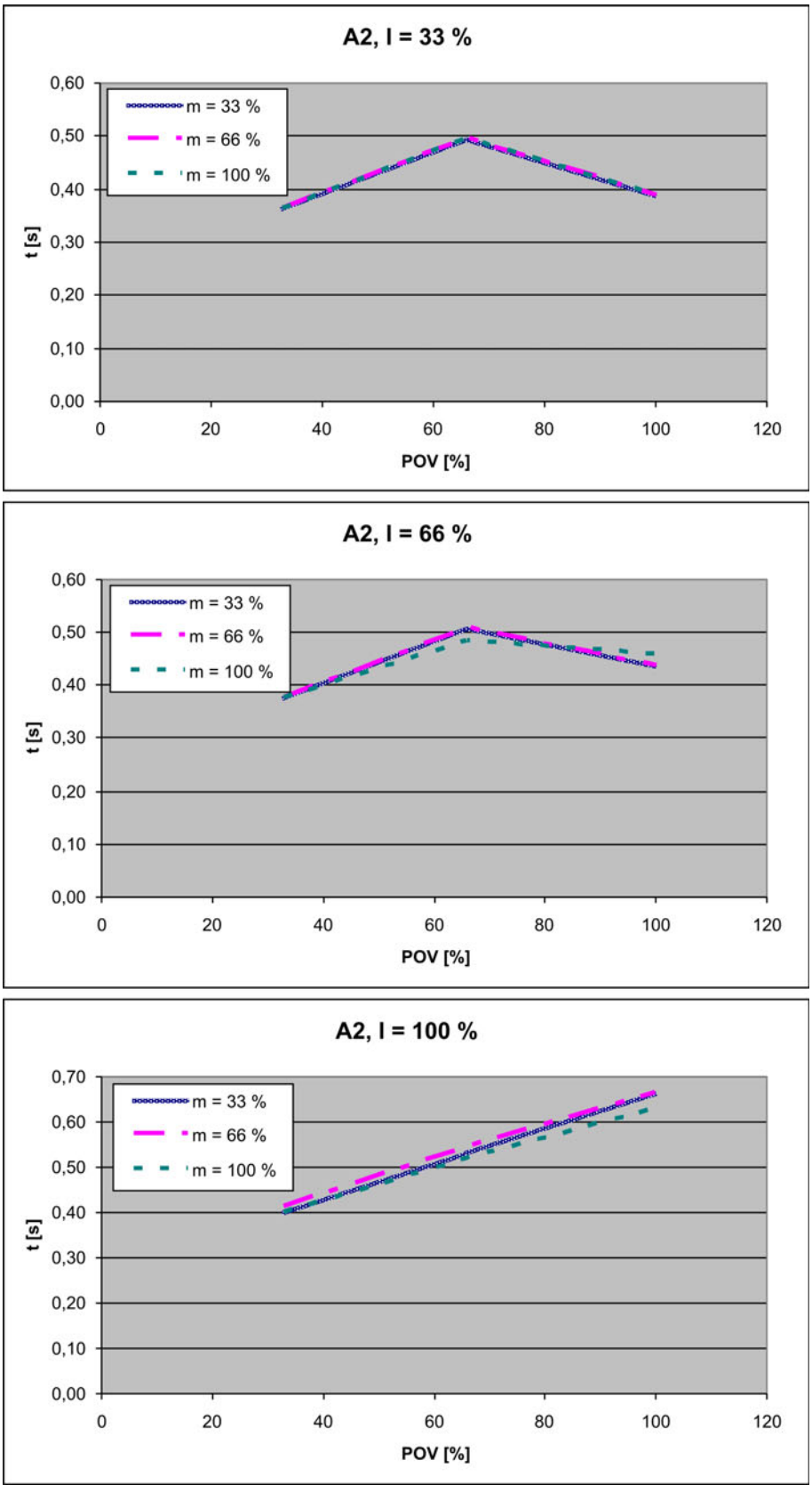


Fig. 4-20: Stopping times for STOP 1, axis 2

4.7.4 Stopping distances and stopping times for STOP 1, axis 3

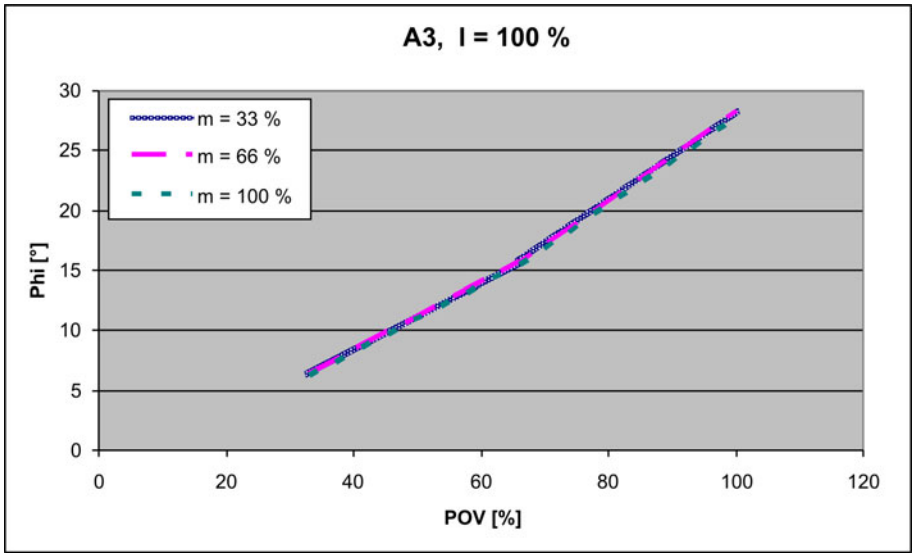


Fig. 4-21: Stopping distances for STOP 1, axis 3

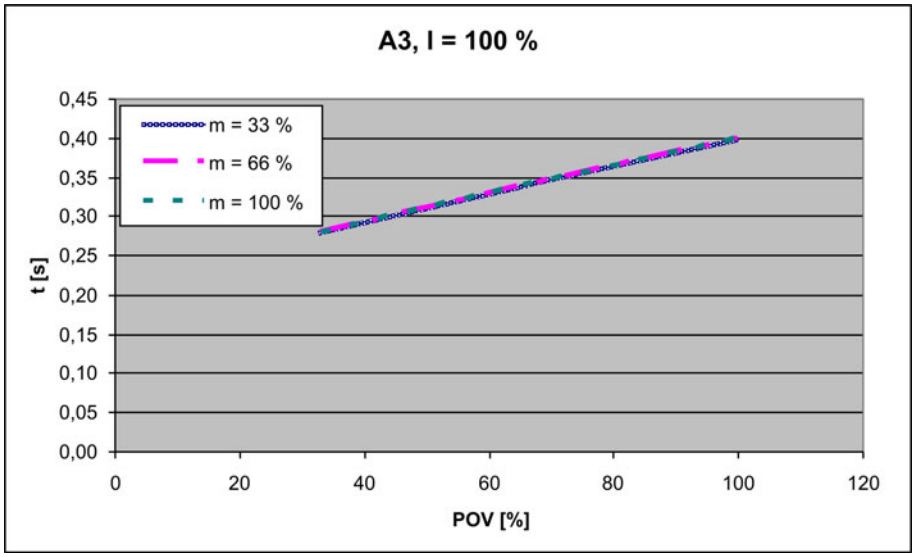


Fig. 4-22: Stopping times for STOP 1, axis 3

4.8 Stopping distances and times, KR 16 L8 arc HW

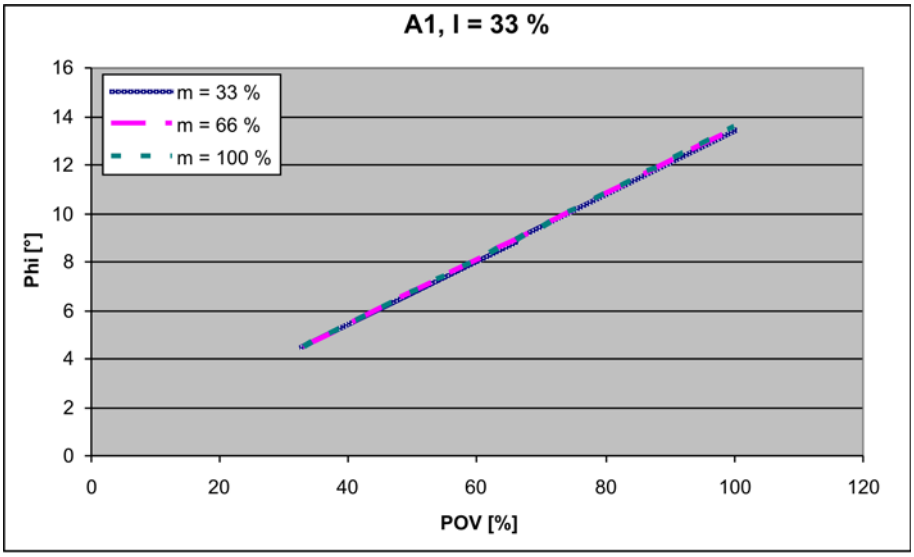
4.8.1 Stopping distances and stopping times for STOP 0, axis 1 to axis 3

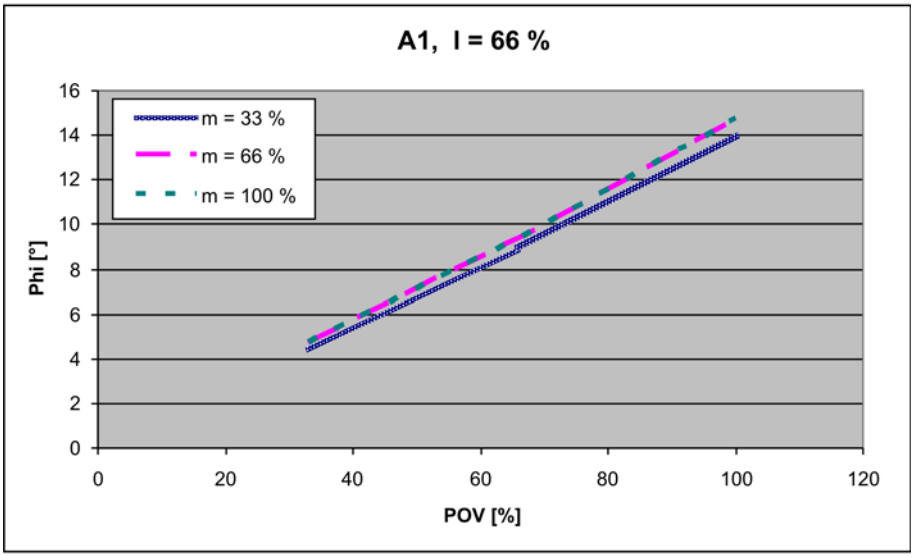
The table shows the stopping distances and stopping times after a STOP 0 (category 0 stop) is triggered. The values refer to the following configuration:

- Extension I = 100%
- Program override POV = 100%
- Mass m = maximum load (rated load + supplementary load on arm)

	Stopping distance (°)	Stopping time (s)
Axis 1	30.49	0.343
Axis 2	31.00	0.324
Axis 3	23.70	0.271

4.8.2 Stopping distances and stopping times for STOP 1, axis 1





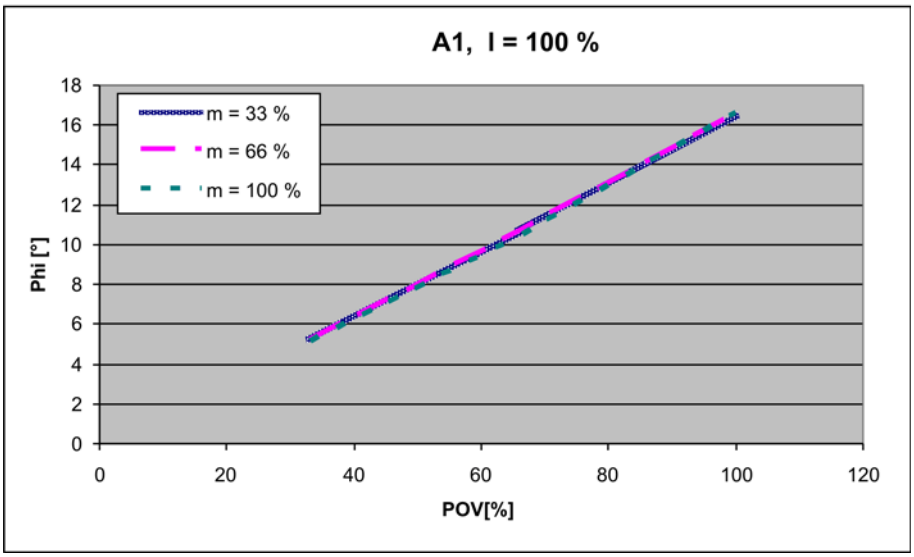


Fig. 4-23: Stopping distances for STOP 1, axis 1

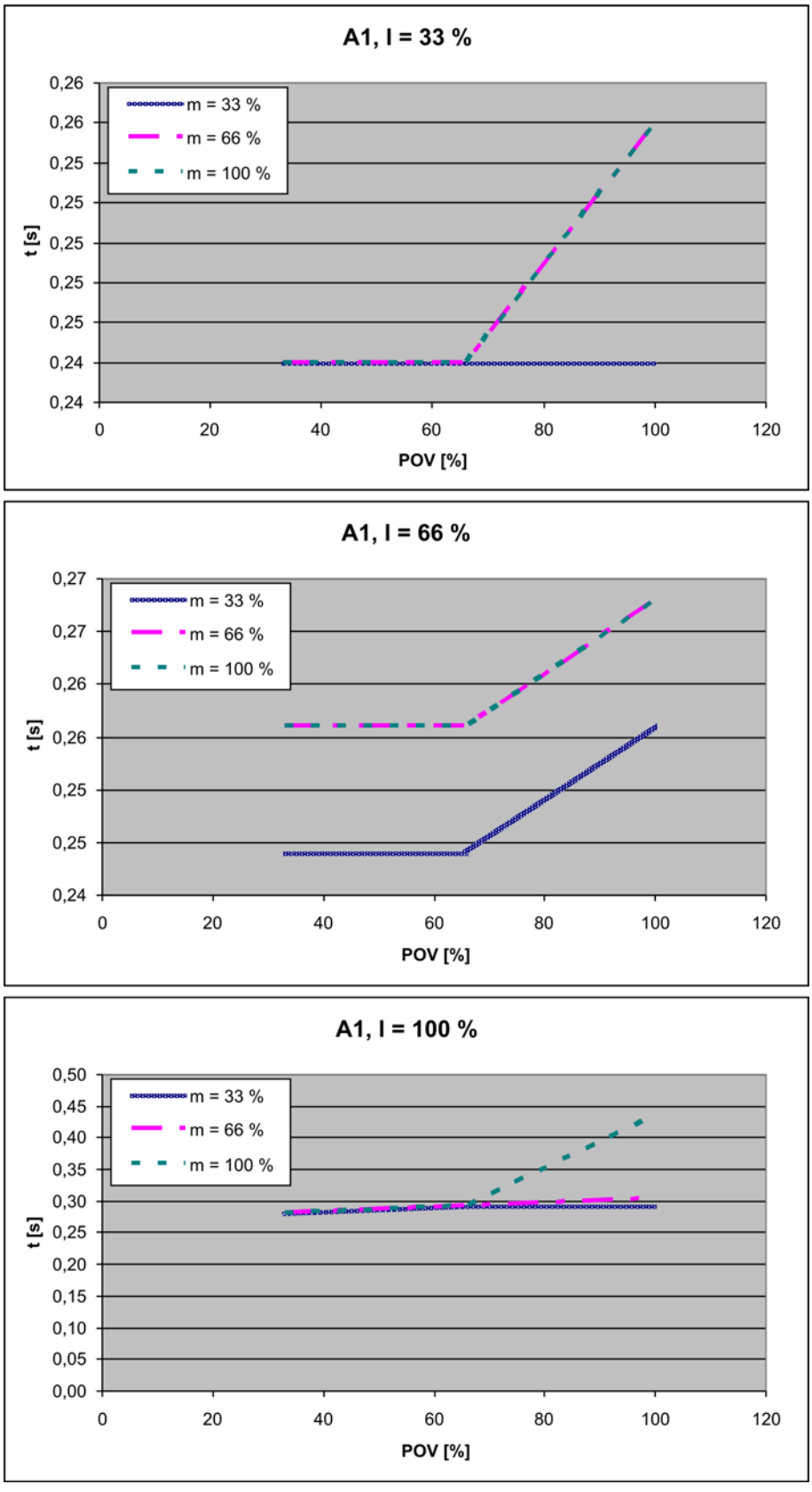


Fig. 4-24: Stopping times for STOP 1, axis 1

4.8.3 Stopping distances and stopping times for STOP 1, axis 2

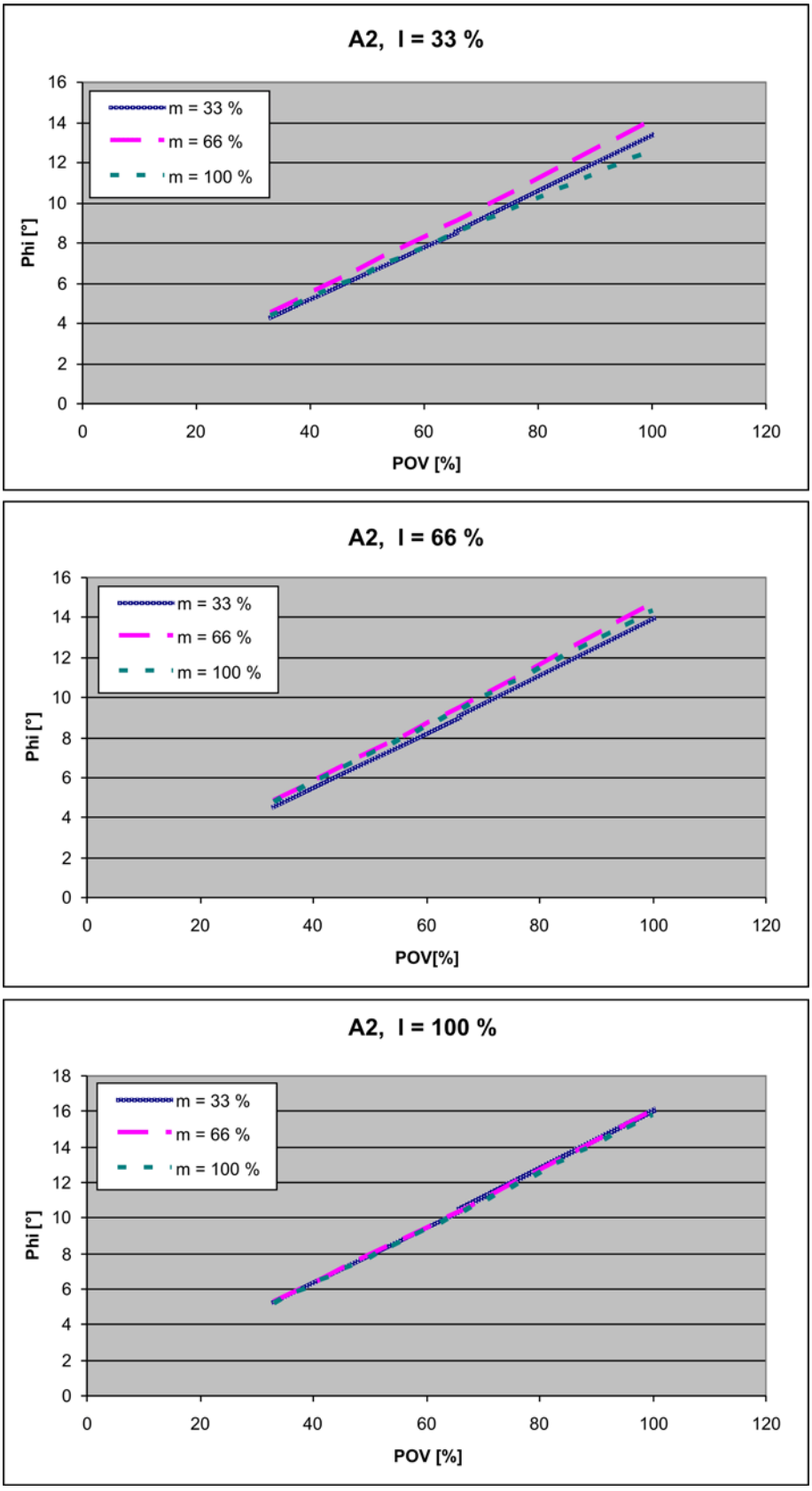


Fig. 4-25: Stopping distances for STOP 1, axis 2

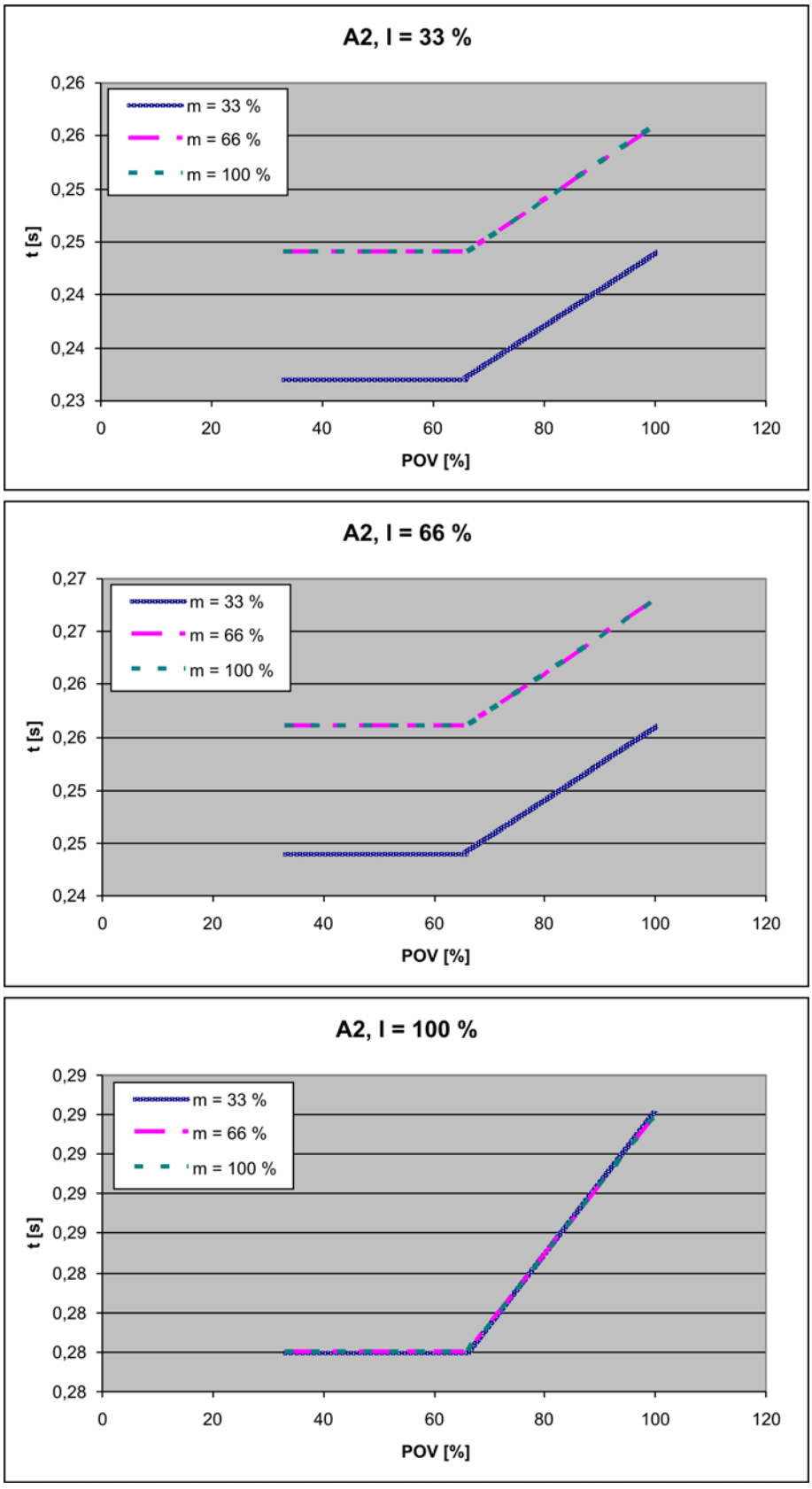


Fig. 4-26: Stopping times for STOP 1, axis 2

4.8.4 Stopping distances and stopping times for STOP 1, axis 3

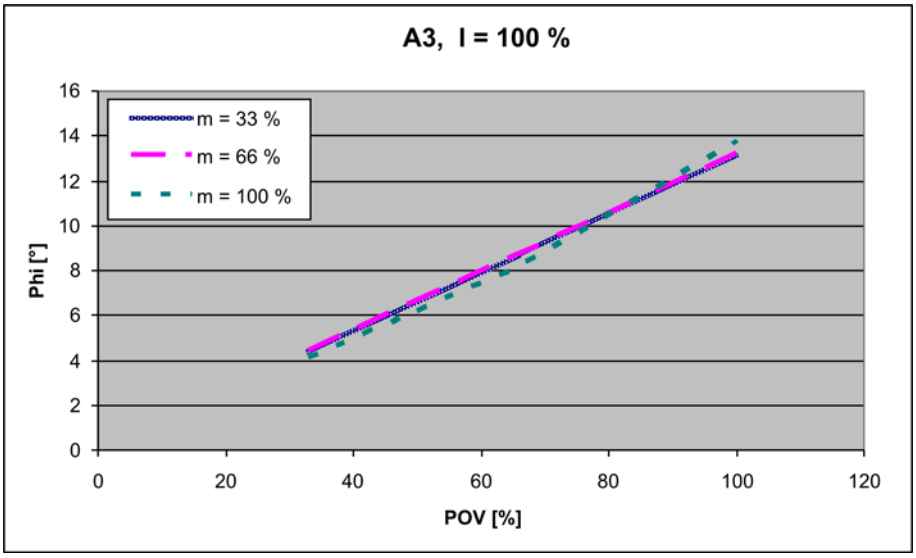


Fig. 4-27: Stopping distances for STOP 1, axis 3

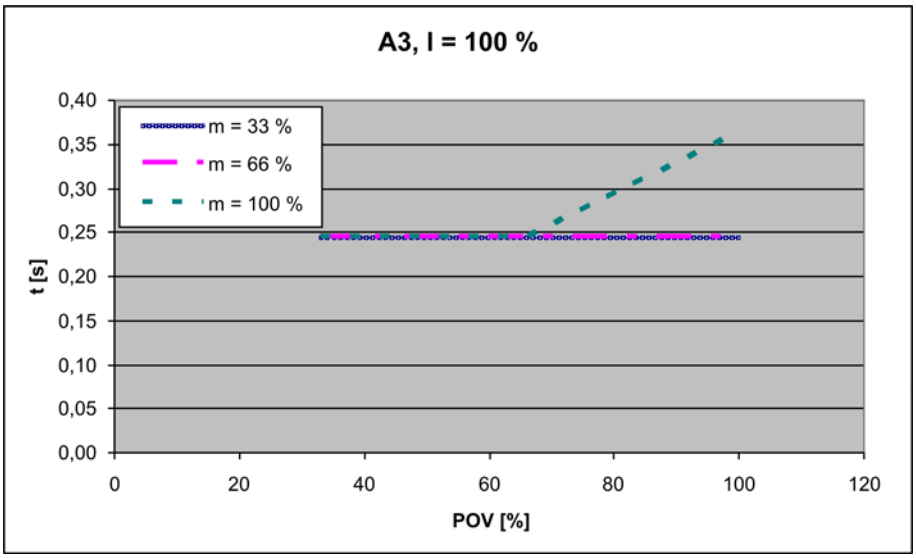


Fig. 4-28: Stopping times for STOP 1, axis 3

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 designated 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 safety 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 industrial robot.

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
- Underground 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 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. The KCP variant for the KR C4 is called KUKA smartPAD. The general term “KCP”, however, is generally used in this documentation.
KUKA smartPAD	See KCP
Manipulator	The robot arm and the associated electrical installations
Safety zone	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

Operator

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	Operator	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
Start-up			x
Maintenance			x
Repair			x
Shutting down			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

Workspaces 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.

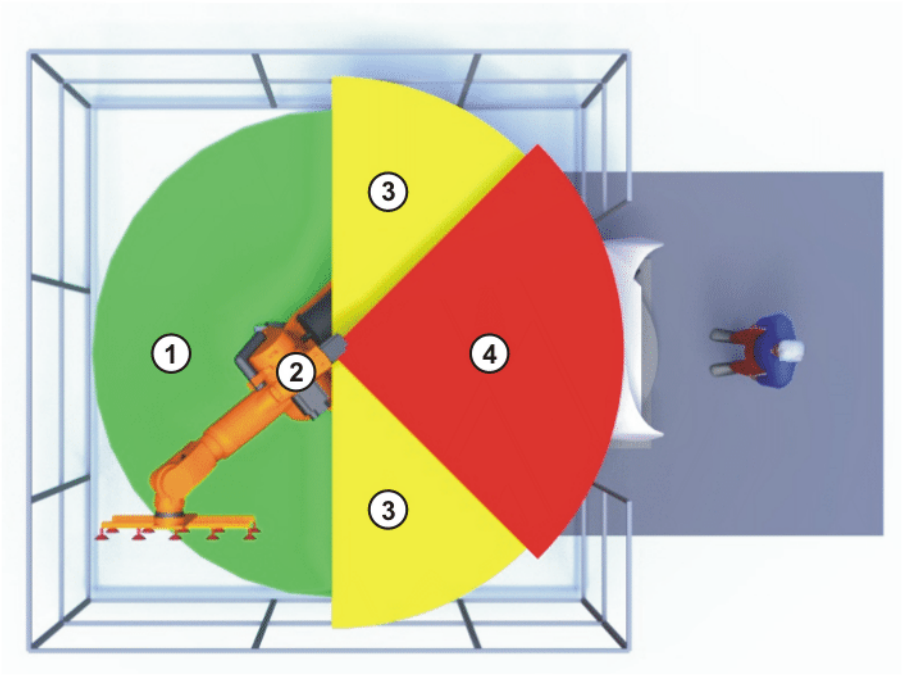


Fig. 5-1: Example of axis range A1

1	Workspace	3	Stopping distance
2	Manipulator	4	Safety zone

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.

⚠ WARNING 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 (>>> 14 "KUKA Service" Page 193).

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 Options for moving the manipulator without the robot controller

Description

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

- Release device (optional)

  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 (option)

  The brake release device is designed for robot variants whose motors are not freely accessible.
- Moving the wrist axes directly by hand

  In the case of the low payload category, no release device for the wrist axes is available. A release device is not necessary, as the wrist axes can be moved directly by hand.

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

Information on the availability of options for specific robot models can be obtained from KUKA Roboter GmbH.

CAUTION 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:

SAFETY INSTRUCTIONS The following procedure must be followed exactly!

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.

⚠ WARNING 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 motor must be exchanged.

⚠ WARNING If a robot axis has been moved by the release device, all robot axes must be remastered. Serious infuries or damage to property may otherwise result.

Procedure **Moving the manipulator with the brake release device:**

⚠ WARNING 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.

SAFETY INSTRUCTIONS The following procedure must be followed exactly!

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 measures

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.

⚠ DANGER 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.

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

⚠ CAUTION 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.

⚠ WARNING 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 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 (tag-out).
- 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 prescribed transport position of the robot controller must be observed. Transportation must be carried out in accordance with the operating instructions or assembly instructions of the robot controller.

Avoid vibrations and impacts during transportation in order to prevent damage to the robot controller.

External axis (optional)

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

NOTICE 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.

⚠ WARNING 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 functions 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.

⚠ WARNING 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 numbers 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

Name	Definition	Edition
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 Planning

6.1 Mounting base with centering

Description

The mounting base with centering is used when the robot is fastened to the floor, i.e. directly on a concrete foundation. There are two variants available, which differ in their construction and method of installation. The installation dimensions on the concrete foundation and the interface dimensions for the robot are identical, however.

- Variant 1: Mounting base with centering (resin capsule)
- Variant 2: Mounting base with centering (resin cartridge)

Both mounting base variants consist of:

- Bedplates
- Resin-bonded anchors
- Fasteners

These mounting variants require a level and smooth surface on a concrete foundation with adequate load bearing capacity.

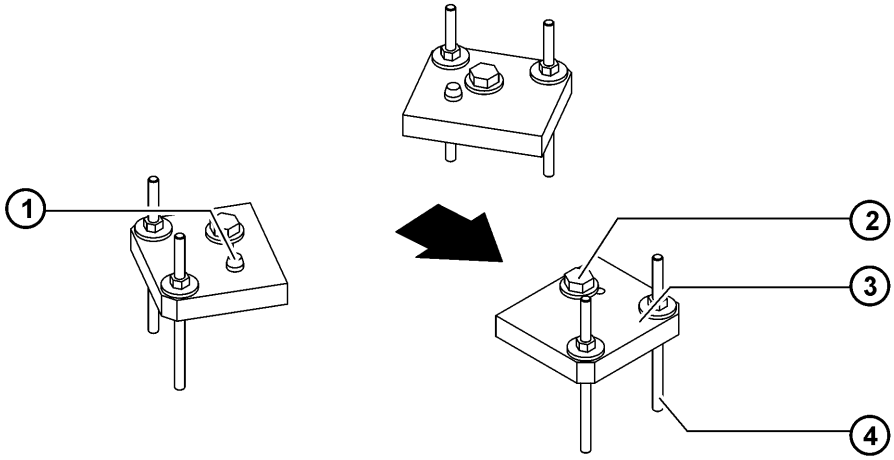


Fig. 6-1: Mounting base with centering

1 Locating pin for centering
2 Hexagon bolt
3 Bedplate
4 Resin-bonded anchor

Grade of concrete for foundations

When producing foundations from concrete, observe the load-bearing capacity of the ground and the country-specific construction regulations. There must be no layers of insulation or screed between the bedplates and the concrete foundation. The quality of the concrete must meet the requirements of the following standard:

- C20/25 according to DIN EN 206-1:2001/DIN 1045-2:2008

Dimensioned drawing

The following illustration (>>> Fig. 6-2) provides all the necessary information on the mounting base, together with the required foundation data.

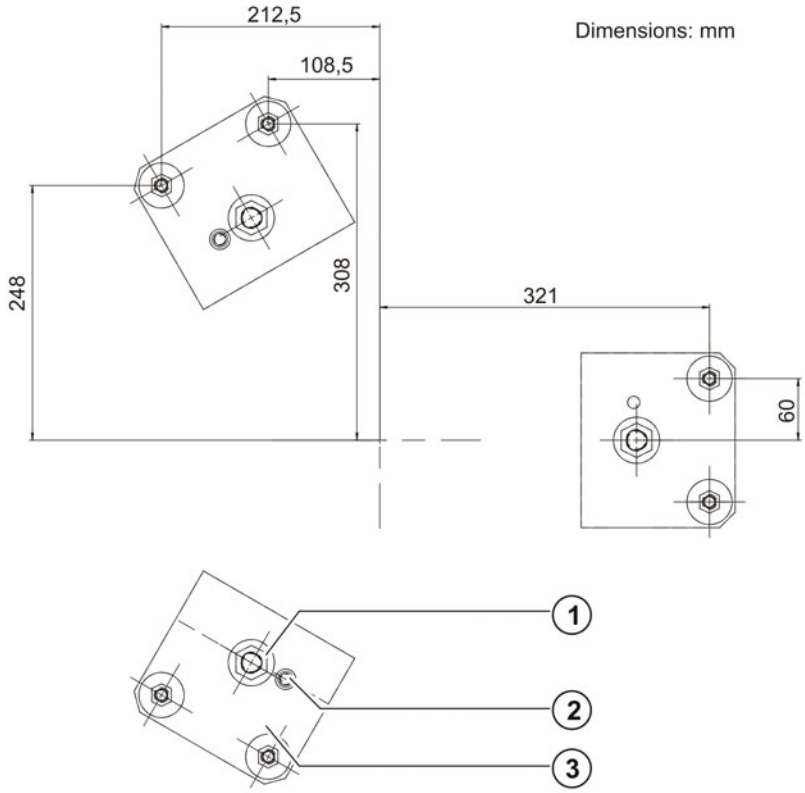


Fig. 6-2: Mounting base with centering, dimensioned drawing

1 Hexagon bolts
2 Locating pin
3 Bedplate

To ensure that the anchor forces are safely transmitted to the foundation, observe the dimensions for concrete foundations specified in the following illustration (>>> Fig. 6-3).

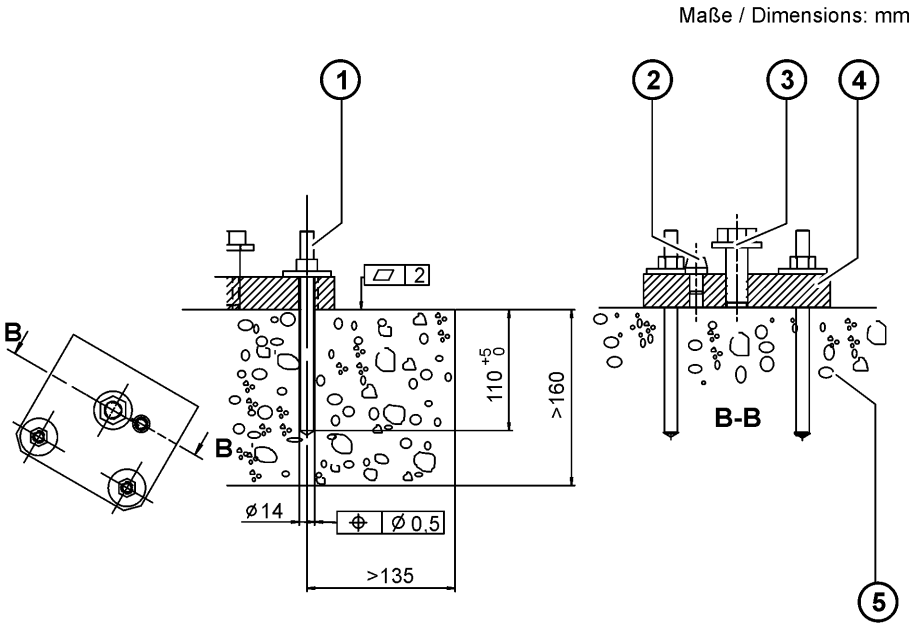


Fig. 6-3: Cross-section of foundations

1	Anchor	4	Bedplate
2	Locating pin	5	Concrete foundation
3	Hexagon bolt		

6.2 Machine frame mounting with centering

Description

The machine frame mounting (>>> Fig. 6-4) with centering is used for installing the robot on a steel structure provided by the customer or on a carriage of a KUKA linear unit. The mounting surface for the robot must be machined and of an appropriate quality. The robot is fastened to the machine frame mounting option using 3 hexagon bolts. Two locating pins are used for centering.

The machine frame mounting assembly consists of:

- Locating pins
- Hexagon bolts with conical spring washers

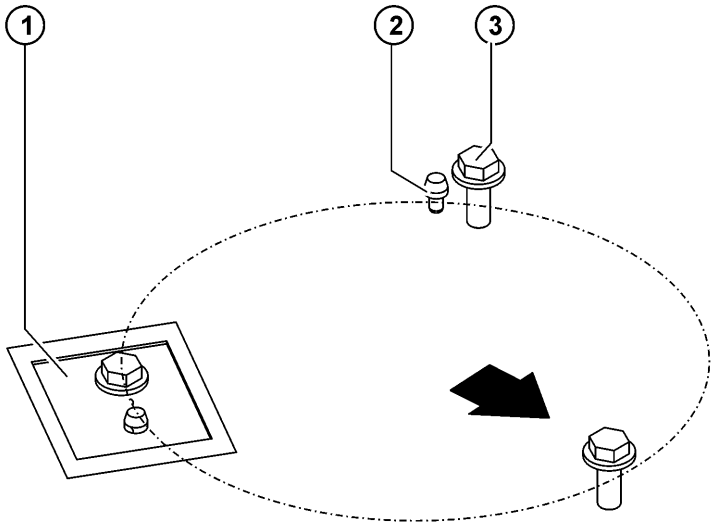


Fig. 6-4: Machine frame mounting

1	Mounting surface
2	Locating pin
3	Hexagon bolt with conical spring washer

Dimensioned drawing

The following illustrations provide all the necessary information on machine frame mounting, together with the required foundation data.

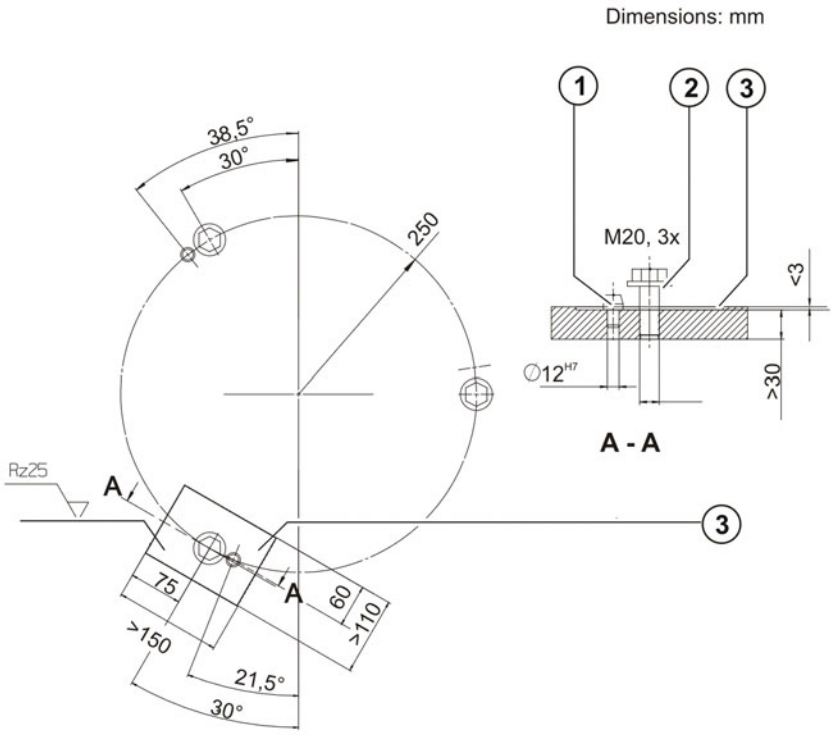


Fig. 6-5: Machine frame mounting, dimensioned drawing

1 Locating pin
2 Hexagon bolt
3 Mounting surface, machined

6.3 Adapter plate

Description

The adapter plate enables the robot to be fastened to

- mounting bases
- steel structures
- carriages of KUKA linear units

which are already equipped with the hole pattern for the KR 6.

The mounting surface for the adapter plate (>>> Fig. 6-6) must be machined and of an appropriate quality. The adapter plate is fastened to the mounting base with the KR 6 hole pattern with 3 Allen screws. 2 pins are used for centering. For fastening the robot to the adapter platte, the “machine frame mounting” assembly with 3 hexagon bolts is required, together with 2 locating pins for centering.

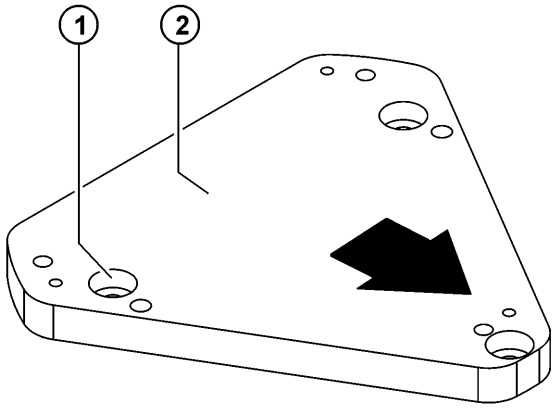


Fig. 6-6: Adapter plate

1 Fastening hole
2 Adapter plate

The size and dimensions of the adapter plate (>>> Fig. 6-7) are given in the following diagram.

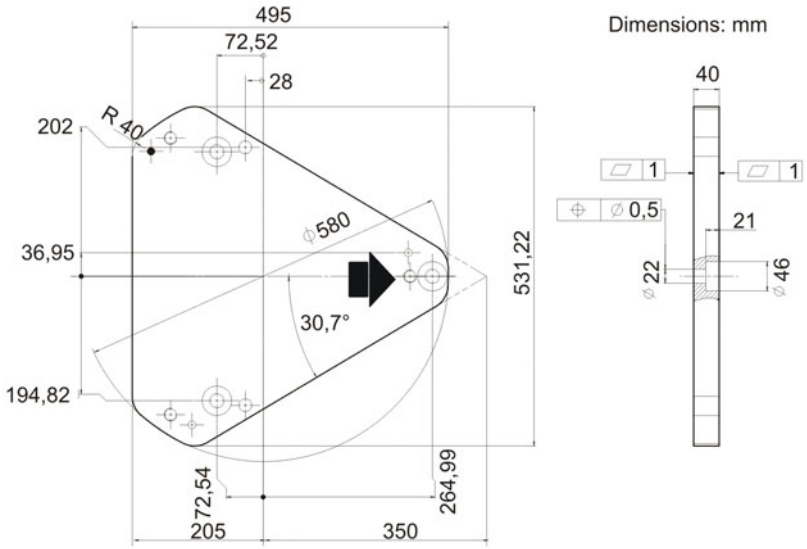


Fig. 6-7: Adapter plate

6.4 Connecting cables and interfaces

The following points must be observed when planning and routing the connecting cables:

- The bending radius for fixed routing must not be less than 150 mm for motor cables and 60 mm for control cables.
- Protect cables against exposure to mechanical stress.
- Route the cables without mechanical stress – no tensile forces on the connectors
- Cables are only to be installed indoors.

- Observe permissible temperature range (fixed installation) of 263 K (-10 °C) to 343 K (+70 °C).
- Route the motor cables and the data cables separately in metal ducts; if necessary, additional measures must be taken to ensure electromagnetic compatibility (EMC).

Interface for energy supply systems

The robot can be equipped with an energy supply system between axis 1 and axis 3 and a second energy supply system between axis 3 and axis 6. The A1 interface required for this is located on the rear of the base frame, the A3 interface is located on the side of the arm and the interface for axis 6 is located on the robot tool. Depending on the application, the interfaces differ in design and scope. They can be equipped e.g. with connections for cables and hoses. Detailed information on the connector pin allocation, threaded unions, etc. is given in separate documentation.

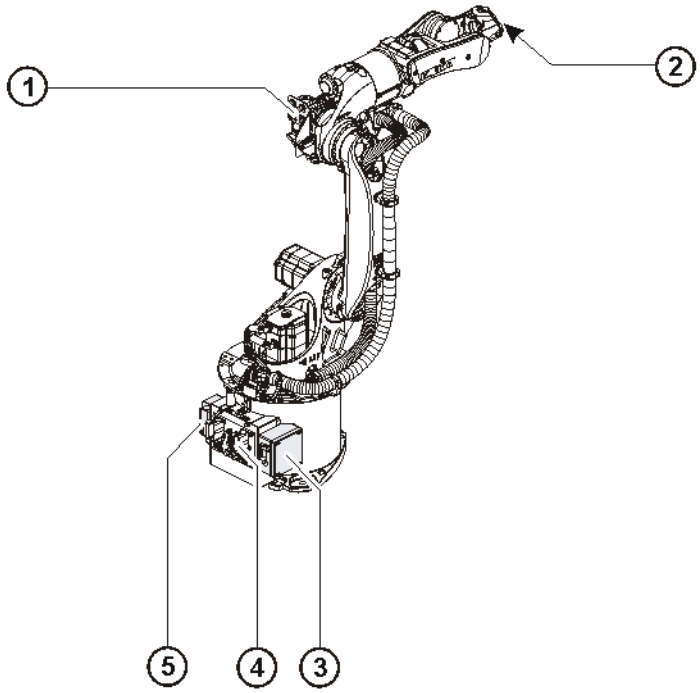


Fig. 6-8: Connecting cables and interfaces

1 Interface A3, arm
2 Interface A6, tool
3 Junction box, control cable X31
2nd control cable X41 (for SafeRobot only)
4 Interface A1, energy supply system
5 Connection, motor cable X30

7 Transportation

7.1 Transporting the robot

Move the robot into its transport position (>>> Fig. 7-1) each time it is transported. It must be ensured that the robot is stable while it is being transported. The robot must remain in its transport position until it has been fastened in position. Before the robot is lifted, it must be ensured that it is free from obstructions. Remove all transport safeguards, such as nails and screws, in advance. First remove any rust or glue on contact surfaces.

Transport position

The transport position is the same for both floor-mounted and ceiling-mounted robots. The robot is in the transport position when the axes are in the following positions:

Axis	A1	A2	A3	A4	A5	A6
Angle	0°	-155°	+154°	0°	+100°	0°

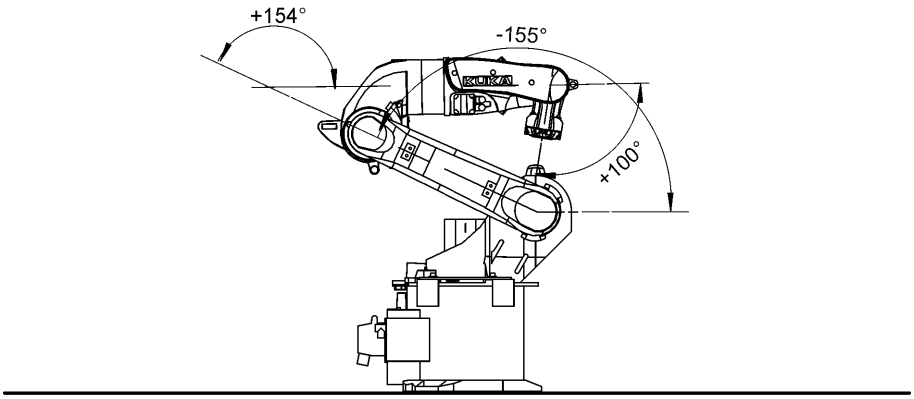


Fig. 7-1: Transport position

Transport dimensions

The transport dimensions for the robot can be noted from the following figures. The position of the center of mass and the weight vary according to the specific configuration. The specified dimensions refer to the robot without equipment.

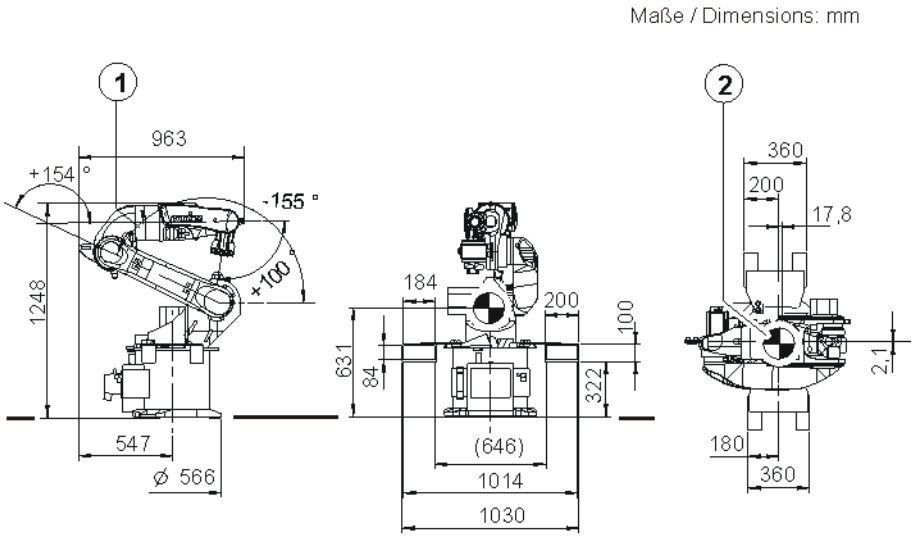


Fig. 7-2: Transport dimensions, floor-mounted robot KR 16 arc HW

1 Robot 2 Center of gravity

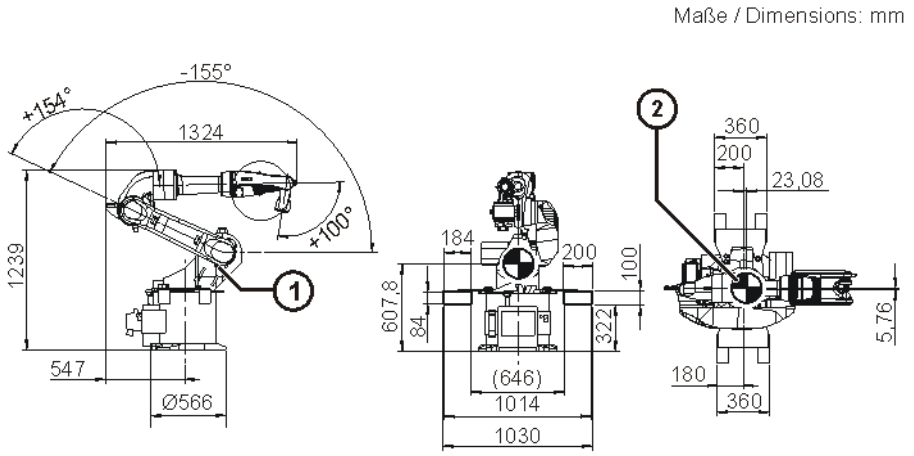


Fig. 7-3: Transport dimensions, floor-mounted robot KR 16 L8 arc HW

1 Robot 2 Center of gravity

Ceiling-mounted robots can also be transported in a transport frame, already in the correct orientation. The transport frame can be picked up with a fork lift truck via the fork slots, or with a crane via eyebolts.

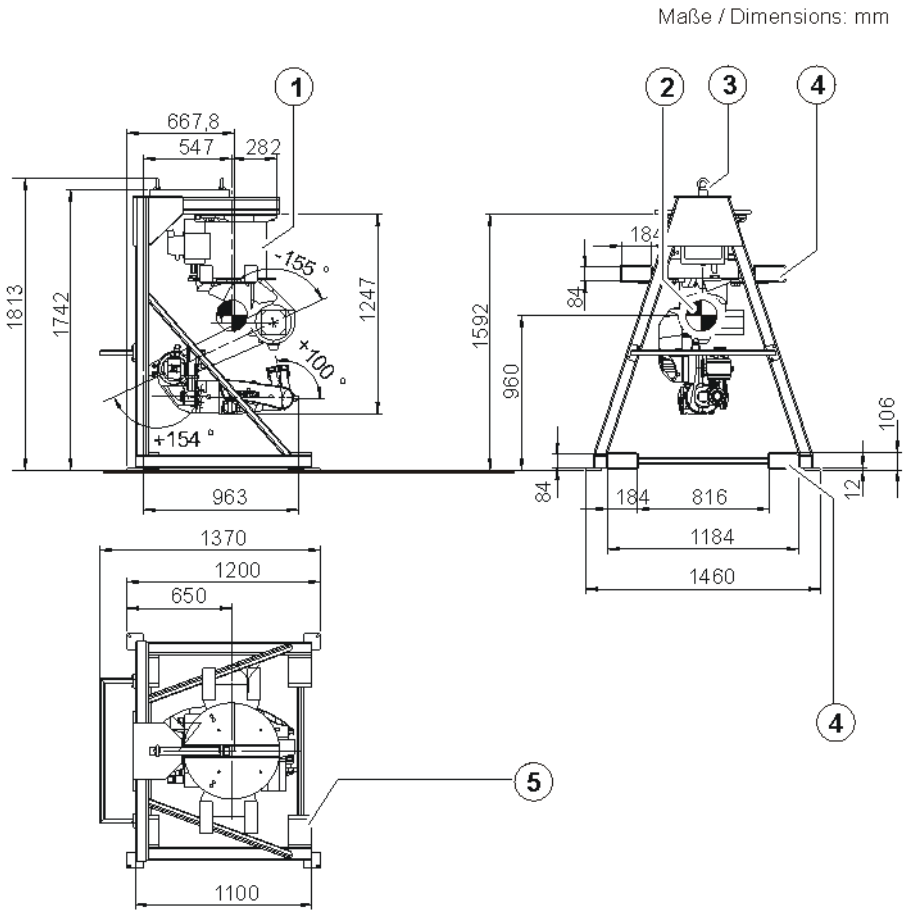


Fig. 7-4: Transport dimensions, ceiling-mounted robot KR 16 arc HW

1 Robot
2 Center of gravity
3 Eyebolts
4 Fork slots
5 Transport frame for ceiling-mounted robot

Maße / Dimensions: mm

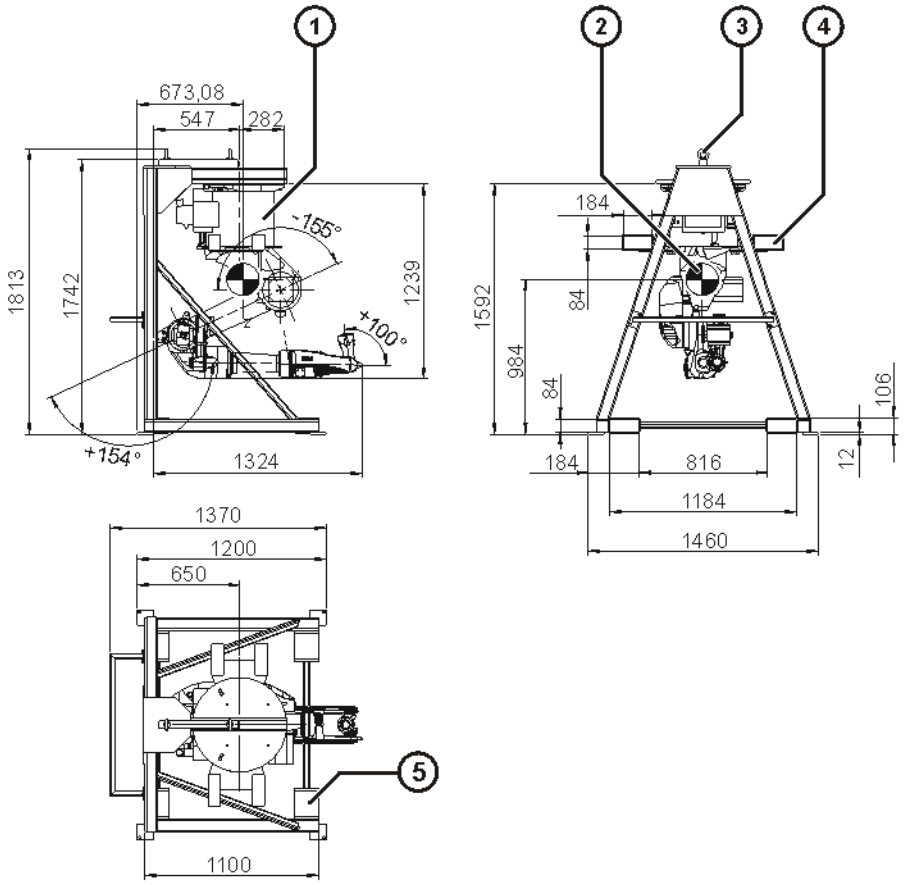


Fig. 7-5: Transport dimensions, ceiling-mounted robot KR 16 L8 arc HW

1 Robot
2 Center of gravity
3 Eyebolts
4 Fork slots
5 Transport frame for ceiling-mounted robot

Transportation

The floor-mounted robot is transported using lifting tackle or via the fork slots. Without the transport frame, ceiling-mounted robots can only be transported in mounting position by fork lift truck. In the transport frame, transportation with fork lift truck or crane is possible.

⚠ WARNING Use of unsuitable handling equipment may result in damage to the robot or injury to persons. Only use authorized handling equipment with a sufficient load-bearing capacity. Only transport the robot in the manner specified here.

Transportation by fork lift truck

The ceiling-mounted robot is transported using a fork lift truck (>>> Fig. 7-6). For transport by fork lift truck, the fork slots must be installed. The robot must be in the transport position for ceiling installation.

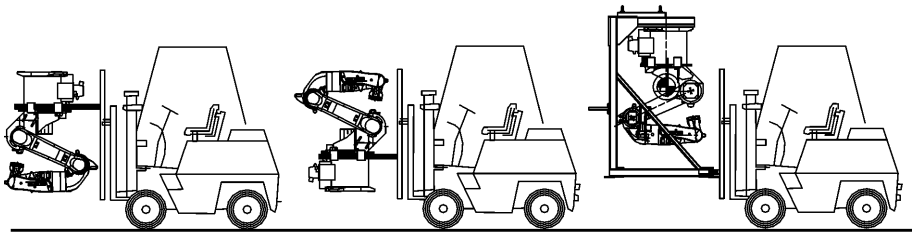


Fig. 7-6: Transportation by fork lift truck

Transportation using lifting tackle

The floor-mounted robot is transported using lifting tackle (>>> Fig. 7-7). The robot must be in the transport position. The lifting tackle is attached to 3 eyebolts that are screwed into the rotating column. All ropes of the lifting tackle must be long enough and must be routed in such a way that the robot is not damaged. Installed tools and pieces of equipment can cause undesirable shifts in the center of gravity. These must therefore be removed if necessary.

The eyebolt must be removed from the rotating column after transportation.

⚠ WARNING The robot may tip during transportation. Risk of personal injury and damage to property.
If the robot is being transported using lifting tackle, special care must be exercised to prevent it from tipping. Additional safeguarding measures must be taken. It is forbidden to pick up the robot in any other way using a crane!

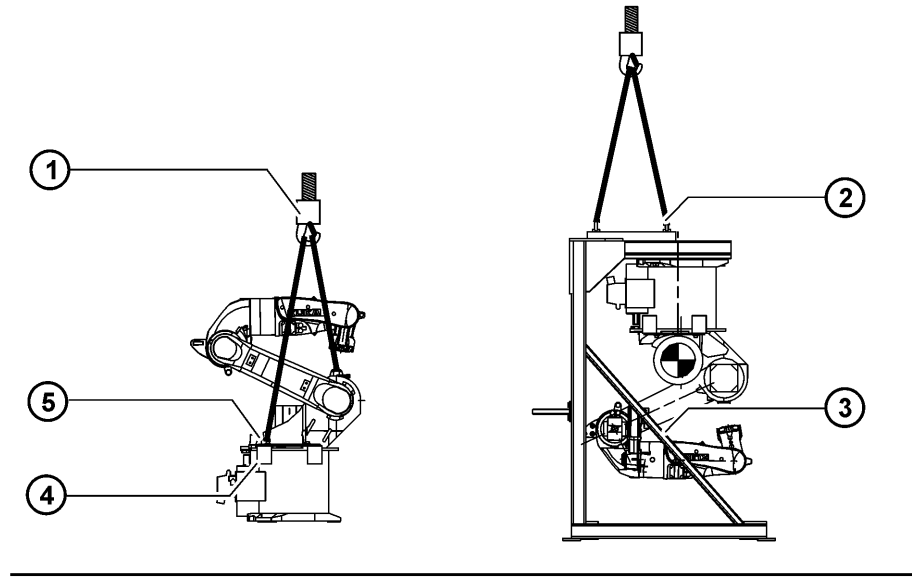


Fig. 7-7: Lifting tackle

1	Crane	4	Fork slots
2	Lifting tackle	5	Eyebolt
3	Transport frame		

8 Start-up and recommissioning

8.1 Installation of the mounting base (resin capsules)

Description

These instructions apply to the variant “mounting base with centering (resin capsule)”. The robot is fastened to an appropriate concrete foundation using 3 bedplates and resin-bonded anchors.

This mounting variant requires a level and smooth surface on a concrete foundation with adequate load bearing capacity. The concrete foundation must be able to accommodate the forces occurring during operation. There must be no layers of insulation or screed between the bedplates and the concrete foundation.

When producing foundations from concrete, observe the load-bearing capacity of the ground and the country-specific construction regulations. The quality of the concrete must meet the requirements of the following standard:

- C20/25 according to DIN EN 206-1:2001/DIN 1045-2:2008

If the surface of the concrete foundation is not sufficiently smooth and even, the differences must be evened out with a suitable leveling compound.

When using resin-bonded anchors, use only resin capsules and anchors from the same manufacturer. 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. Observe also the manufacturer’s instructions for the use of resin-bonded anchors.

Preconditions

- The concrete foundation must have the required dimensions and cross-section.
- The surface of the foundation must be smooth and even.
- The “mounting base” assembly must be complete.
- Have the leveling compound readily at hand.

Special tools

The following special tools are required:

- Drill with a ø 14 mm bit
- Setting tool approved by the anchor manufacturer

Procedure

1. Lift the robot with fork lift truck or lifting tackle.
2. Fasten the 3 bedplates to the robot using one M20x55 hexagon bolt and conical spring washer for each one; M_A = 370 Nm.

   2 bedplates are fitted with locating pins for centering.
3. Determine the position of the robot on the foundation in relation to the working envelope.
4. Set the robot down on the foundation in its installation position.
5. Align the robot horizontally.

NOTICE If the bedplates are not fully seated on the concrete foundation, this can result in distortion or loosening of the mounting base. Fill any gaps with leveling compound. To do this, lift the robot again and apply sufficient leveling compound to the underside of the bedplates. Then set the robot down again and align it, removing any excess leveling compound.
The area under the hexagon bolt for robot fastening must be kept free from leveling compound.
Allow the leveling compound to cure for about 3 hours. The curing time is longer at temperatures below 293 K (+20 °C).

6. Drill 6 anchor holes (>>> Fig. 8-1) through the holes of the bedplates into the foundation.
7. Clean the anchor holes by blowing them out, brushing them and then blowing them out again.
8. Insert 6 resin capsules one after the other.
9. Clamp the setting tool with the anchor rod in the hammer drill and insert it into the anchor hole at max. 750 rpm^{-1}. The anchor rod is set correctly if the resin is completely mixed and the anchor hole in the concrete is completely filled to the upper edge.

Maße / Dimensions: mm

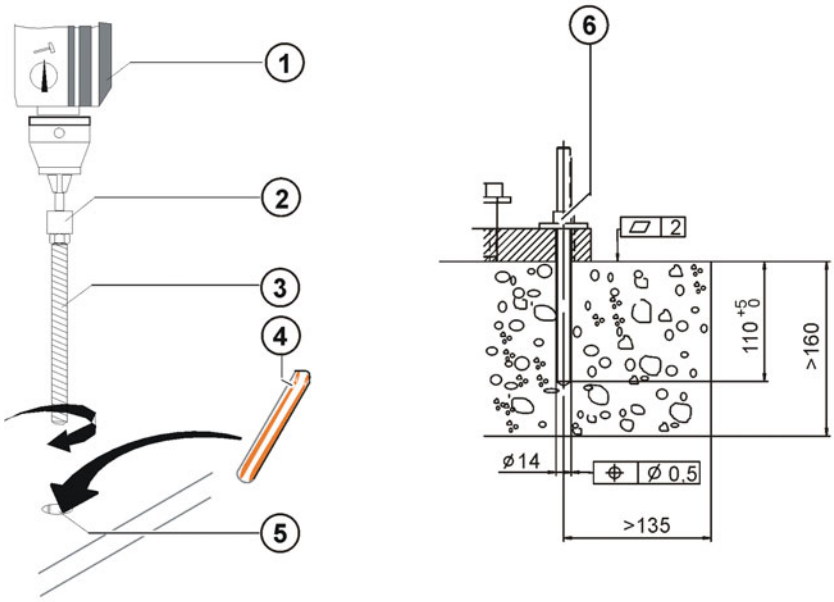


Fig. 8-1: Installation of resin-bonded anchors

1	Drill	4	Resin capsule
2	Setting tool	5	Anchor hole
3	Anchor rod	6	Hexagon nut with lock washer

10. Allow the resin to cure. See table, or as specified by manufacturer.

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

11. Fit 6 lock washers and 6 hexagon nuts one after the other. Tighten the hexagon nuts with a torque wrench. Gradually increase the tightening torque to a value of 40 Nm.
12. Retighten the hexagon nuts after 100 hours of operation.

The robot is now ready for connection.

8.2 Installation of the mounting base (resin cartridge)

Description

These instructions apply to the variant “mounting base with centering (resin cartridge)”. The robot is fastened to an appropriate concrete foundation using 3 bedplates and resin-bonded anchors.

This mounting variant requires a level and smooth surface on a concrete foundation with adequate load bearing capacity. The concrete foundation must be able to accommodate the forces occurring during operation. There must be no layers of insulation or screed between the bedplates and the concrete foundation.

When producing foundations from concrete, observe the load-bearing capacity of the ground and the country-specific construction regulations. The quality of the concrete must meet the requirements of the following standard:

- C20/25 according to DIN EN 206-1:2001/DIN 1045-2:2008

If the surface of the concrete foundation is not sufficiently smooth and even, the differences must be evened out with a suitable leveling compound.

When using resin-bonded anchors, use only resin cartridges and anchors from the same manufacturer. 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. Observe also the manufacturer's instructions for the use of resin-bonded anchors.

The following resin cartridge is available for this installation variant:

- Resin cartridge with mixer nozzle for up to seven anchor holes with commercially available caulking gun.

Only correctly mixed resin may be used. To ensure this, as much resin as necessary must be rejected after start-up until the emerging resin is homogenous. The same applies to breaks in work (processing time exceeded); if required, a new mixer nozzle must be used.

Preconditions

- The concrete foundation must have the required dimensions and cross-section.
- The surface of the foundation must be smooth and even.
- The "mounting base" assembly must be complete.
- Have the leveling compound readily at hand.

Special tools

The following special tools are required:

- Drill with a ø 14 mm bit
- Use the resin cartridges with a commercially available caulking gun in accordance with the instructions provided by the anchor manufacturer.

Procedure

1. Lift the robot with fork lift truck or lifting tackle.
2. Fasten the 3 bedplates to the robot using one M20x55-8.8 hexagon bolt and conical spring washer for each one; M_A = 370 Nm.

   2 bedplates are fitted with locating pins for centering.
3. Determine the position of the robot on the foundation in relation to the working envelope.
4. Set the robot down on the foundation in its installation position.
5. Align the robot horizontally.

NOTICE If the bedplates are not fully seated on the concrete foundation, this can result in distortion or loosening of the mounting base. Fill any gaps with leveling compound. To do this, lift the robot again and apply sufficient leveling compound to the underside of the bedplates. Then set the robot down again and align it, removing any excess leveling compound.
The area under the hexagon bolt for robot fastening must be kept free from leveling compound.
Allow the leveling compound to cure for about 3 hours. The curing time is longer at temperatures below 293 K (+20 °C).

6. Drill 6 anchor holes (>>> Fig. 8-2) through the holes of the bedplates into the foundation.
7. Clean the anchor holes by blowing them out, brushing them and then blowing them out again.
8. Fill the anchor hole with resin (8 scale divisions on the resin cartridge), then insert anchor immediately. The anchor hole must be filled completely. If this is not the case, pull the anchor out immediately, inject additional resin and re-insert the anchor.
9. Perform the insertion procedure for the remaining anchors.

Maße / Dimensions: mm

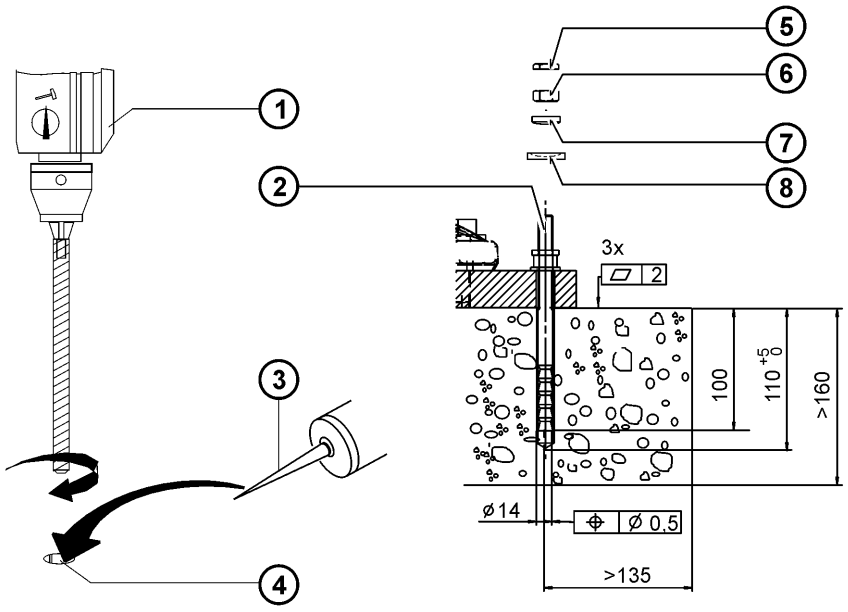


Fig. 8-2: Installation of resin-bonded anchors

1	Drill	5	Lock nut
2	Anchor	6	Hexagon nut
3	Mixer nozzle	7	Spherical washer
4	Anchor hole	8	Ball cup

10. Allow the resin to cure. The following processing and curing times must be observed:

Cartridge temperature	Processing time
< 278 K (+5 °C)	Not permissible
278 K (+5 °C)	15 minutes
293 K (+20 °C)	6 minutes
303 K (+30 °C)	4 minutes
318 K (+40 °C)	2 minutes

Foundation temperature	Curing time
268 K (-5 °C)	360 minutes
273 K (0 °C)	180 minutes
278 K (+5 °C)	90 minutes
293 K (+20 °C)	35 minutes
303 K (+30 °C)	20 minutes
318 K (+40 °C)	12 minutes

These times apply to dry concrete; in the case of damp concrete, the curing times are doubled.

The resin must not be processed in standing water.

11. For each anchor, fit a washer with ball cup (facing upwards) and spherical washer, then screw on a hexagon nut.
12. Tighten the hexagon nuts with a torque wrench. Gradually increase the tightening torque to a value of 40 Nm.
13. Fit and tighten a lock nut; M_A = 40 Nm.
14. Fit the mixer nozzle with a filler tube and completely fill the through-hole of the ball cup with resin.
15. Retighten the hexagon nuts after 100 hours of operation.

The robot is now ready for connection.

8.3 Installation of the machine frame mounting assembly

Description

The machine frame mounting assembly is used for installing robots on a steel structure prepared by the customer or on the carriage of a linear unit.

Preconditions

- The mounting surface is prepared as shown in the diagram (>>> 6.2 "Machine frame mounting with centering" Page 61).
- The substructure is checked for sufficient safety.
- The machine frame mounting assembly is complete.

Procedure

1. Clean the mounting surface (>>> Fig. 8-3) of the robot.
2. Check the hole pattern.
3. Press in 2 locating pins.
4. Prepare 3 M12x55 hexagon bolts and conical spring washers.

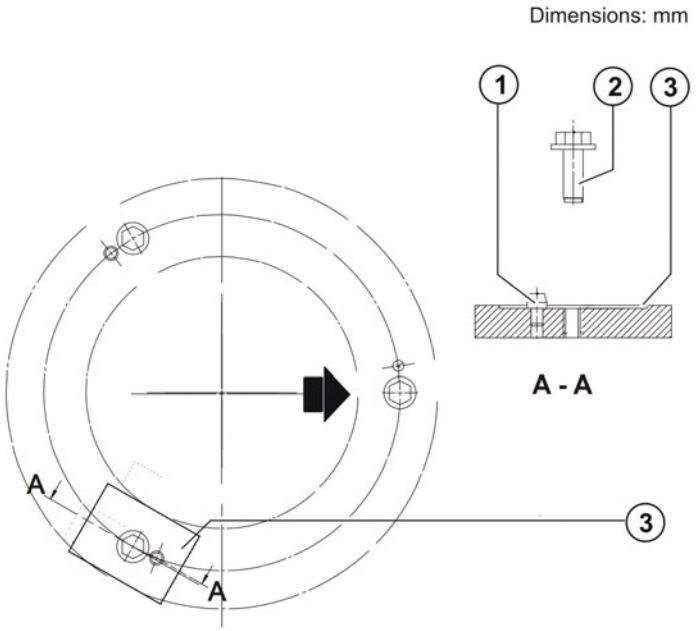


Fig. 8-3: Machine frame mounting

1 Locating pin
2 Hexagon bolt with conical spring washer
3 Mounting surface

The mounting base is now ready for the robot to be installed.

8.4 Installing the adapter plate

Description

The adapter plate is used to mount a robot on

- a mounting base
- a steel structure provided by the customer (mounting base)
- the carriage of a linear unit

with the hole pattern of the KR 6 robot.

Preconditions

- The mounting surface has been prepared.
- The adapter plate and fastening elements are available.

Procedure

1. Clean the mounting surfaces of the robot and of the mounting base (>>> Fig. 8-4).
2. Check the hole pattern.
3. Bring the adapter plate to the site of installation and align it. For transportation, three M20 DIN 580 eyebolts can be installed.
4. Press in 2 locating pins from the “machine frame mounting” assembly in accordance with the installation position of the adapter plate.
5. Insert 3 M20x55 Allen screws together with conical spring washers into the holes and tighten; tightening torque M_A = 370 Nm.
6. Prepare 3 M12x30 Allen screws together with conical spring washers.

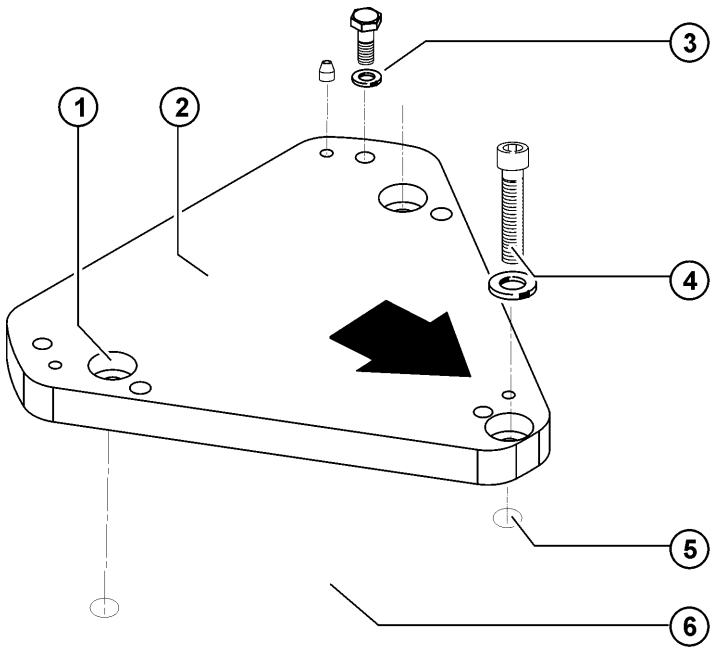


Fig. 8-4: Adapter plate, installation

1 Hole
2 Adapter plate
3 Hexagon bolt
4 Allen screw
5 Hole pattern
6 Mounting surface

The adapter plate is now ready for the robot to be installed.

8.5 Installing the robot

Description

This description is valid for the installation of robots on the floor and ceiling, with the mounting variants: mounting base (floor mounting only), machine frame mounting and adapter plates.

Ceiling-mounted robots are installed in the same way as floor-mounted robots. Ceiling-mounted robots can only be removed from the transport frame and moved to the installation site using the fork slots.

The installation and start-up of the robot controller, the tools mounted and the applications are not described here.

⚠ CAUTION A manipulator configured for the floor mounting position may not be installed in the ceiling mounting position, as this is liable to cause lubrication problems on axis 1 due to the different quantities of oil in gear unit A1.

Precondition

- The required mounting base is installed.
- The installation site is accessible with a crane or fork lift truck.
- Any tools or other system components which would hinder the work have been removed.
- The robot is in the transport position.
- The connecting cables and ground conductors are routed to the robot and installed.
- The eyebolts and lifting tackle (00-154-134) or the fork slots are attached to the robot (>>> Fig. 8-5).

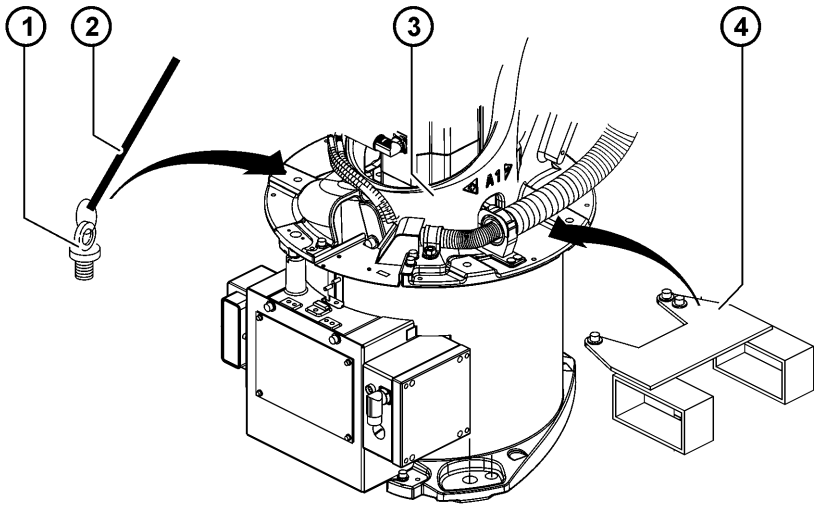


Fig. 8-5: Transporting the robot during installation

1	M20 DIN 580 eyebolt	3	Rotating column
2	Lifting tackle	4	Fork slots

⚠ WARNING Use of unsuitable handling equipment may result in damage to the robot or injury to persons. Only use authorized handling equipment with a sufficient load-bearing capacity. Only transport the robot in the manner specified here.

Procedure

1. Check that both locating pins (>>> Fig. 8-6) are undamaged and fitted securely.
2. Bring the robot to the installation site by crane or fork lift truck.

The lifting tackle must not damage the robot.

3. Clean the mounting surface on the robot.
4. Lower the robot vertically onto the mounting base. Ensure that an entirely vertical position is maintained in order to prevent damage to the locating pins.
5. Insert 3 M20x55 hexagon bolts with conical spring washers.
6. Tighten the hexagon bolts with torque wrench. Gradually increase the tightening torque to 370 Nm.
7. Remove the lifting tackle and eyebolts or the fork slots.
8. Connect motor cable X30 and control cable X31.

   With SafeRobot, additionally plug in connectors X40, X41 and X42.
9. Connect the ground conductor between the robot controller and the robot to the ground conductor connection.
10. Connect the ground conductor between the system component and the robot to the ground conductor connection.
11. Check the equipotential bonding in accordance with VDE 0100 and EN 30204-1.

> Further information is contained in the assembly or operating instructions for the robot controller.

12. Mount tooling, if required.
13. Retighten the hexagon bolts with a torque wrench after 100 hours of operation.

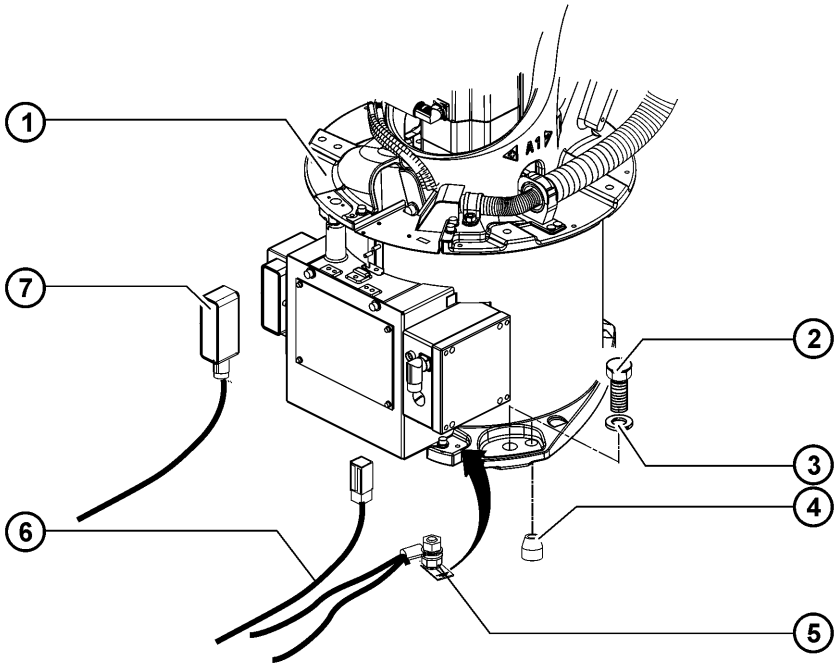


Fig. 8-6: Installing the robot

1	Rotating column	5	Ground conductor connection
2	Hexagon bolt	6	Control cable
3	Conical spring washer	7	Motor cable
4	Locating pin		

Put the robot into operation in accordance with the “Start-up” chapter of the operating and programming instructions for the KUKA System Software and the assembly instructions or operating instructions for the robot controller.

8.6 Description of the connecting cables for KR C2

Configuration

The connecting cables are used to transfer power and signals between the robot controller and the robot.

The connecting cables comprise:

- Motor cable
- Control cable
- SafeRobot control cable (optional)
- Ground conductor, with connecting cable set >25 m

Interface

For the connection of the connecting cables between the robot controller and the robot, the following connectors are available on the junction boxes.

Cable designation	Connector designation robot controller - robot	Connection
Motor cable	X20 - X30	Han size 24
Control cable	X21 - X31	Circular connector
SafeRobot control cable	X21.1 - X41	Circular connector
Ground conductor		Ring cable lug

Standard connecting cable

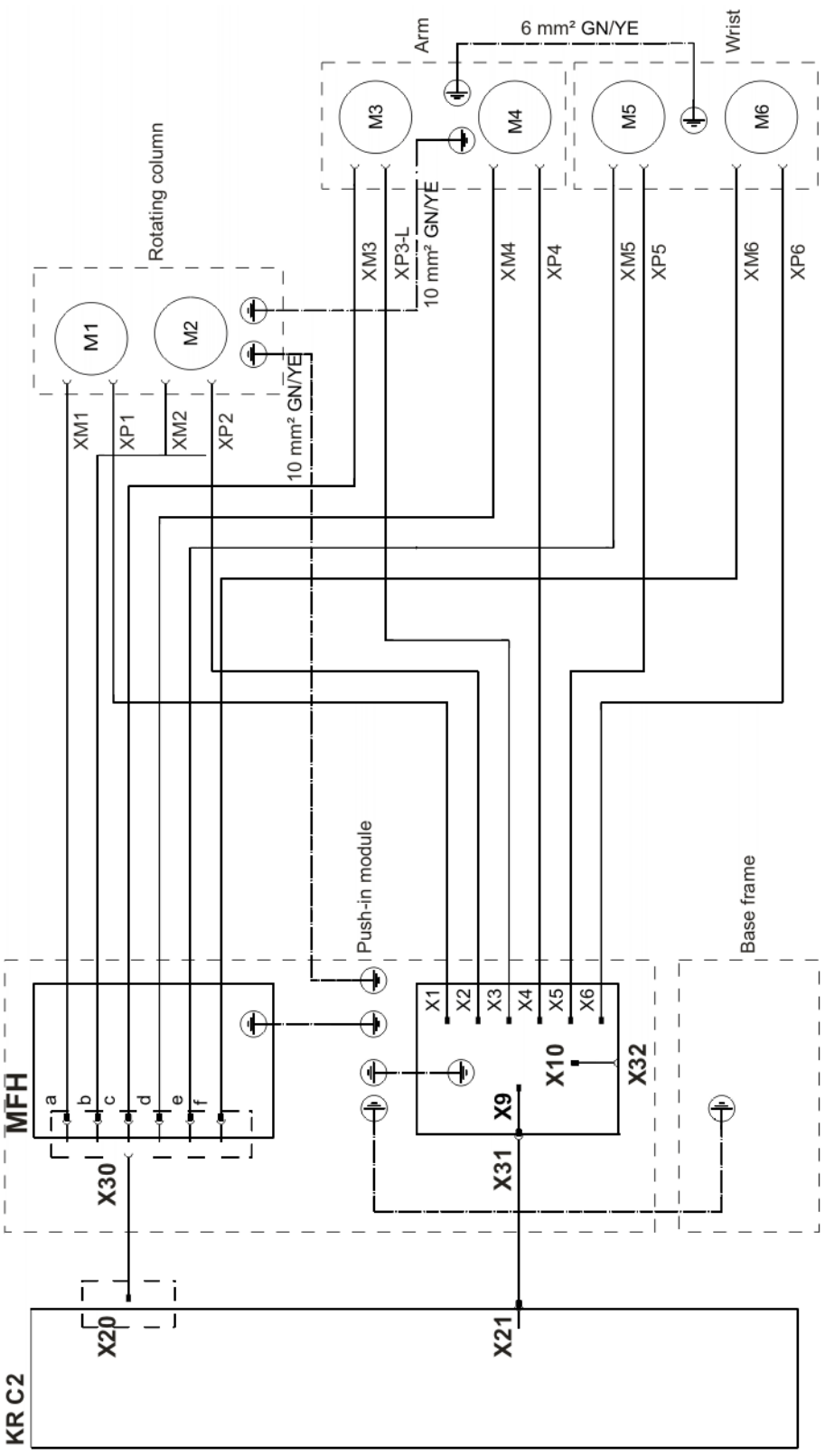


Fig. 8-7: Connecting cables and junction box, overview

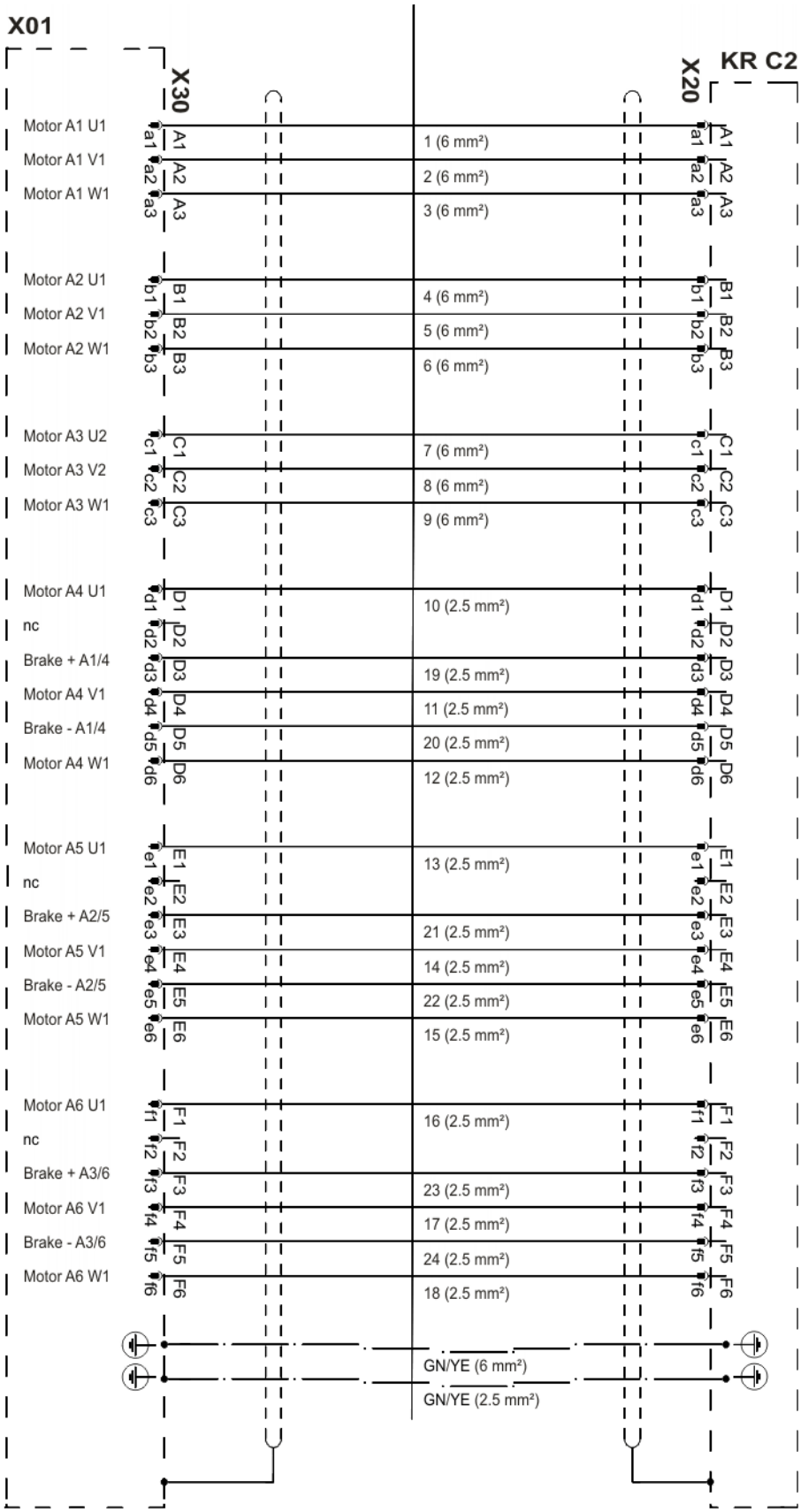


Fig. 8-8: Connecting cable, motor cable

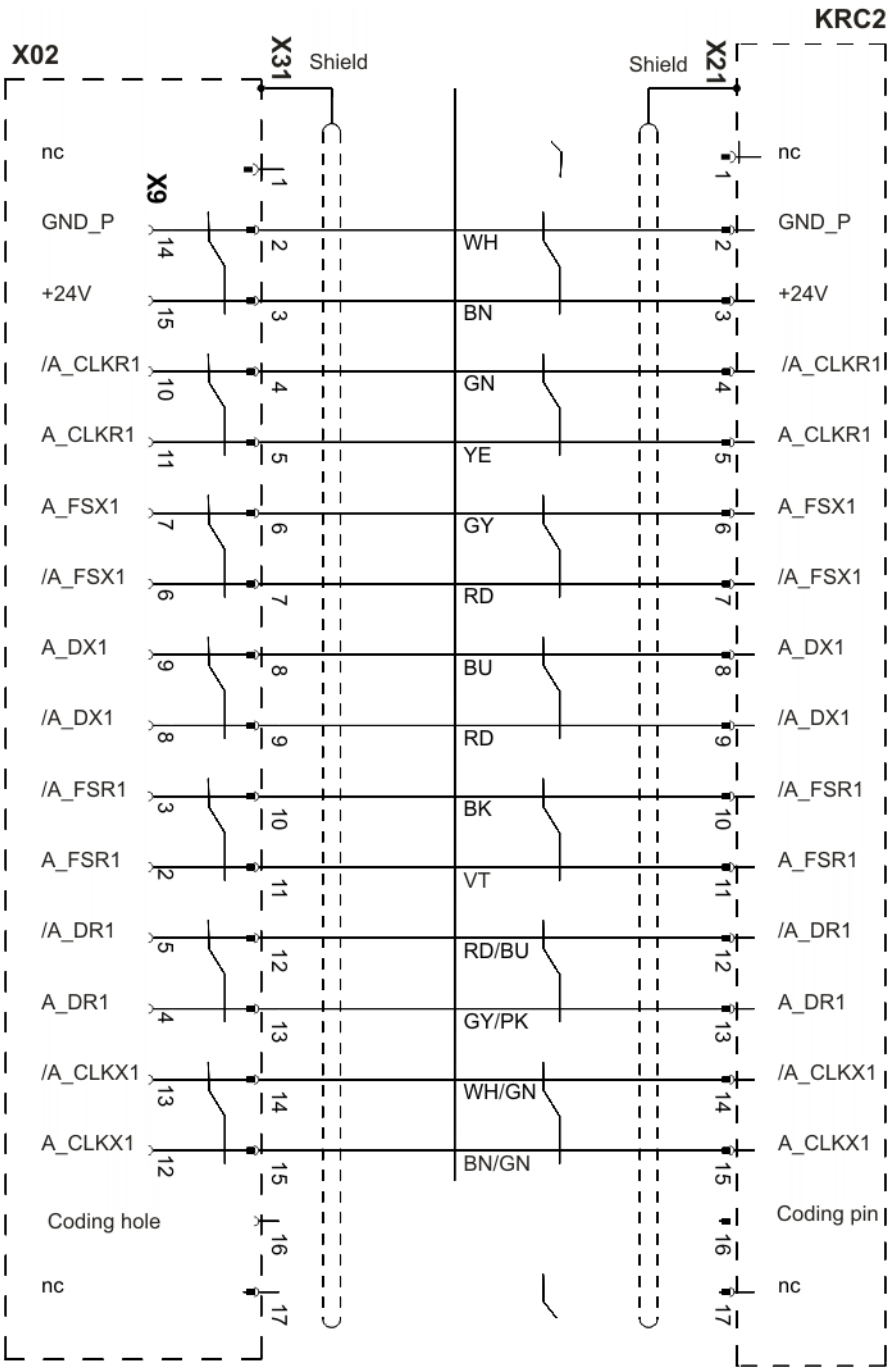


Fig. 8-9: Connecting cables, standard control cable

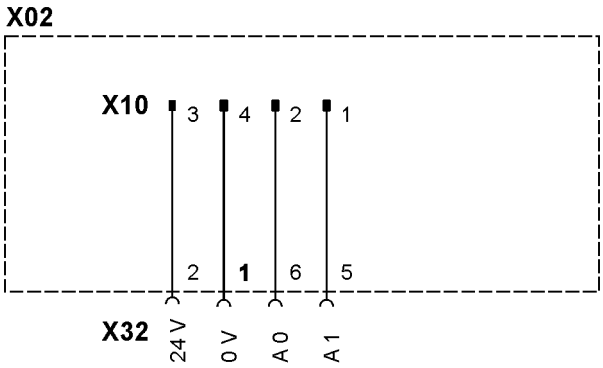


Fig. 8-10: Mastering cable

RoboTeam connecting cable

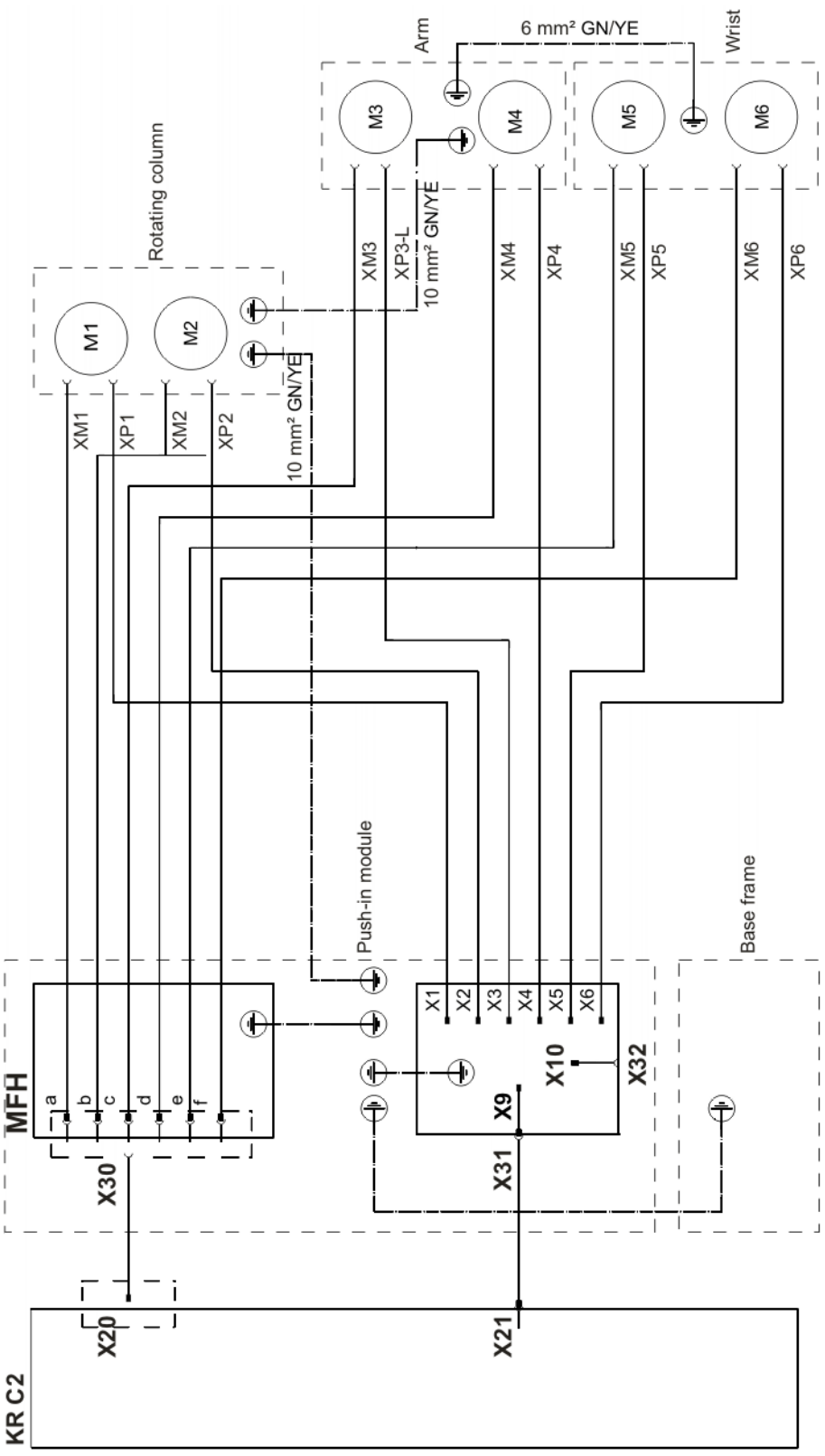


Fig. 8-11: Connecting cables and junction box, overview

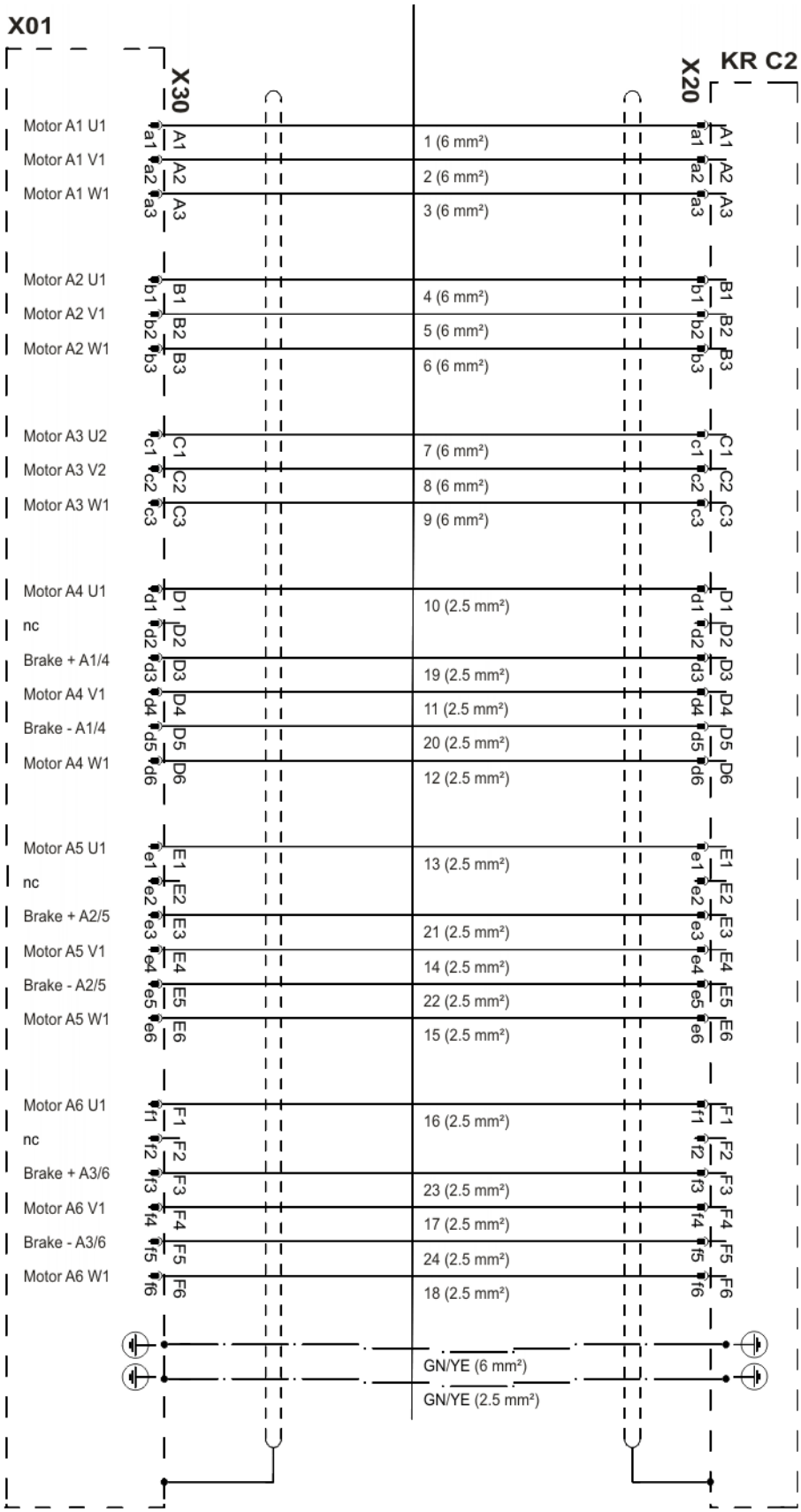


Fig. 8-12: Connecting cable, motor cable

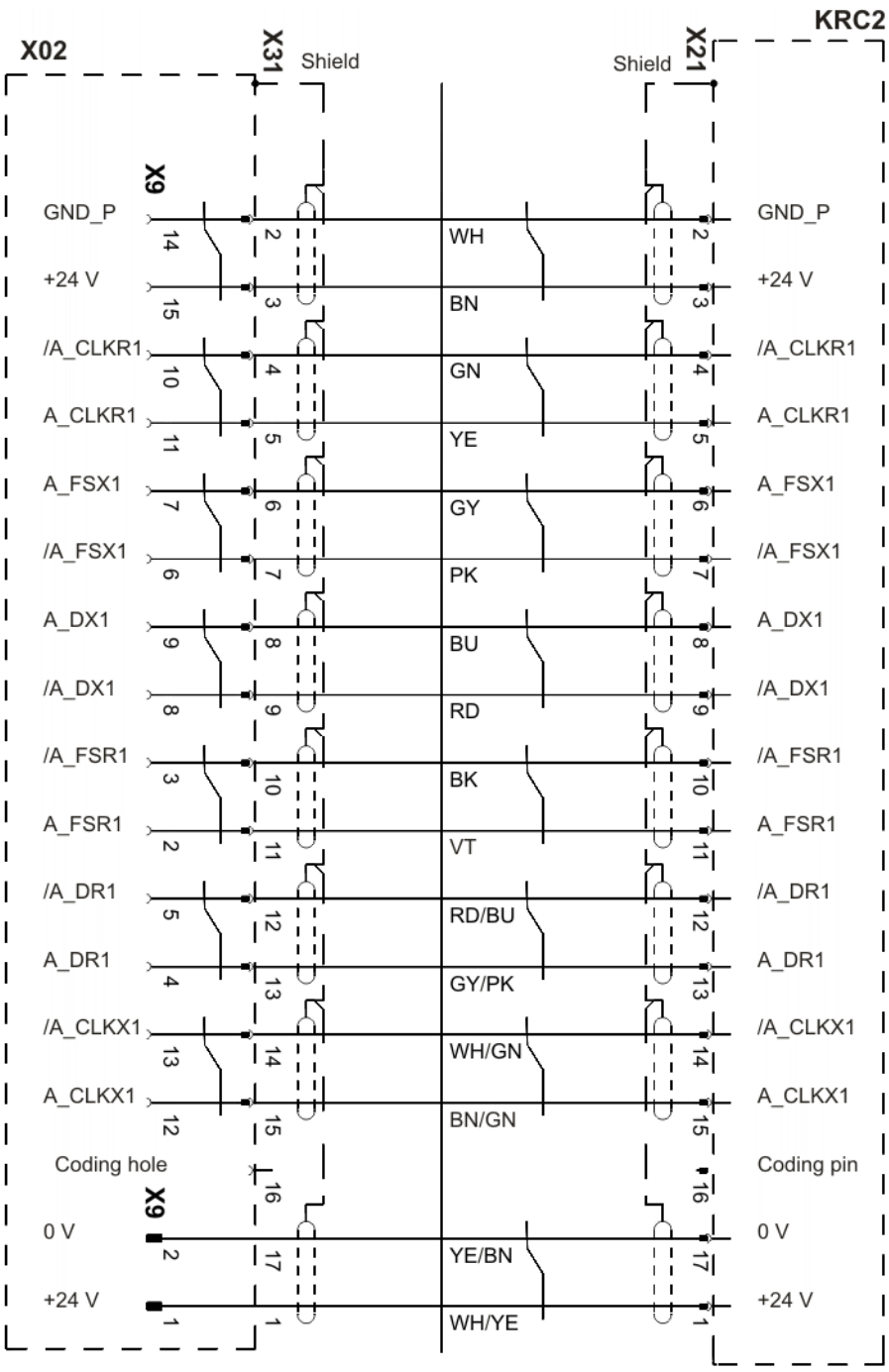


Fig. 8-13: Connecting cables, RoboTeam control cable

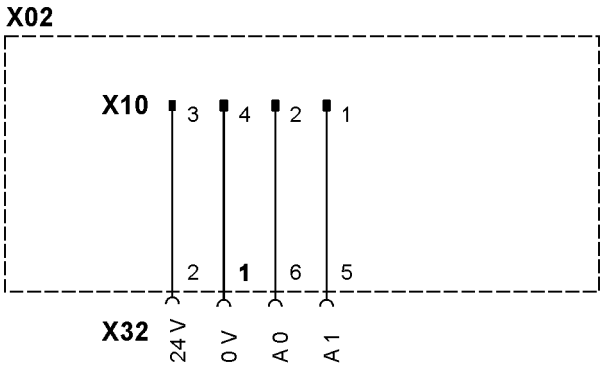


Fig. 8-14: Mastering cable

SafeRobot connecting cable

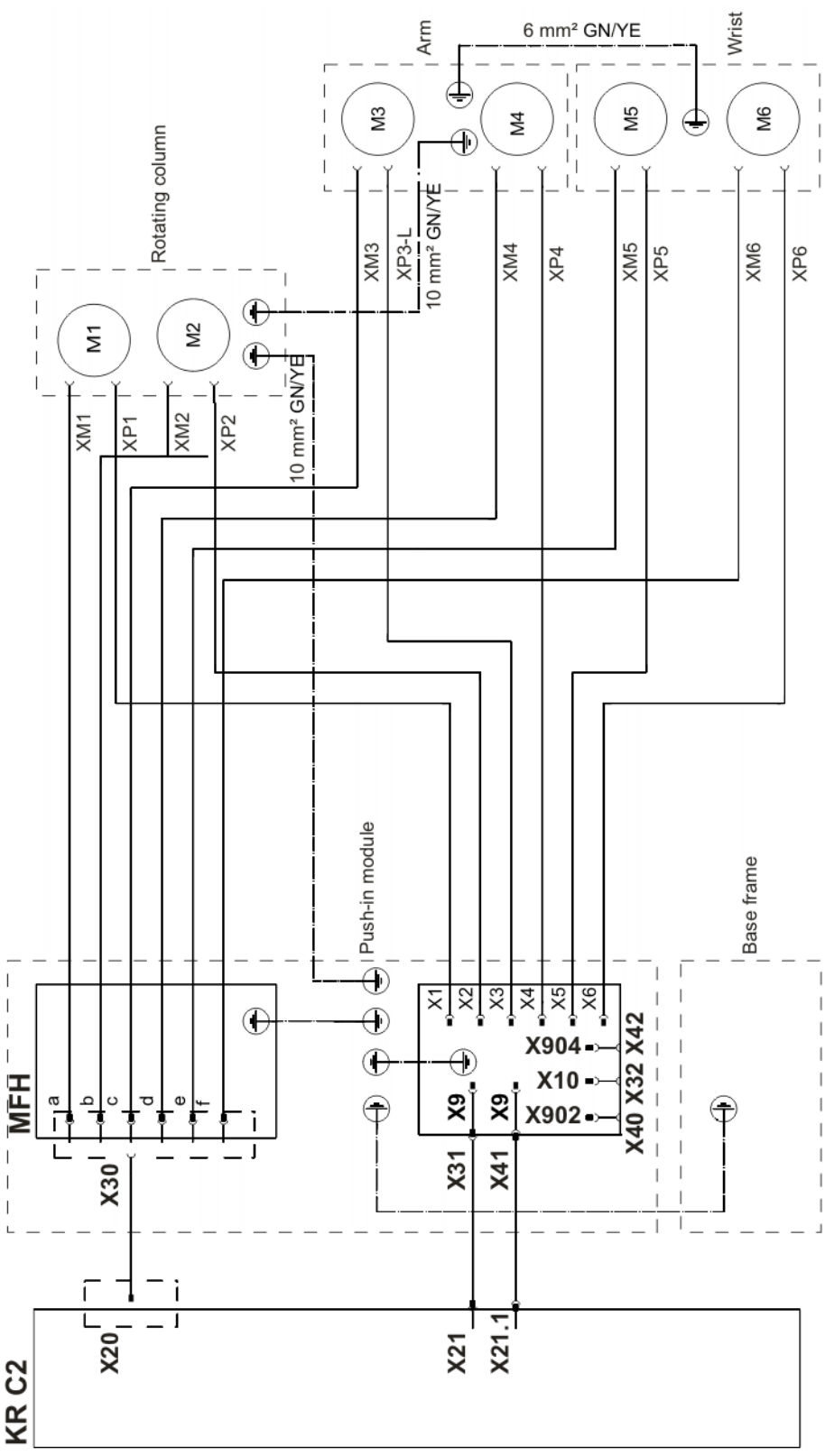


Fig. 8-15: Connecting cables and junction boxes, SafeRobot, overview

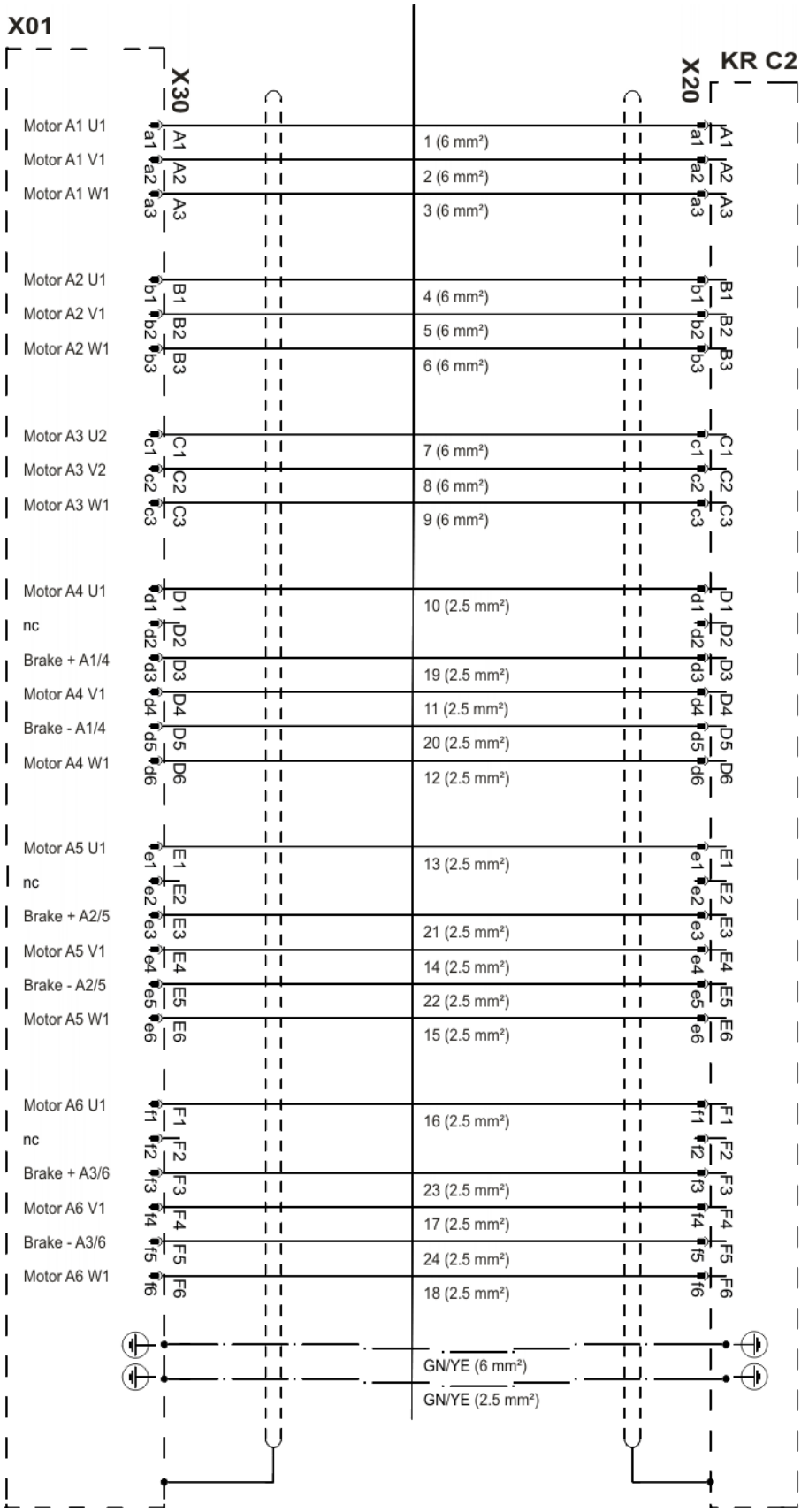


Fig. 8-16: Connecting cable, motor cable

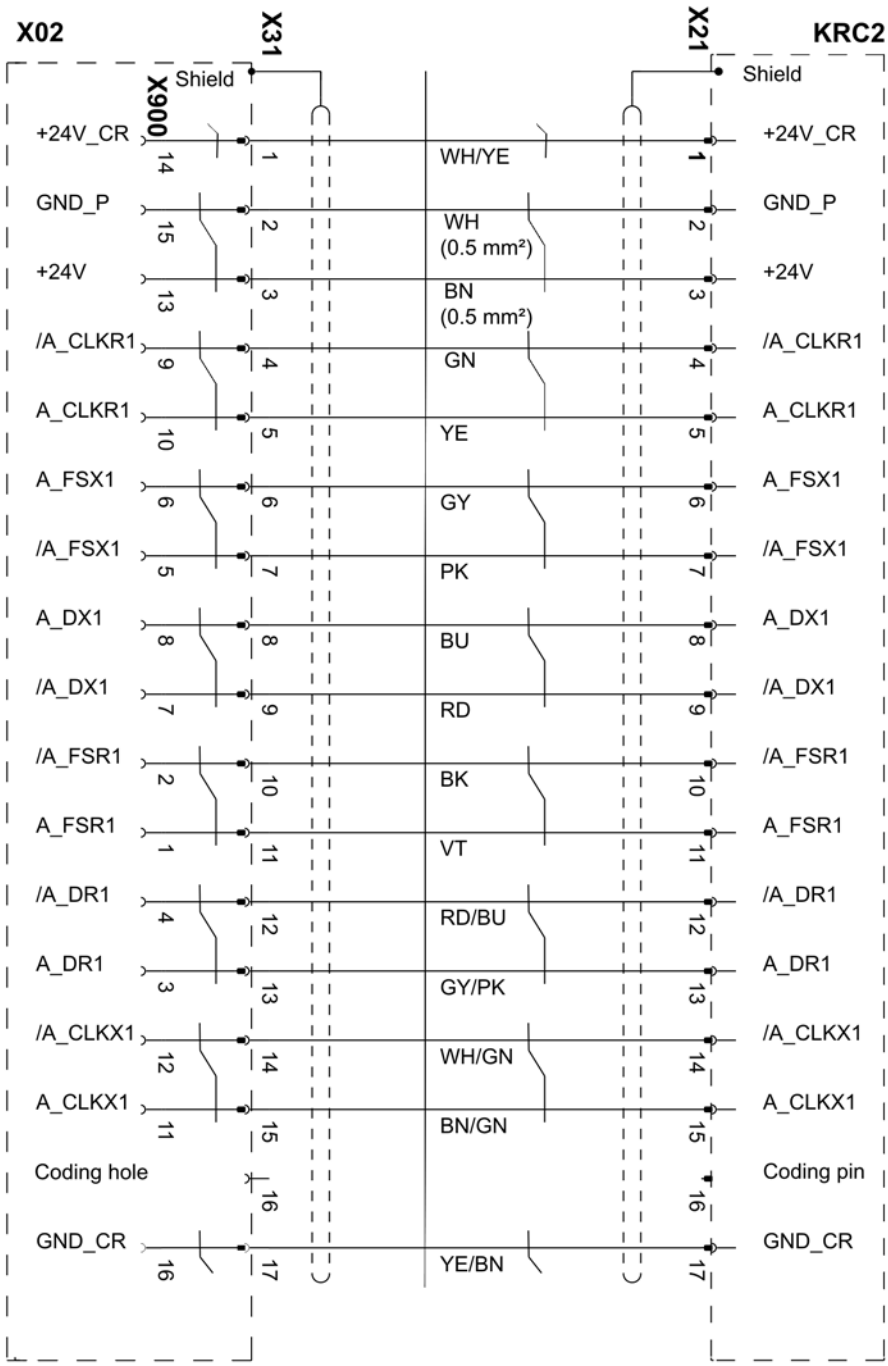


Fig. 8-17: Connecting cable, control cable 1, SafeRobot

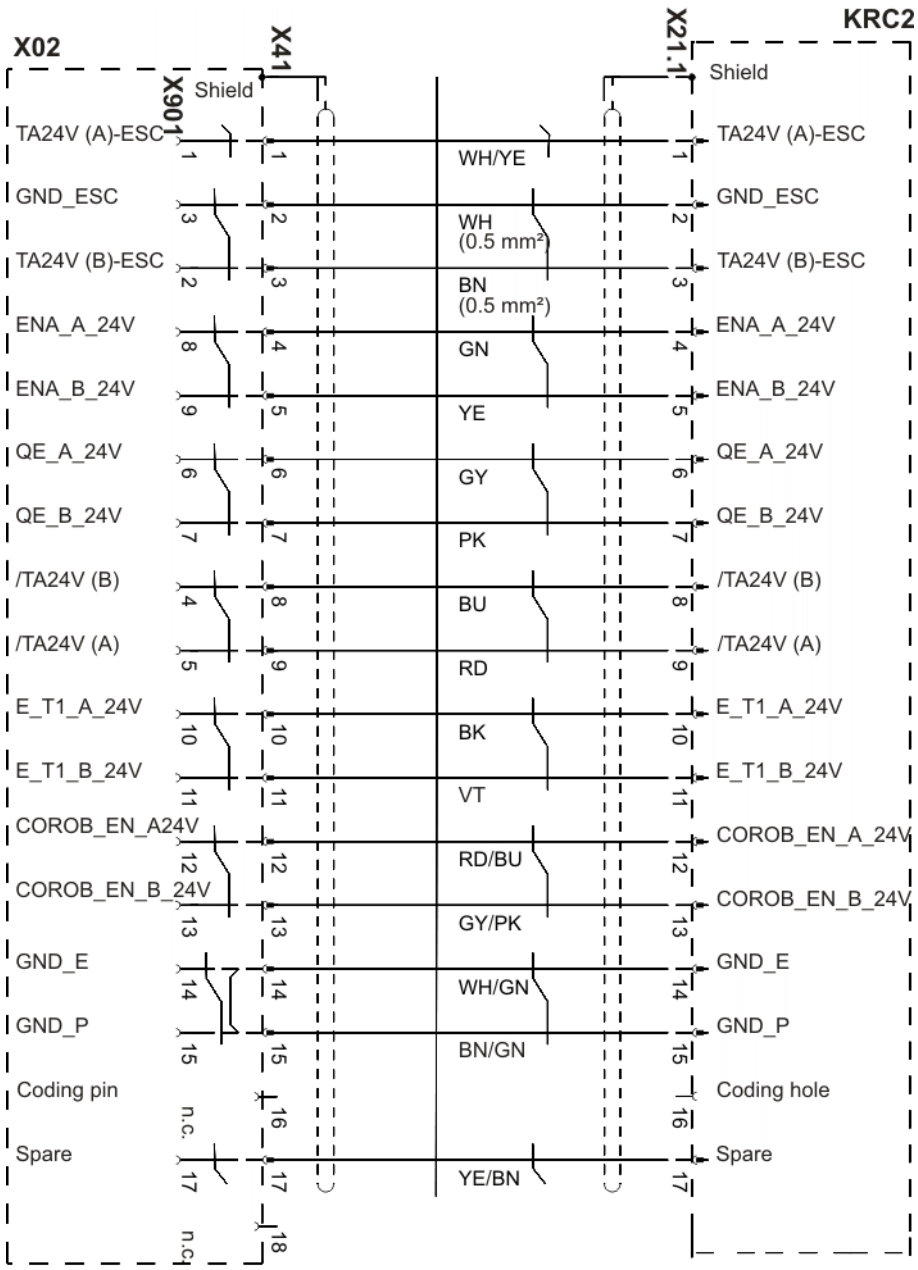


Fig. 8-18: Connecting cable, control cable 2, SafeRobot

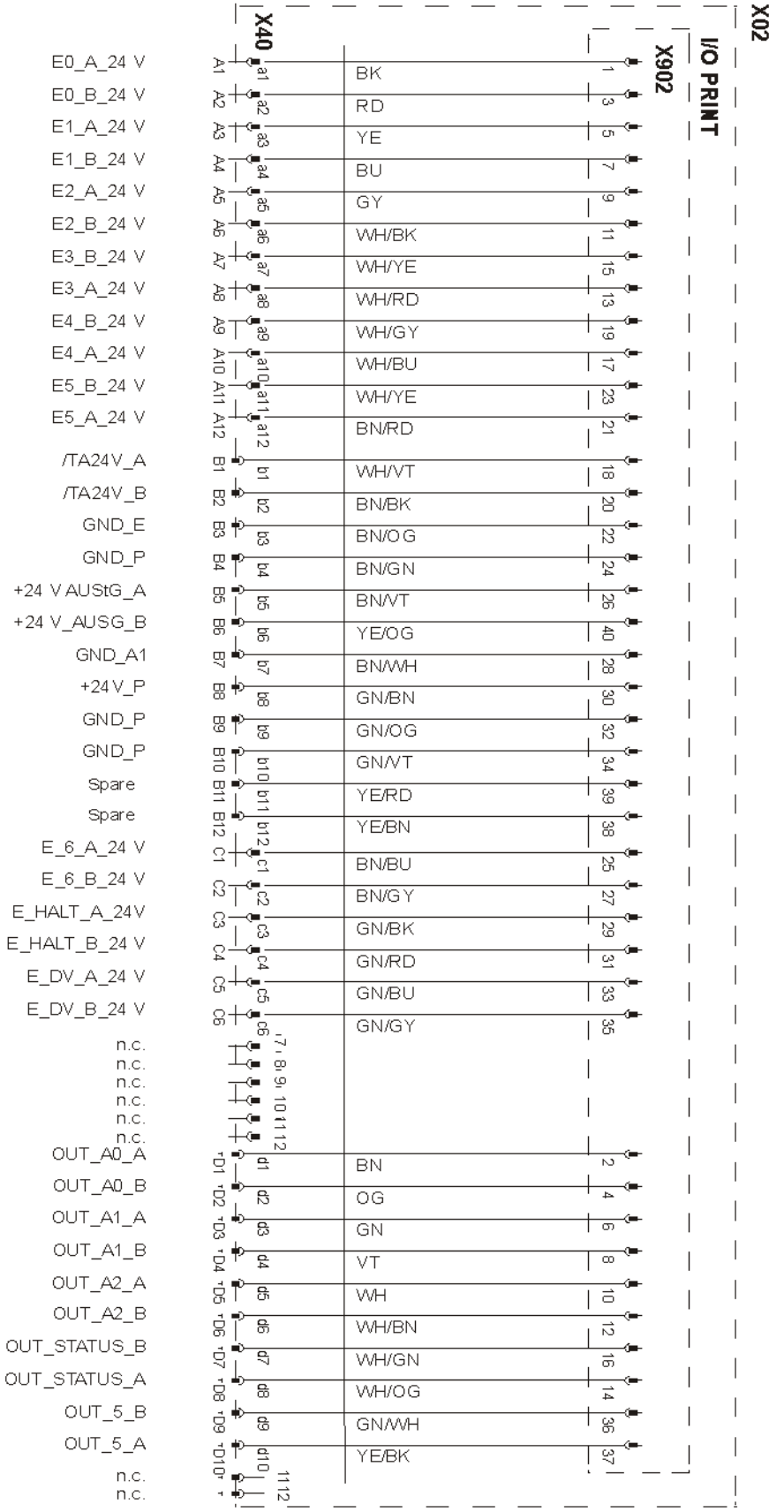


Fig. 8-19: Safe I/Os, SafeRobot

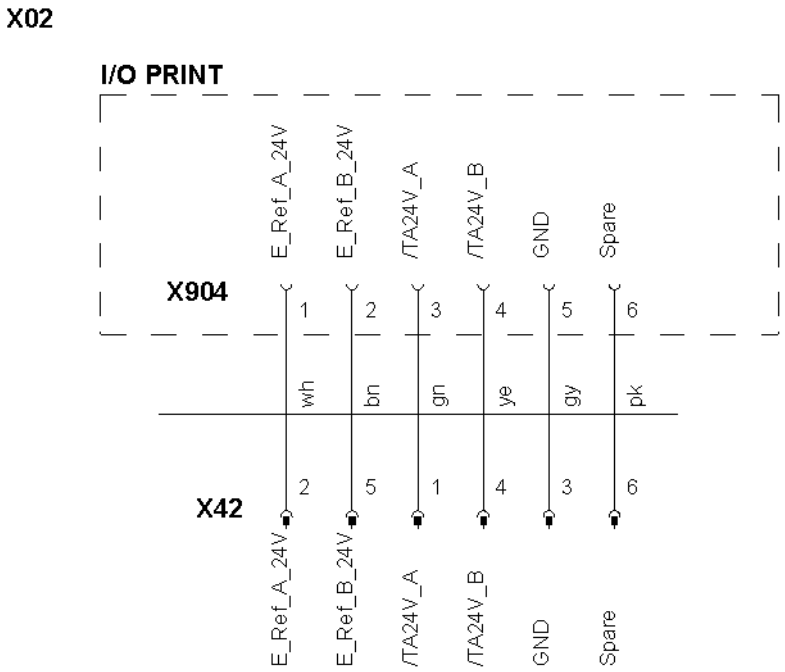


Fig. 8-20: I/O Print, SafeRobot

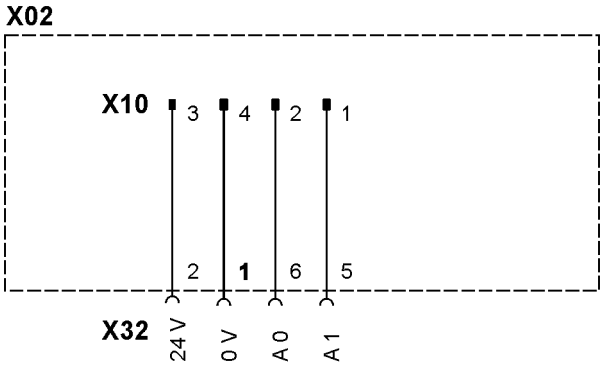


Fig. 8-21: Mastering cable

8.7 Description of the connecting cables for KR C4

Configuration

The connecting cables are used to transfer power and signals between the robot controller and the robot.

The connecting cables comprise:

- Motor cable
- Data cable
- Ground conductor (optional)

Interface

For the connection of the connecting cables between the robot controller and the robot, the following connectors are available on the junction boxes.

Cable designation	Connector designation robot controller - robot	Connection
Motor cable	X20 - X30	HAN size 24

Cable designation	Connector designation robot controller - robot	Connection
Data cable	X21 - X31	Rectangular connector
Ground conductor (optional)		M8 ring cable lug

Standard connecting cable

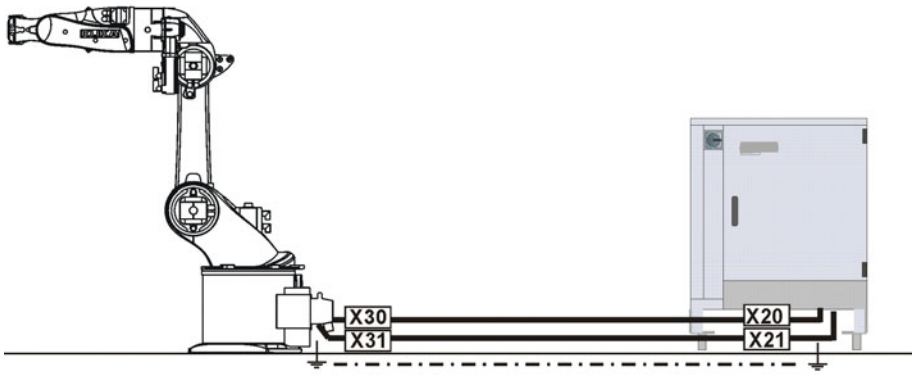


Fig. 8-22: Connecting cables, overview showing KR 16-3 arc HW

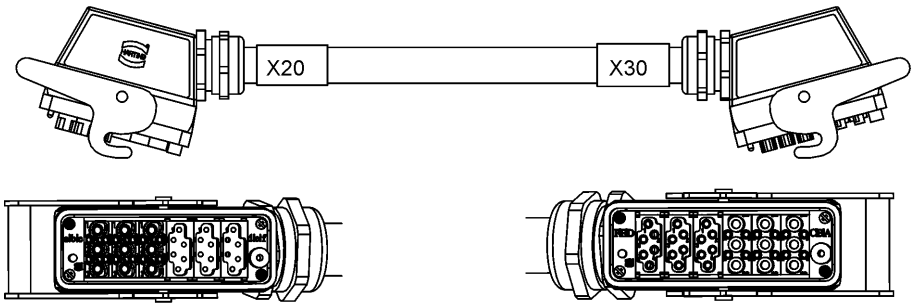


Fig. 8-23: Connecting cable, motor cable, X20 - X30

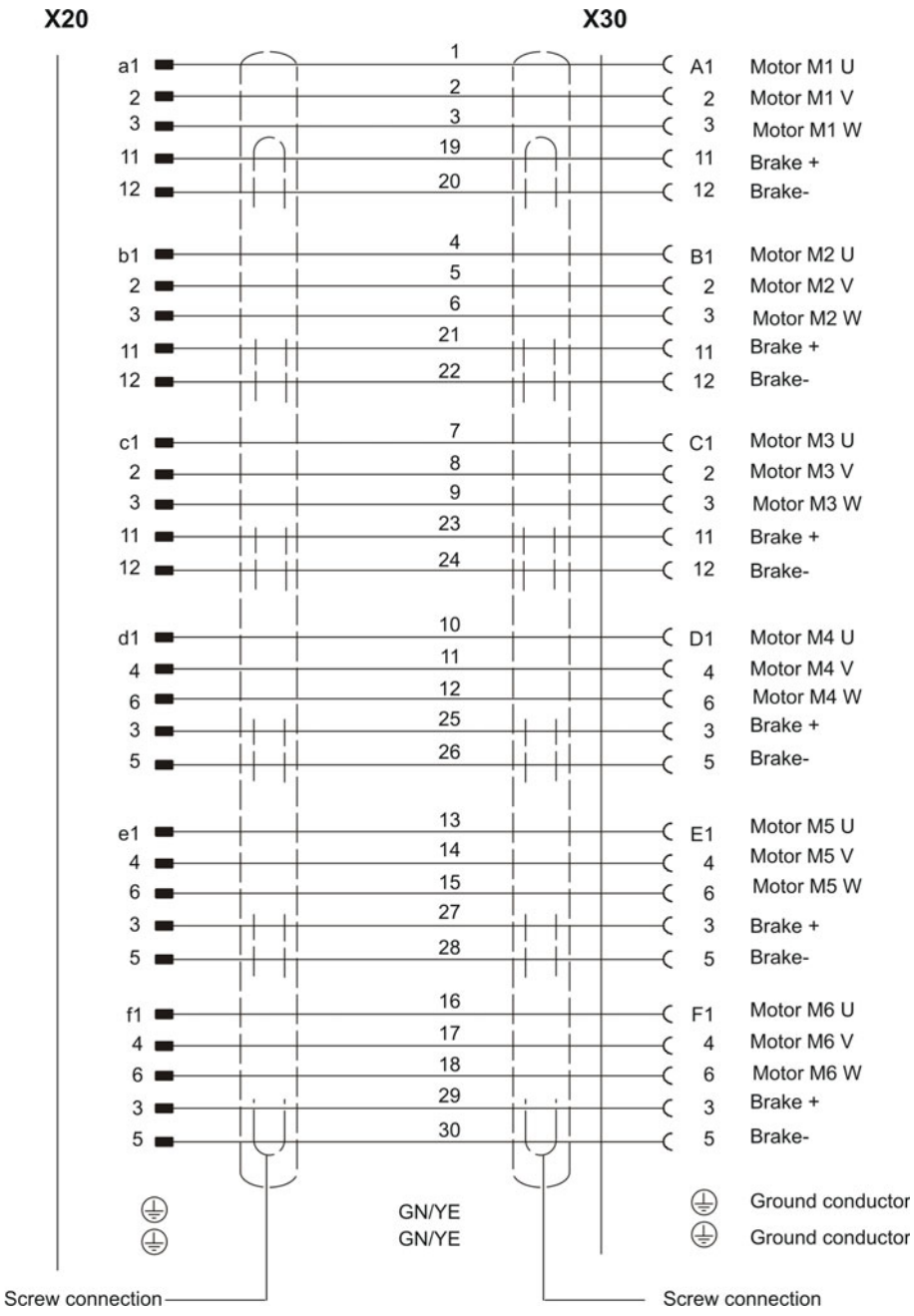


Fig. 8-24: Connecting cable, wiring diagram, motor cable

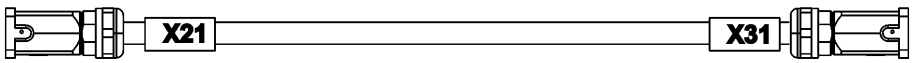


Fig. 8-25: Connecting cable, data cable X21 - X31

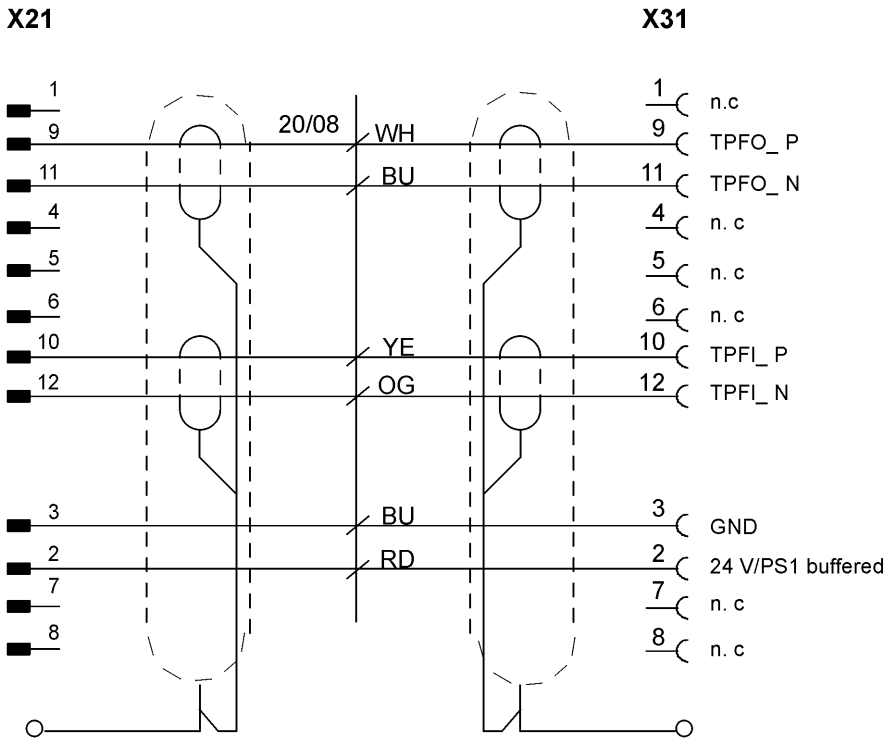


Fig. 8-26: Connecting cable, wiring diagram, data cable X21 - X31

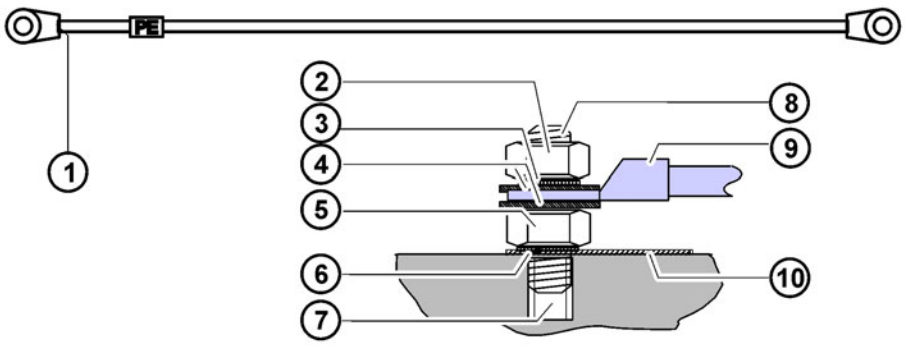


Fig. 8-27: Connecting cable, ground conductor

1	Ground conductor	6	Conical spring washer
2	Hexagon nut	7	Robot
3	Conical spring washer 2x	8	Setscrew
4	Plain washer 2x	9	Ground conductor connection, M8 ring cable lug
5	Hexagon nut	10	Ground plate

9 Maintenance

Maintenance symbols


Oil change


Lubricate with grease gun


Lubricate with brush


Tighten screw/nut


Check component, visual inspection


Replace toothed belts


Check toothed belt tension

9.1 Maintenance, KR 16 arc HW

9.1.1 Maintenance table

Description

The table provides an overview of the maintenance work (maintenance intervals, activities, lubrication work) and required lubricants applicable to this robot.

Lubrication is performed either at the specified maintenance intervals or every 5 years after commissioning by the customer. With a maintenance interval of 10,000 operating hours, for example, the first maintenance (oil change) is performed either after 10,000 operating hours or 5 years after commissioning by the customer, whichever is reached first.

The maintenance intervals given in the tables are valid for the operating conditions specified in the technical data (>>> 4 "Technical data" Page 15). 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.

If the robot is fitted with a KUKA energy supply system (optional), additional maintenance work must be carried out.

NOTICE Only lubricants approved by KUKA Roboter GmbH may be used.

Precondition

- The maintenance points must be freely accessible.
- Remove the tools and any additional items of equipment if they impede maintenance work.

⚠ WARNING When carrying out the following work, the robot must be moved several times between the individual work steps.
While work is being carried out on the robot, it must always be secured by activating the EMERGENCY STOP device.
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot that is switched on, the robot can only be moved in T1 mode (reduced velocity). It must be possible to stop the robot at any time by activating an EMERGENCY STOP device. Operation must be limited to what is absolutely necessary.
Warn all persons concerned before switching on and moving the robot.

If oil temperatures of more than 333 K (+60 °C) are reached during operation, shorter maintenance intervals must be observed; for this, consultation with KUKA Roboter GmbH is necessary.

NOTICE When draining the oil, remember that the quantity drained is dependent on time and temperature. The quantity of oil drained must be determined. Only this quantity of oil may be used when refilling. The oil quantities specified are the actual amounts of oil in the gear unit at first filling.
If less than 70% of the specified oil quantity flows out, flush the gear unit with the determined 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.

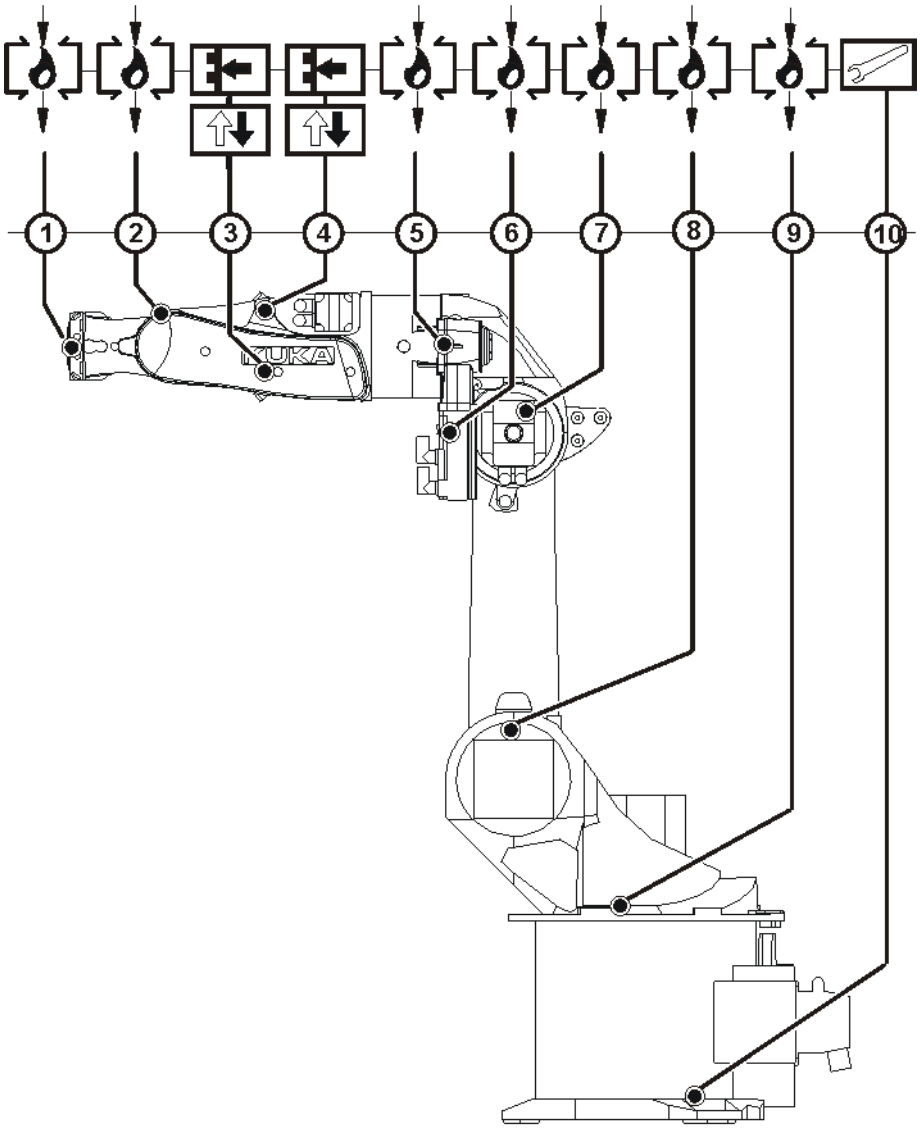


Fig. 9-1: Maintenance work

Interval	Item	Activity	Lubricant
100 h*	10	Check tightening torque for anchor nuts and holding-down bolts. * Once only, after initial start-up or recommissioning.	
2 years	3	Exchange toothed belt on axis 5 (>>> 11.1.7 "Removal, installation of toothed belt for axis 5" Page 140)	
2 years	4	Exchange toothed belt on axis 6 (>>> 11.1.8 "Removal, installation of toothed belt for axis 6" Page 141)	

Interval	Item	Activity	Lubricant
10,000 h	3	Check the toothed belt tension on axis 5. (>>> 10.1.1 "Measuring and adjusting the toothed belt tension on A5" Page 121) Check toothed belt on axis 5. Replace the toothed belt if cracks or signs of deterioration are found. (>>> 11.1.7 "Removal, installation of toothed belt for axis 5" Page 140)	
10,000 h	4	Check the toothed belt tension on axis 6. (>>> 10.1.2 "Measuring and adjusting the toothed belt tension on A6" Page 122) Check toothed belt on axis 6. Replace the toothed belt if cracks or signs of deterioration are found. (>>> 11.1.8 "Removal, installation of toothed belt for axis 6" Page 141)	
20,000 h	2	Carry out oil change on A5. (>>> 9.1.6 "Changing the gear oil on axes 5 and 6 for IW 16 arc HW" Page 108)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.225 l
20,000 h	5	Carry out oil change on A4. (>>> 9.1.5 "Changing the gear oil in axis 4" Page 105)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.115 l
20,000 h	6	Carry out oil change on input stage A4. (>>> 9.1.5 "Changing the gear oil in axis 4" Page 105)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.305 l
20,000 h	7	Carry out oil change on A3. (>>> 9.2.4 "Changing the gear oil in axis 3" Page 116)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.200 l
20,000 h	8	Carry out oil change on A2. (>>> 9.2.3 "Changing the gear oil in axis 2" Page 114)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.500 l
20,000 h	9	Floor-mounted robots Carry out oil change on A1. (>>> 9.2.2 "Changing the gear oil in axis 1" Page 113)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.500 l

Interval	Item	Activity	Lubricant
20,000 h	9	Ceiling-mounted robots Carry out oil change on A1. (>>> 9.2.2 "Changing the gear oil in axis 1" Page 113)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.600 l (with compensation vessel)
30,000 h	1	Carry out oil change on A6. (>>> 9.1.6 "Changing the gear oil on axes 5 and 6 for IW 16 arc HW" Page 108)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.380 l

9.1.2 Changing the gear oil in axis 1

Precondition

- The gear unit is at operating temperature.

⚠ WARNING If the oil change is carried out immediately after the robot has stopped operating, the oil temperature and the surface temperature are liable to be high and could result in burn injuries. Protective gloves must be worn.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

Draining oil

1. Remove 4 M6x10 Allen screws and lock washers (>>> Fig. 9-2), and take off the cover.
2. Remove the cable straps and pull the oil drain hose out of the base frame.
3. Place a suitable receptacle under the drain hole.
4. Unscrew the sealing cap from the oil drain hose.
5. Remove and inspect the magnetic screw plug for metallic deposits and clean it.
6. Catch the oil as it drains out.
7. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
8. Fit the sealing cap on the oil drain hose and tighten; M_A = 12 Nm.

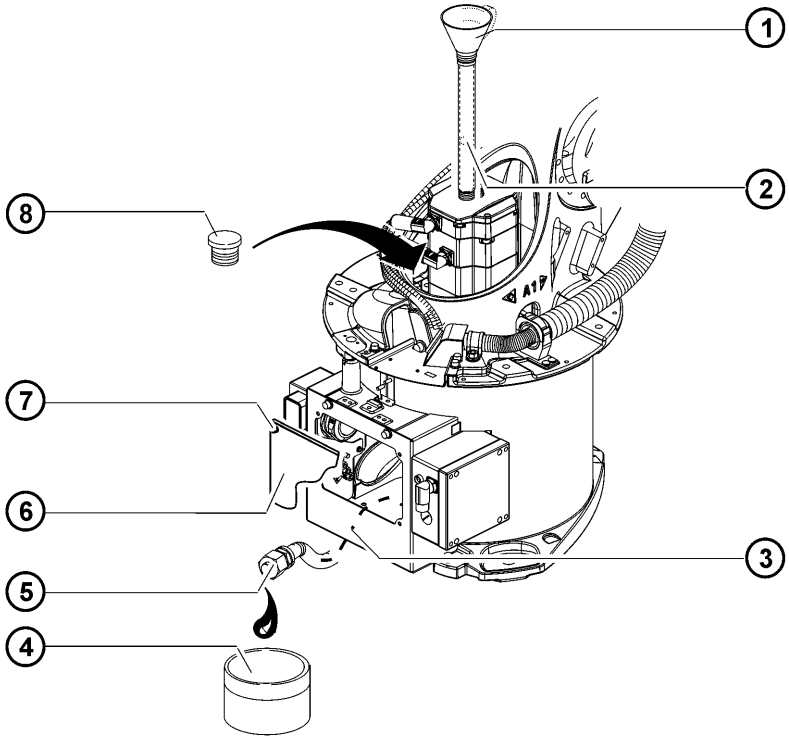


Fig. 9-2: Oil change on axis 1

1	Funnel	5	Sealing cap
2	Oil filling hose	6	Cover
3	Drain hose	7	Allen screws
4	Collection receptacle	8	Magnetic screw plug

Filling with oil

1. Pour the specified amount of oil into the filler hole of the magnetic screw plug (>>> Fig. 9-2).
   When pouring in the oil, use a hose approx. 1 m long with an M18x1.5 straight union together with a funnel which fits into the free end of the hose.
2. Insert and tighten the M18x1.5 magnetic screw plug; M_A = 20 Nm.
3. Check the sealing cap and magnetic screw plug for leaks.
4. Push the oil drain hose back into the base frame and attach cable straps.
5. Mount the cover and fasten it with 4 M6x10 Allen screws and lock washers.
6. Connect any peripheral supply lines required.

9.1.3 Changing the gear oil in axis 2

Precondition

- The robot is in a position in which gear unit A 2 is accessible.
- The gear unit is at operating temperature.

⚠ WARNING If the oil change is carried out immediately after the robot has stopped operating, the oil temperature and the surface temperature are liable to be high and could result in burn injuries. Protective gloves must be worn.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

It is easier to drain and fill the oil if a transparent hose is connected to the oil drain hole.

Draining oil

1. Place a suitable receptacle under the oil drain hole (>>> Fig. 9-3).
2. Remove the lower magnetic screw plug and screw in the oil drain hose.
3. Remove the upper magnetic screw plug and catch the oil as it drains out.
4. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
5. Inspect magnetic screw plugs for metallic deposits and clean them.
6. Remove the oil drain hose.
   The oil drain hose can be left in the gear unit for oil filling, if the oil is to be filled from the bottom up.

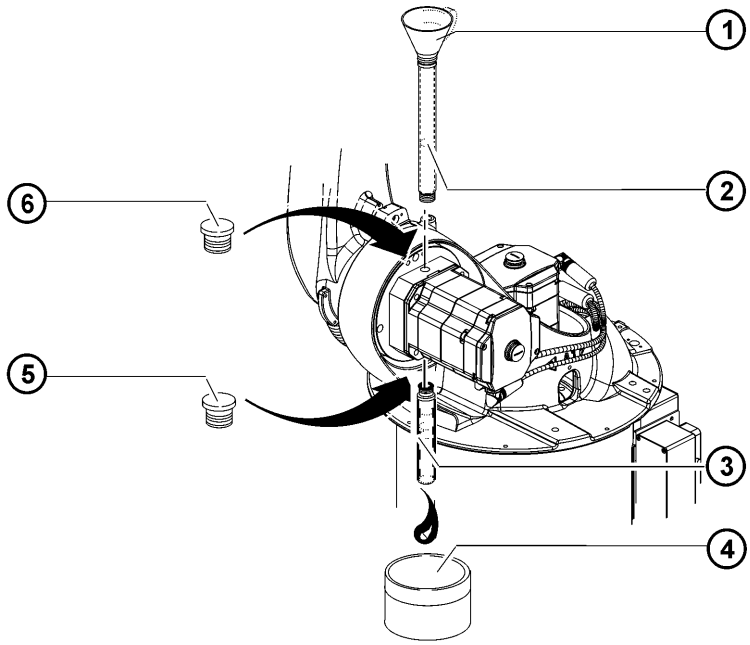


Fig. 9-3: Oil change on axis 2

1	Funnel
2	Hose
3	Oil drain hose
4	Collection receptacle
5	Lower magnetic screw plug
6	Upper magnetic screw plug

Filling with oil

1. Screw in the hose at the top (>>> Fig. 9-3).
2. Insert and tighten the lower M18x1.5 magnetic screw plug; M_A = 20 Nm.
3. Pour in the specified amount of oil via the funnel and hose.
4. Unscrew the hose.
5. Insert and tighten the upper M18x1.5 magnetic screw plug; M_A = 20 Nm.

6. Check both magnetic screw plugs for leaks.

9.1.4 Changing the gear oil in axis 3

Precondition

- The robot is in a position in which gear unit A3 is accessible; arm pointing upwards.
- The magnetic screw plugs on axis 3 are aligned vertically.
- The gear unit is at operating temperature.

⚠ WARNING If the oil change is carried out immediately after the robot has stopped operating, the oil temperature and the surface temperature are liable to be high and could result in burn injuries. Protective gloves must be worn.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

It is easier to drain and fill the oil if a transparent hose is connected to the oil drain hole.

Draining oil

1. Place a suitable receptacle under the oil drain hole (>>> Fig. 9-4).
2. Remove the lower magnetic screw plug and screw in the oil drain hose.
3. Remove the upper magnetic screw plug and catch the oil as it drains out.
4. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
5. Inspect magnetic screw plugs for metallic deposits and clean them.
6. Remove the oil drain hose.
   The oil drain hose can be left in the gear unit for oil filling, if the oil is to be filled from the bottom up.

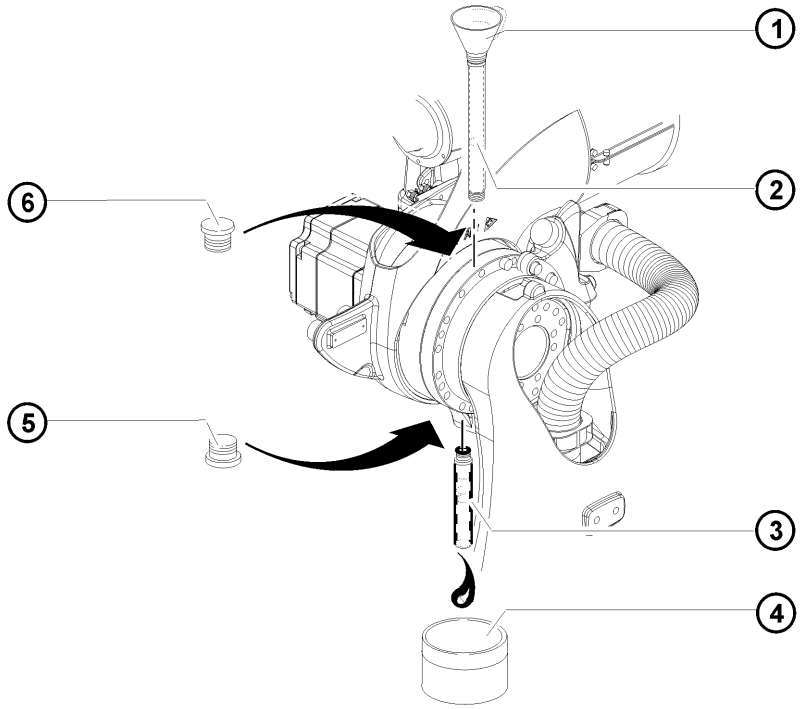


Fig. 9-4: Oil change on axis 3

1 Funnel
2 Hose
3 Oil drain hose
4 Collection receptacle
5 Lower magnetic screw plug
6 Upper magnetic screw plug

Filling with oil

1. Screw in the hose at the top (>>> Fig. 9-4).
2. Insert and tighten the lower M18x1.5 magnetic screw plug; M_A = 20 Nm.
3. Pour in the specified amount of oil via the funnel and hose.
4. Remove the hose.
5. Insert and tighten the M18x1.5 magnetic screw plug; M_A = 20 Nm.
6. Check both magnetic screw plugs for leaks.

9.1.5 Changing the gear oil in axis 4

Description

Axis 4 has two separate oil chambers.

⚠ WARNING When carrying out the following work, the robot must be moved several times between the individual work steps. While work is being carried out on the robot, it must always be secured by activating the EMERGENCY STOP device.
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot that is switched on, the robot can only be moved in T1 mode (reduced velocity). It must be possible to stop the robot at any time by activating an EMERGENCY STOP device. Operation must be limited to what is absolutely necessary.
Warn all persons concerned before switching on and moving the robot.

⚠ WARNING If the oil change is carried out immediately after the robot has stopped operating, the oil temperature and the surface temperature are liable to be high and could result in burn injuries. Protective gloves must be worn.

Preconditions

- The robot is in a position in which the gear units are accessible.
- The robot can be moved.
- The gear units are at operating temperature.

Input stage A 4, draining oil

1. Move axis 3 (>>> Fig. 9-5) into the 0° position.
2. Remove the magnetic screw plug.
3. Place a suitable receptacle under the drain hole.
4. Remove the sealing cap and catch the oil as it drains out.
5. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
6. Inspect the magnetic screw plug for metallic deposits and clean it.
7. Insert and tighten the sealing cap; M_A = 20 Nm.
8. Move axis 3 into the +90° position.

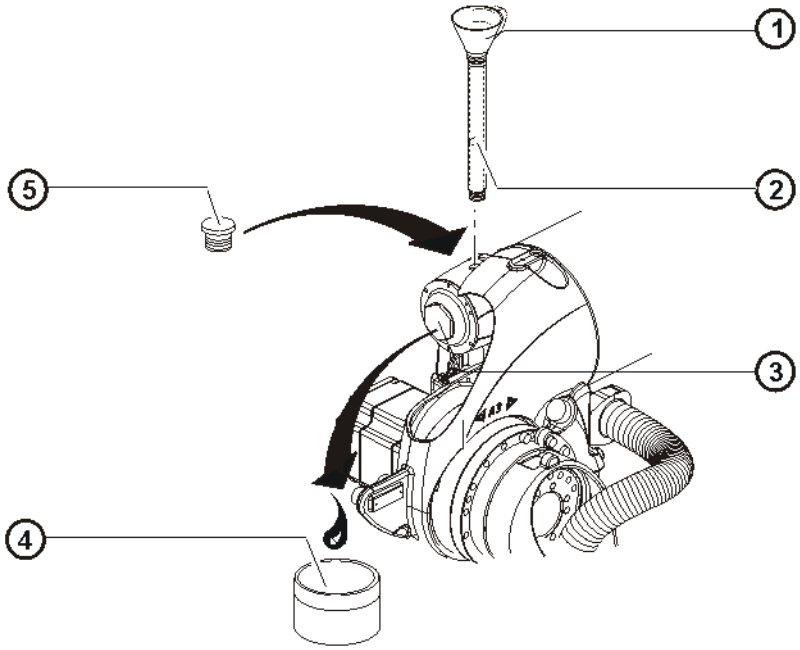


Fig. 9-5: Changing the oil on axis 4, input stage

1	Funnel	4	Collection receptacle
2	Hose	5	Magnetic screw plug
3	Sealing cap		

Input stage A 4, filling oil

1. Screw in the hose (>>> Fig. 9-5).
2. Pour in the specified amount of oil via the funnel and hose.
3. Insert and tighten the M10x1 magnetic screw plugs; M_A = 7.5 Nm.
4. Check the sealing cap and magnetic screw plug for leaks.

Gear unit A 4, draining oil

1. Remove the lower magnetic screw plug (>>> Fig. 9-6) and screw in the oil drain hose.

2. Place a suitable receptacle under the oil drain hose.
3. Remove the upper magnetic screw plug and catch the oil as it drains out.
4. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
5. Remove the oil drain hose.
6. Inspect the magnetic screw plug for metallic deposits and clean it.
7. Insert and tighten the lower M10x1 magnetic screw plug; M_A = 7.5 Nm.

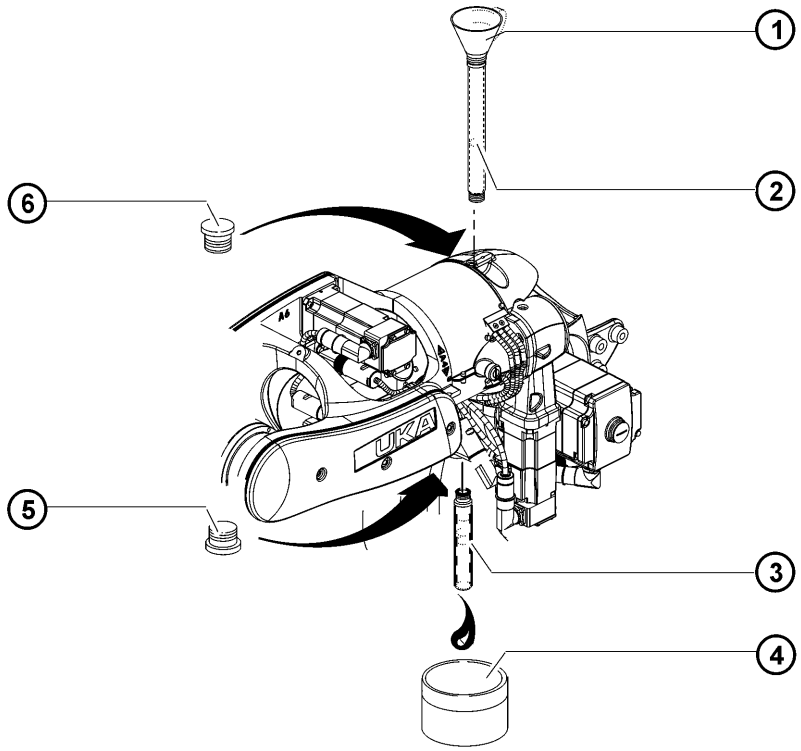


Fig. 9-6: Changing the oil on axis 4, gear unit

1 Funnel
2 Hose
3 Oil drain hose
4 Collection receptacle
5 Lower magnetic screw plug
6 Upper magnetic screw plug

Gear unit A 4, filling oil

1. Screw in the hose (>>> Fig. 9-6).
2. Pour in the specified amount of oil via the funnel and hose.
3. Unscrew the hose.
4. Insert and tighten the upper M10x1 magnetic screw plug; M_A = 7.5 Nm.
5. Check both magnetic screw plugs for leaks.

9.1.6 Changing the gear oil on axes 5 and 6 for IW 16 arc HW

⚠ WARNING When carrying out the following work, the robot must be moved several times between the individual work steps.
While work is being carried out on the robot, it must always be secured by activating the EMERGENCY STOP device.
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot that is switched on, the robot can only be moved in T1 mode (reduced velocity). It must be possible to stop the robot at any time by activating an EMERGENCY STOP device. Operation must be limited to what is absolutely necessary.
Warn all persons concerned before switching on and moving the robot.

Precondition

- The arm is in the horizontal position.
- Axes 4, 5 and 6 are in the 0° position.
- The robot can be moved.
- The gear unit is at operating temperature.

⚠ WARNING If the oil change is carried out immediately after the robot has stopped operating, the oil temperature and the surface temperature are liable to be high and could result in burn injuries. Protective gloves must be worn.

Draining oil

1. Remove the lower magnetic screw plug (>>> Fig. 9-7).
2. Place a suitable receptacle under the oil drainage hole.
3. Remove the upper magnetic screw plug and catch the oil as it drains out.
4. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
5. Inspect magnetic screw plugs for metallic deposits and clean them.
6. Insert and tighten the lower M8x1 magnetic screw plug; M_A = 5 Nm.

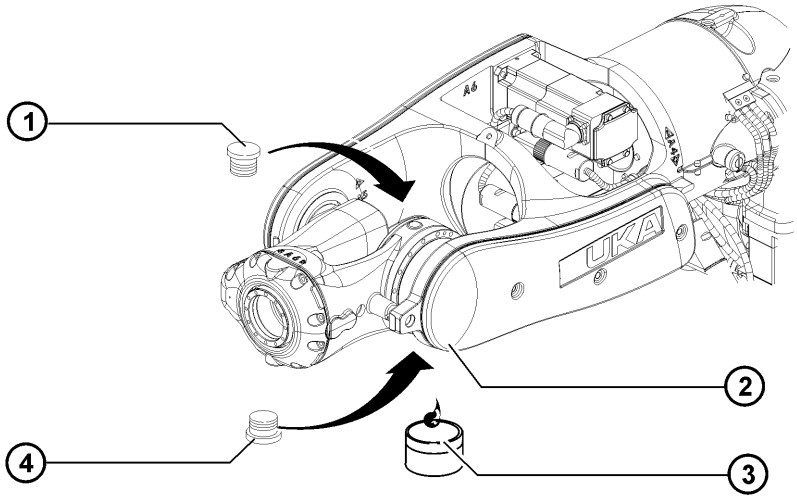


Fig. 9-7: Oil change on wrist axis A5

1 Upper magnetic screw plug
2 Oil drain hole
3 Collection receptacle
4 Lower magnetic screw plug

7. Remove the rear magnetic screw plugs (>>> Fig. 9-8) from the housing.
8. Place a suitable receptacle under the drain hole.

9. Move axis 5 through 90°; the mounting flange points upward.
10. Unscrew the front magnetic screw plugs.
11. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
12. Inspect the magnetic screw plug for metallic deposits and clean it.
13. Insert and tighten the front M10x1 magnetic screw plug; M_A = 7.5 Nm.

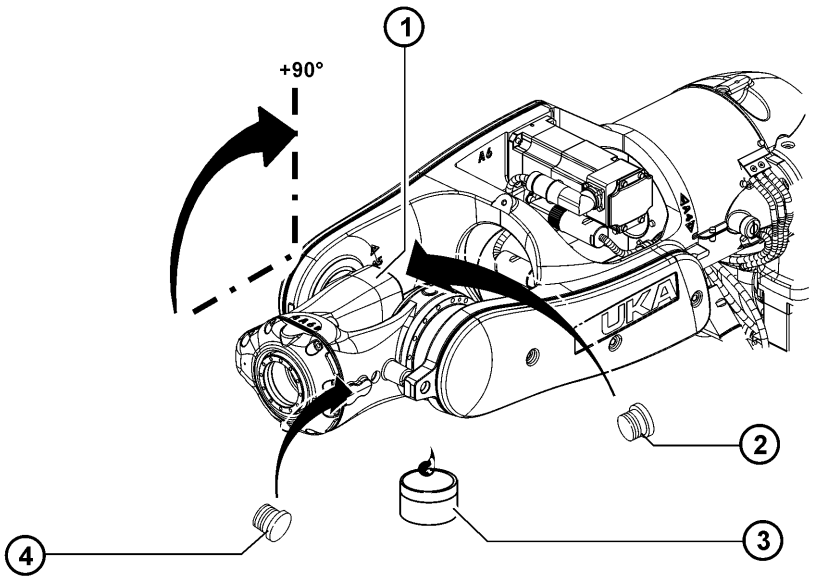


Fig. 9-8: Oil change on wrist A6

1	Housing	3	Collection receptacle
2	Rear magnetic screw plug	4	Front magnetic screw plug

Filling with oil

1. Move axis 5 through -180°; the mounting flange points downward.
2. Pour the specified amount of oil into the filler holes of the upper magnetic screw plug.
3. Insert and tighten the upper M10x1 magnetic screw plug; M_A = 7.5 Nm.
4. Move axis 5 through 0°; the mounting flange points forward.
5. Pour the specified amount of oil into the filler holes of the rear magnetic screw plug (>>> Fig. 9-7).
6. Insert and tighten the rear M10x1 magnetic screw plugs; M_A = 7.5 Nm.
7. Check all magnetic screw plugs for leaks.

9.1.7 Cleaning the robot

Description

The robot must be cleaned in compliance with the instructions given here in order to prevent damage. These instructions only refer to the robot. System components, tools and the robot controller must be cleaned in accordance with the cleaning instructions relevant to them.

The following must be taken into consideration when using cleaning agents and carrying out cleaning work:

- Only use solvent-free, water-soluble cleaning agents.
- Do not use flammable cleaning agents.
- Do not use aggressive cleaning agents.
- Do not use steam or refrigerants for cleaning.
- Do not use high-pressure cleaners.

- It must be ensured that no cleaning agent enters electrical or mechanical system components.
- Personnel protection measures must be taken.

Precondition

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

Procedure

1. Shut down the robot.
2. If necessary, stop adjacent system components and lock them.
3. Remove enclosures if this is necessary in order to carry out the cleaning work.
4. Clean the robot.
5. Fully remove all cleaning agents from the robot.
6. Clean any areas of corrosion and reapply corrosion protection.
7. Remove cleaning agents and equipment from the workspace of the robot.
8. Dispose of cleaning agents properly.
9. Install any safety equipment that has been removed and check that it is functioning correctly.
10. Replace any damaged or illegible plates and covers.
11. Put back in place any enclosures that have been removed.
12. Only put fully functional robots and systems back into operation.

9.2 Maintenance, KR 16 L8 arc HW

9.2.1 Maintenance table

Description

The table provides an overview of the maintenance work (maintenance intervals, activities, lubrication work) and required lubricants applicable to this robot.

Lubrication is performed either at the specified maintenance intervals or every 5 years after commissioning by the customer. With a maintenance interval of 10,000 operating hours, for example, the first maintenance (oil change) is performed either after 10,000 operating hours or 5 years after commissioning by the customer, whichever is reached first.

The maintenance intervals given in the tables are valid for the operating conditions specified in the technical data (>>> 4 "Technical data" Page 15). 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.

If the robot is fitted with a KUKA energy supply system (optional), additional maintenance work must be carried out.

NOTICE Only lubricants approved by KUKA Roboter GmbH may be used.

Precondition

- The maintenance points must be freely accessible.
- Remove the tools and any additional items of equipment if they impede maintenance work.

⚠ WARNING When carrying out the following work, the robot must be moved several times between the individual work steps.
While work is being carried out on the robot, it must always be secured by activating the EMERGENCY STOP device.
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot that is switched on, the robot can only be moved in T1 mode (reduced velocity). It must be possible to stop the robot at any time by activating an EMERGENCY STOP device. Operation must be limited to what is absolutely necessary.
Warn all persons concerned before switching on and moving the robot.

If oil temperatures of more than 333 K (+60 °C) are reached during operation, shorter maintenance intervals must be observed; for this, consultation with KUKA Roboter GmbH is necessary.

NOTICE When draining the oil, remember that the quantity drained is dependent on time and temperature. The quantity of oil drained must be determined. Only this quantity of oil may be used when refilling. The oil quantities specified are the actual amounts of oil in the gear unit at first filling.
If less than 70% of the specified oil quantity flows out, flush the gear unit with the determined 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.

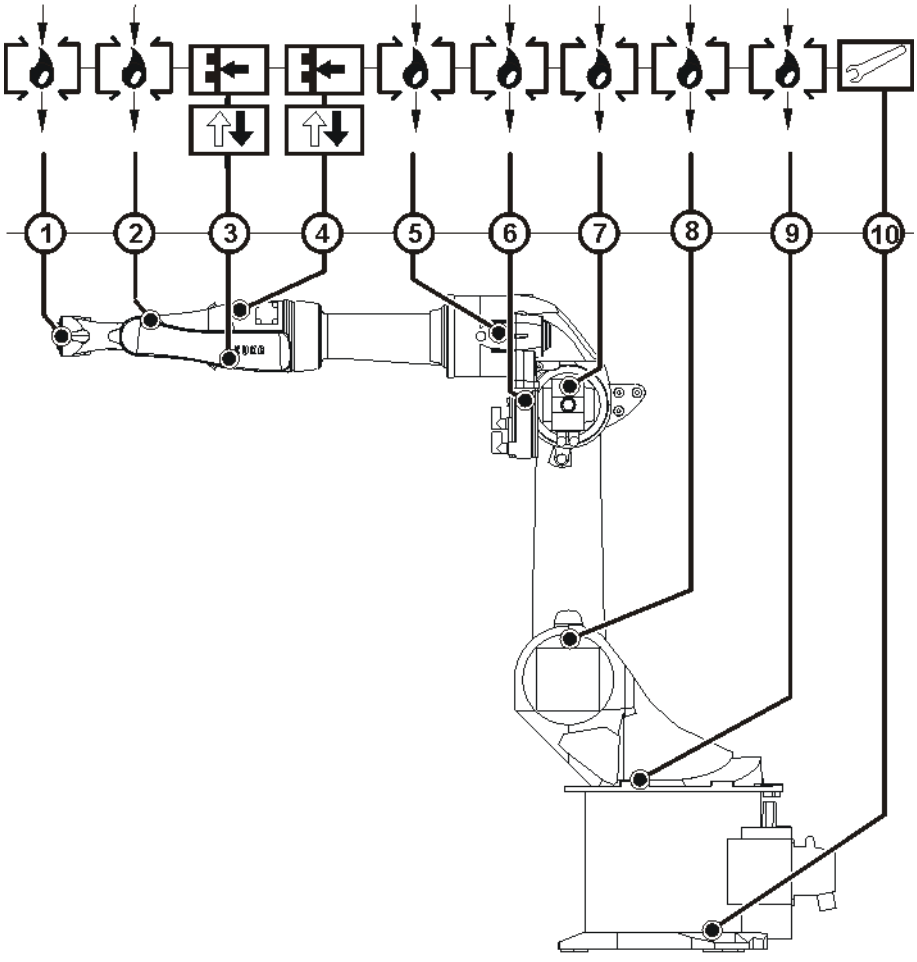


Fig. 9-9: Maintenance work

Interval	Item	Activity	Lubricant
100 h*	10	Check tightening torque for anchor nuts and holding-down bolts. * Once only, after initial start-up or recommissioning.	
2 years	3	Exchange toothed belt on axis 5 (>>> 11.2.5 "Removal, installation of toothed belt for axis 5" Page 149)	
2 years	4	Exchange toothed belt on axis 6 (>>> 11.2.6 "Removal, installation of toothed belt for axis 6" Page 150)	
10,000 h	3	Check the toothed belt tension on axis 5. (>>> 10.2.1 "Measuring and adjusting the toothed belt tension on A5" Page 124) Check toothed belt on axis 5. Replace the toothed belt if cracks or signs of deterioration are found. (>>> 11.2.5 "Removal, installation of toothed belt for axis 5" Page 149)	
10,000 h	4	Check the toothed belt tension on axis 6. (>>> 10.2.2 "Measuring and adjusting the toothed belt tension on A6" Page 125) Check toothed belt on axis 6. Replace the toothed belt if cracks or signs of deterioration are found. (>>> 11.2.6 "Removal, installation of toothed belt for axis 6" Page 150)	
20,000 h	2	Carry out oil change on A5. (>>> 9.2.6 "Changing the gear oil on axes 5 and 6" Page 119)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.01 l
20,000 h	5	Carry out oil change on A4. (>>> 9.2.5 "Changing the gear oil in axis 4" Page 117)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.115 l

Interval	Item	Activity	Lubricant
20,000 h	6	Carry out oil change on input stage A4. (>>> 9.2.5 "Changing the gear oil in axis 4" Page 117)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.305 l
20,000 h	7	Carry out oil change on A3. (>>> 9.2.4 "Changing the gear oil in axis 3" Page 116)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.200 l
20,000 h	8	Carry out oil change on A2. (>>> 9.2.3 "Changing the gear oil in axis 2" Page 114)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.500 l
20,000 h	9	Floor-mounted robots Carry out oil change on A1. (>>> 9.2.2 "Changing the gear oil in axis 1" Page 113)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.500 l
20,000 h	9	Ceiling-mounted robots Carry out oil change on A1. (>>> 9.2.2 "Changing the gear oil in axis 1" Page 113)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.600 l (with compensation vessel)
30,000 h	1	Carry out oil change on A6. (>>> 9.1.6 "Changing the gear oil on axes 5 and 6 for IW 16 arc HW" Page 108)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 0.10 l

9.2.2 Changing the gear oil in axis 1

Precondition

- The gear unit is at operating temperature.

⚠ WARNING If the oil change is carried out immediately after the robot has stopped operating, the oil temperature and the surface temperature are liable to be high and could result in burn injuries. Protective gloves must be worn.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

Draining oil

1. Remove 4 M6x10 Allen screws and lock washers (>>> Fig. 9-10), and take off the cover.
2. Remove the cable straps and pull the oil drain hose out of the base frame.
3. Place a suitable receptacle under the drain hole.
4. Unscrew the sealing cap from the oil drain hose.
5. Remove and inspect the magnetic screw plug for metallic deposits and clean it.
6. Catch the oil as it drains out.

7. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
8. Fit the sealing cap on the oil drain hose and tighten; M_A = 12 Nm.

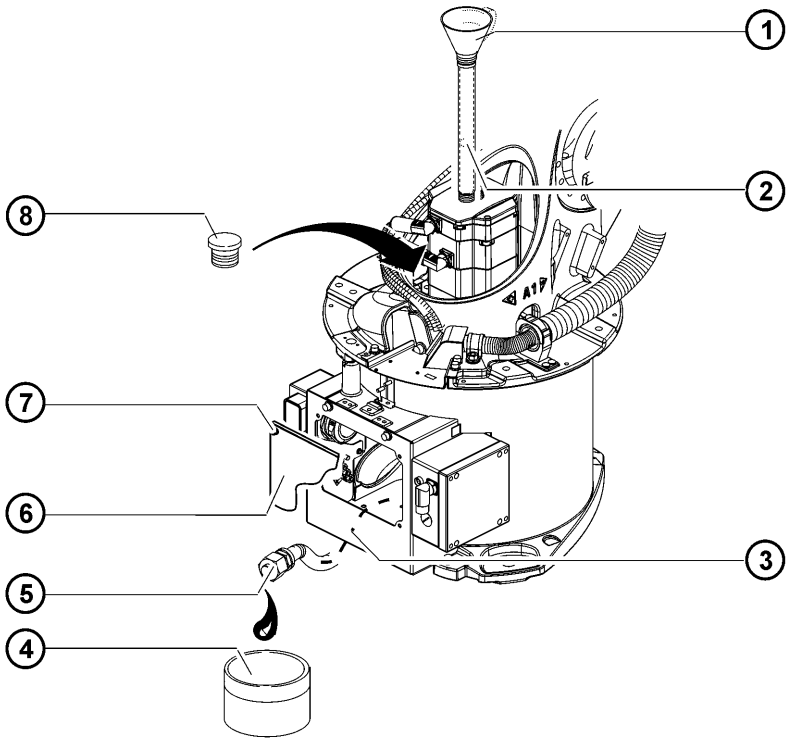


Fig. 9-10: Oil change on axis 1

1	Funnel	5	Sealing cap
2	Oil filling hose	6	Cover
3	Drain hose	7	Allen screws
4	Collection receptacle	8	Magnetic screw plug

Filling with oil

1. Pour the specified amount of oil into the filler hole of the magnetic screw plug (>>> Fig. 9-10).
   When pouring in the oil, use a hose approx. 1 m long with an M18x1.5 straight union together with a funnel which fits into the free end of the hose.
2. Insert and tighten the M18x1.5 magnetic screw plug; M_A = 20 Nm.
3. Check the sealing cap and magnetic screw plug for leaks.
4. Push the oil drain hose back into the base frame and attach cable straps.
5. Mount the cover and fasten it with 4 M6x10 Allen screws and lock washers.
6. Connect any peripheral supply lines required.

9.2.3 Changing the gear oil in axis 2

Precondition

- The robot is in a position in which gear unit A 2 is accessible.
- The gear unit is at operating temperature.

⚠ WARNING If the oil change is carried out immediately after the robot has stopped operating, the oil temperature and the surface temperature are liable to be high and could result in burn injuries. Protective gloves must be worn.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

It is easier to drain and fill the oil if a transparent hose is connected to the oil drain hole.

Draining oil

1. Place a suitable receptacle under the oil drain hole (>>> Fig. 9-11).
2. Remove the lower magnetic screw plug and screw in the oil drain hose.
3. Remove the upper magnetic screw plug and catch the oil as it drains out.
4. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
5. Inspect magnetic screw plugs for metallic deposits and clean them.
6. Remove the oil drain hose.
   The oil drain hose can be left in the gear unit for oil filling, if the oil is to be filled from the bottom up.

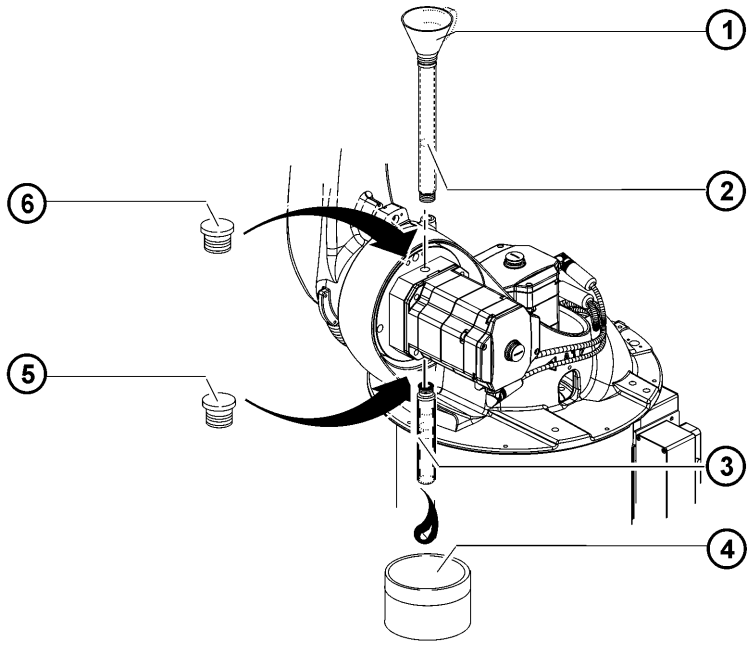


Fig. 9-11: Oil change on axis 2

1	Funnel
2	Hose
3	Oil drain hose
4	Collection receptacle
5	Lower magnetic screw plug
6	Upper magnetic screw plug

Filling with oil

1. Screw in the hose at the top (>>> Fig. 9-11).
2. Insert and tighten the lower M18x1.5 magnetic screw plug; M_A = 20 Nm.
3. Pour in the specified amount of oil via the funnel and hose.
4. Unscrew the hose.
5. Insert and tighten the upper M18x1.5 magnetic screw plug; M_A = 20 Nm.

6. Check both magnetic screw plugs for leaks.

9.2.4 Changing the gear oil in axis 3

Precondition

- The robot is in a position in which gear unit A3 is accessible; arm pointing upwards.
- The magnetic screw plugs on axis 3 are aligned vertically.
- The gear unit is at operating temperature.

⚠ WARNING If the oil change is carried out immediately after the robot has stopped operating, the oil temperature and the surface temperature are liable to be high and could result in burn injuries. Protective gloves must be worn.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

It is easier to drain and fill the oil if a transparent hose is connected to the oil drain hole.

Draining oil

1. Place a suitable receptacle under the oil drain hole (>>> Fig. 9-12).
2. Remove the lower magnetic screw plug and screw in the oil drain hose.
3. Remove the upper magnetic screw plug and catch the oil as it drains out.
4. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
5. Inspect magnetic screw plugs for metallic deposits and clean them.
6. Remove the oil drain hose.
   The oil drain hose can be left in the gear unit for oil filling, if the oil is to be filled from the bottom up.

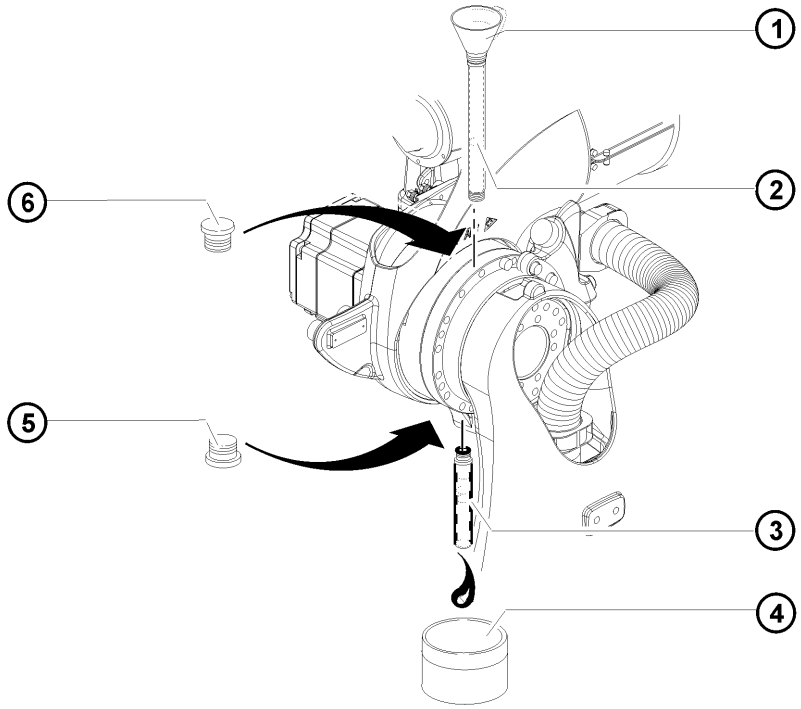


Fig. 9-12: Oil change on axis 3

1 Funnel
2 Hose
3 Oil drain hose
4 Collection receptacle
5 Lower magnetic screw plug
6 Upper magnetic screw plug

Filling with oil

1. Screw in the hose at the top (>>> Fig. 9-12).
2. Insert and tighten the lower M18x1.5 magnetic screw plug; M_A = 20 Nm.
3. Pour in the specified amount of oil via the funnel and hose.
4. Remove the hose.
5. Insert and tighten the M18x1.5 magnetic screw plug; M_A = 20 Nm.
6. Check both magnetic screw plugs for leaks.

9.2.5 Changing the gear oil in axis 4

Description

Axis 4 has two separate oil chambers.

⚠ WARNING When carrying out the following work, the robot must be moved several times between the individual work steps. While work is being carried out on the robot, it must always be secured by activating the EMERGENCY STOP device.
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot that is switched on, the robot can only be moved in T1 mode (reduced velocity). It must be possible to stop the robot at any time by activating an EMERGENCY STOP device. Operation must be limited to what is absolutely necessary.
Warn all persons concerned before switching on and moving the robot.

⚠ WARNING If the oil change is carried out immediately after the robot has stopped operating, the oil temperature and the surface temperature are liable to be high and could result in burn injuries. Protective gloves must be worn.

Preconditions

- The robot is in a position in which the gear units are accessible.
- The robot can be moved.
- The gear units are at operating temperature.

Input stage A 4, draining oil

1. Move axis 3 (>>> Fig. 9-13) into the 0° position.
2. Remove the magnetic screw plug.
3. Place a suitable receptacle under the drain hole.
4. Remove the sealing cap and catch the oil as it drains out.
5. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
6. Inspect the magnetic screw plug for metallic deposits and clean it.
7. Insert and tighten the sealing cap; M_A = 20 Nm.
8. Move axis 3 into the +90° position.

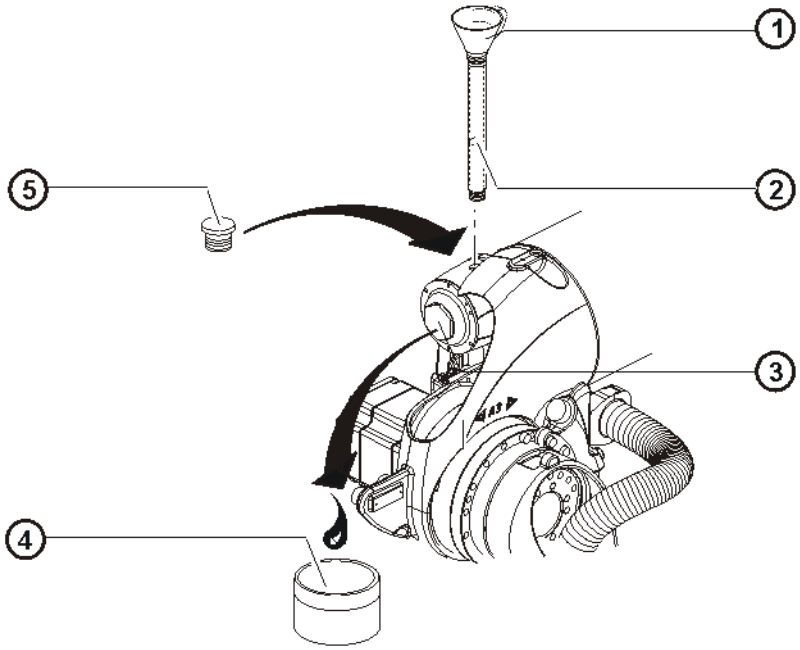


Fig. 9-13: Changing the oil on axis 4, input stage

1	Funnel	4	Collection receptacle
2	Hose	5	Magnetic screw plug
3	Sealing cap		

Input stage A 4, filling oil

1. Screw in the hose (>>> Fig. 9-13).
2. Pour in the specified amount of oil via the funnel and hose.
3. Insert and tighten the M10x1 magnetic screw plugs; M_A = 7.5 Nm.
4. Check the sealing cap and magnetic screw plug for leaks.

Gear unit A 4, draining oil

1. Remove the lower magnetic screw plug (>>> Fig. 9-6) and screw in the oil drain hose.

2. Place a suitable receptacle under the oil drain hose.
3. Remove the upper magnetic screw plug and catch the oil as it drains out.
4. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
5. Remove the oil drain hose.
6. Inspect the magnetic screw plug for metallic deposits and clean it.
7. Insert and tighten the lower M10x1 magnetic screw plug; M_A = 7.5 Nm.

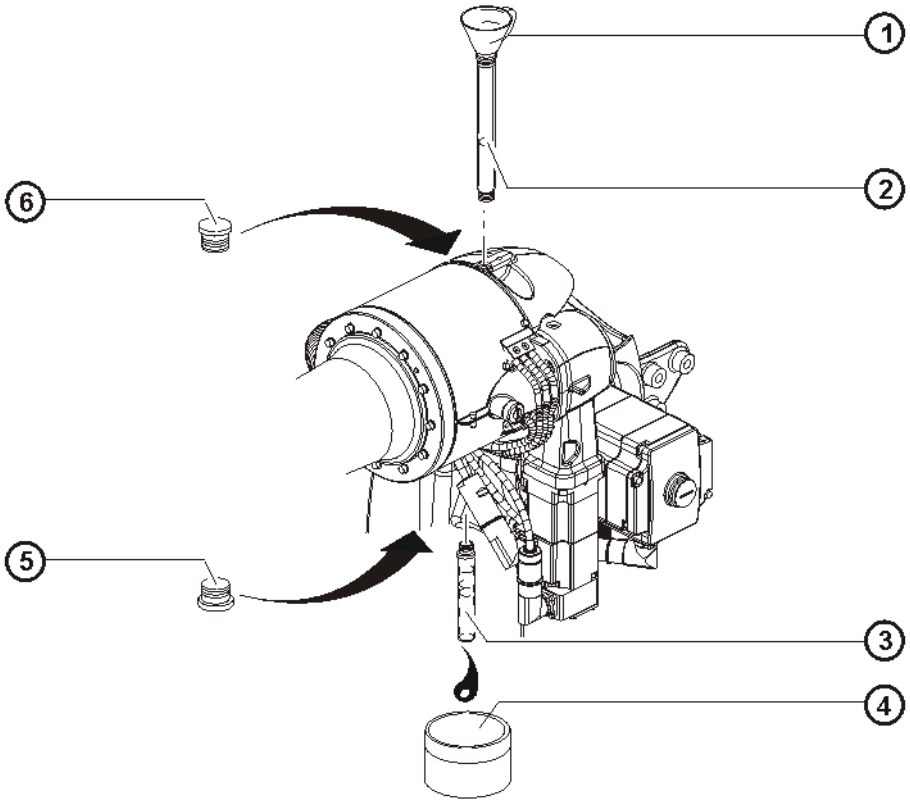


Fig. 9-14: Changing the oil on axis 4, gear unit

1 Funnel
2 Hose
3 Oil drain hose
4 Collection receptacle
5 Lower magnetic screw plug
6 Upper magnetic screw plug

Gear unit A 4, filling oil

1. Screw in the hose (>>> Fig. 9-6).
2. Pour in the specified amount of oil via the funnel and hose.
3. Unscrew the hose.
4. Insert and tighten the upper M10x1 magnetic screw plug; M_A = 7.5 Nm.
5. Check both magnetic screw plugs for leaks.

9.2.6 Changing the gear oil on axes 5 and 6

Precondition

- The arm is in the horizontal position.
- Axes 4, 5 and 6 are in the 0° position.
- The gear unit is at operating temperature.

⚠ WARNING When carrying out the following work, the robot must be moved several times between the individual work steps.
While work is being carried out on the robot, it must always be secured by activating the EMERGENCY STOP device.
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot that is switched on, the robot can only be moved in T1 mode (reduced velocity). It must be possible to stop the robot at any time by activating an EMERGENCY STOP device. Operation must be limited to what is absolutely necessary.
Warn all persons concerned before switching on and moving the robot.

⚠ WARNING If the oil change is carried out immediately after the robot has stopped operating, the oil temperature and the surface temperature are liable to be high and could result in burn injuries. Protective gloves must be worn.

9.2.7 Cleaning the robot

Description

The robot must be cleaned in compliance with the instructions given here in order to prevent damage. These instructions only refer to the robot. System components, tools and the robot controller must be cleaned in accordance with the cleaning instructions relevant to them.

The following must be taken into consideration when using cleaning agents and carrying out cleaning work:

- Only use solvent-free, water-soluble cleaning agents.
- Do not use flammable cleaning agents.
- Do not use aggressive cleaning agents.
- Do not use steam or refrigerants for cleaning.
- Do not use high-pressure cleaners.
- It must be ensured that no cleaning agent enters electrical or mechanical system components.
- Personnel protection measures must be taken.

Precondition

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

Procedure

1. Shut down the robot.
2. If necessary, stop adjacent system components and lock them.
3. Remove enclosures if this is necessary in order to carry out the cleaning work.
4. Clean the robot.
5. Fully remove all cleaning agents from the robot.
6. Clean any areas of corrosion and reapply corrosion protection.
7. Remove cleaning agents and equipment from the workspace of the robot.
8. Dispose of cleaning agents properly.
9. Install any safety equipment that has been removed and check that it is functioning correctly.
10. Replace any damaged or illegible plates and covers.
11. Put back in place any enclosures that have been removed.
12. Only put fully functional robots and systems back into operation.

10 Adjustment

10.1 Settings for IW 16 arc HW

10.1.1 Measuring and adjusting the toothed belt tension on A5

Precondition

- Axis 5 is free from load.
- The arm is positioned horizontally.
- No tools are installed on axis 6.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

⚠ WARNING If the toothed belt tension is measured and adjusted immediately after the robot has stopped operating, surface temperatures are likely to be high and could result in burn injuries. Protective gloves must be worn.

Measuring toothed belt tension

1. Remove 3 fillister head screws (>>> Fig. 10-2) and take off the cover.
2. Switch on the belt tension measuring device (>>> Fig. 10-1).

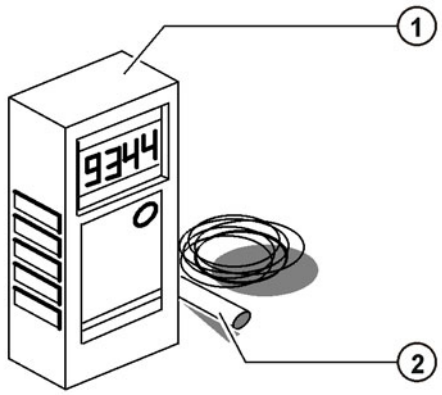


Fig. 10-1: Belt tension measuring device

1 Belt tension measuring device
2 Sensor

3. Pluck the toothed belt (>>> Fig. 10-2) in the middle of the free length and hold the sensor at a distance of 2 to 3 mm from the vibrating toothed belt.
4. Read the measurement on the belt tension measuring device.
5. Repeat the measurement three times and calculate the mean value.
   If the specified value is obtained, continue with step 6.
   If the measurement deviates from the specified value, adjust the toothed belt tension. Then carry out steps 6 to 8.
   Toothed belt tension

Axis	Toothed belt	Frequency
5	SFX10 AT5/900 GEN3	98-5 Hz

6. Check the seal and replace it with a new one if damaged.

7. Clean the mounting surface for the seal on the main body and on the cover.
8. Mount the cover and seal and fasten with 3 M5x25-10.9 Zn fillister head screws; M_A = 7.5 Nm.

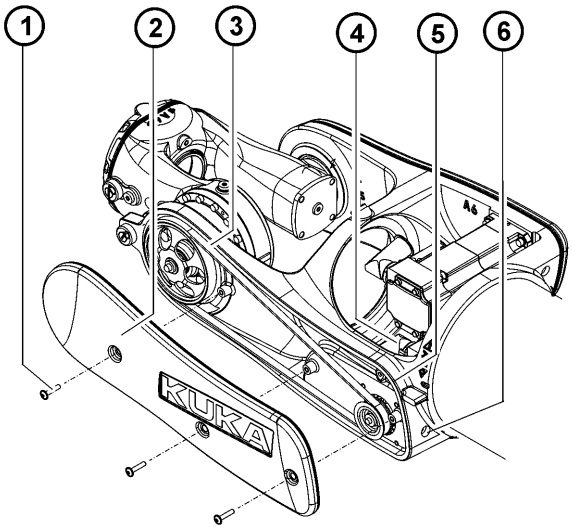


Fig. 10-2: Measuring and adjusting the toothed belt tension on axis 5

1	Fillister head screw	4	Motor A5
2	Cover	5	Seal
3	Toothed belt	6	Allen screw

Adjusting the toothed belt tension

1. Slacken the Allen screw (>>> Fig. 10-2) and nut on the rear of motor A5.
2. Slacken the 4 Allen screws on the motor until motor A5 can only just be shifted.
3. Carefully tighten or slacken the Allen screw and measure the toothed belt tension again.
4. Repeat steps 1 to 3 until the specified frequency is obtained.
5. Tighten the 4 M5x16 Allen screws on the motor with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 5.6 Nm.
6. Measure the tension of the toothed belt again.
7. Tighten the nut on the Allen screw; M_A 2.8 Nm.

NOTICE If a new toothed belt is installed, the belt tension must be rechecked after approximately 100 hours of operation and readjusted if necessary.

10.1.2 Measuring and adjusting the toothed belt tension on A6

Precondition

- Axis 5 is free from load.
- The arm is positioned horizontally.
- No tools are installed on axis 6.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

⚠ WARNING If the toothed belt tension is measured and adjusted immediately after the robot has stopped operating, surface temperatures are likely to be high and could result in burn injuries. Protective gloves must be worn.

Measuring toothed belt tension

1. Remove 3 fillister head screws (>>> Fig. 10-4) and take off the cover.
2. Switch on the belt tension measuring device (>>> Fig. 10-3).

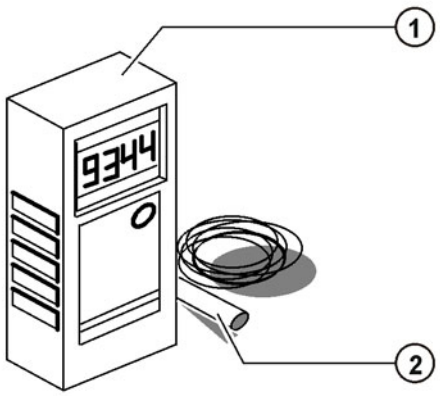


Fig. 10-3: Belt tension measuring device

1 Belt tension measuring device
2 Sensor

3. Pluck the toothed belt (>>> Fig. 10-4) in the middle of the free length and hold the sensor at a distance of 2 to 3 mm from the vibrating toothed belt.
4. Read the measurement on the belt tension measuring device.
5. Repeat the measurement three times and calculate the mean value.
   If the specified value is obtained, continue with step 6.
   If the measurement deviates from the specified value, adjust the toothed belt tension. Then carry out steps 6 to 8.
   Toothed belt tension

Axis	Toothed belt	Frequency
6	SFX10 AT5/900 GEN3	98-5 Hz

6. Check the seal (>>> Fig. 10-4) and replace it with a new one if damaged.
7. Clean the mounting surface for the seal on the main body and on the cover.
8. Mount the cover and seal and fasten with 3 M5x25-10.9 Zn fillister head screws; M_A = 7.5 Nm.

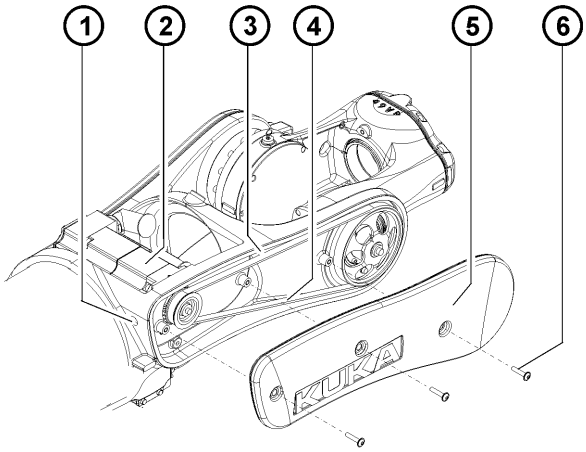


Fig. 10-4: Measuring and adjusting the toothed belt tension on axis 6

1	Allen screw	4	Toothed belt
2	Motor A6	5	Cover
3	Seal	6	Fillister head screws

Adjusting the toothed belt tension

1. Slacken the Allen screw (>>> Fig. 10-4) and nut on the rear of motor A6.
2. Slacken the 4 Allen screws on the motor until motor A6 can only just be shifted.
3. Carefully tighten or slacken the Allen screw and measure the toothed belt tension again.
4. Repeat steps 1 to 3 until the specified frequency is obtained.
5. Tighten the 4 M5x16 Allen screws on the motor with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 5.6 Nm.
6. Measure the tension of the toothed belt again.
7. Tighten the nut on the Allen screw; M_A 2.8 Nm.

NOTICE If a new toothed belt is installed, the belt tension must be rechecked after approximately 100 hours of operation and readjusted if necessary.

10.2 Settings for IW 5 arc HW

10.2.1 Measuring and adjusting the toothed belt tension on A5

Precondition

- Axis 5 is free from load.
- The arm is positioned horizontally.
- No tools are installed on axis 6.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

⚠ CAUTION If the toothed belt tension is measured and adjusted immediately after the robot has stopped operating, surface temperatures are likely to be high and could result in burn injuries. Protective gloves must be worn.

10.2.2 Measuring and adjusting the toothed belt tension on A6

Precondition

- Axis 5 is free from load.
- The arm is positioned horizontally.
- No tools are installed on axis 6.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

⚠ CAUTION If the toothed belt tension is measured and adjusted immediately after the robot has stopped operating, surface temperatures are likely to be high and could result in burn injuries. Protective gloves must be worn.

11 Repair

NOTICE When installing components and assemblies, the fastening screws (standard, strength class 8.8) must be tightened with the specified KUKA tightening torque. Exceptions to this will be clearly marked.
The specified screw sizes and strength classes are those 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 strength class 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.

11.1 Repair, KR 16 arc HW

11.1.1 Removal, installation of motor A1

Precondition

- The robot is secured against rotational motions about axis 1.

⚠ WARNING When work is performed on this system, live parts and unintentional robot motions can cause injuries and damage to property. If work is carried out on an operable system, the main switch on the control cabinet must be turned to the OFF position and secured with a padlock to prevent unauthorized persons from switching it on again.
Warn all persons concerned before putting the system back into operation.

⚠ WARNING If the motor change is carried out immediately after the robot has stopped operating, the surface temperatures of the motor are liable to be high and could result in burn injuries. Protective gloves must be worn.

⚠ WARNING When removing or installing the motor, care must be taken to avoid injury to hands by crushing. Protective gloves must be worn.

Removal

1. Release and unplug connectors XM1 (>>> Fig. 11-1) and XP1 from motor A1.
2. Remove 4 Allen screws.
3. Release and lift out motor A1. Do not tilt it when lifting it.
4. If motor A1 is not to be reinstalled, it must be protected against corrosion before being put into storage.

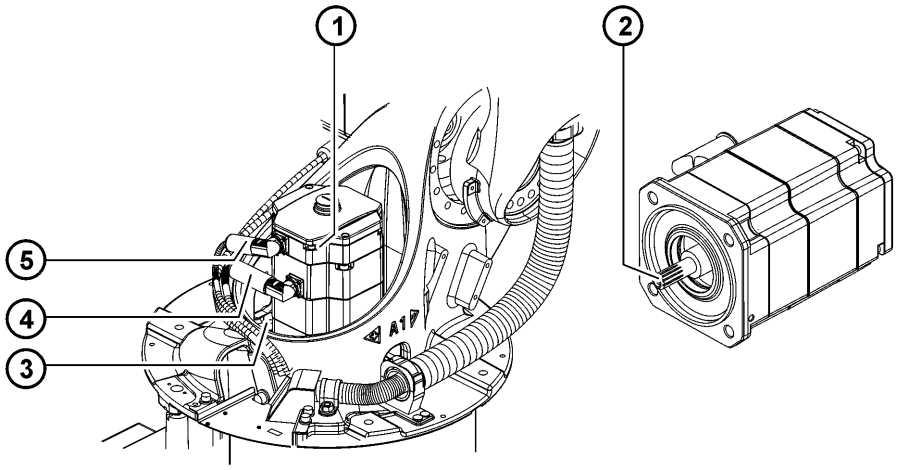


Fig. 11-1: Removal, installation of motor A1

1	Motor A1	4	Connector XM1
2	Toothing	5	Connector XP1
3	Allen screw		

Installation

NOTICE When installing the motor, it must be ensured that the toothing of the motor and gear unit is not damaged.

1. If necessary, remove all protective coatings and oil from the new motor A1.
2. Clean toothing (>>> Fig. 11-1) of motor and gear unit before installation and apply a thin but continuous coat of Microlube GL 261 grease.

Insertion of motor can be facilitated by turning it gently about its rotational axis.

3. Clean the mounting surface of motor A1 on the gear unit.
4. Align and insert motor A1 as shown in the illustration. Do not tilt during installation.

Insertion of motor can be facilitated by turning it gently about its rotational axis.

5. Fasten motor A1 with 4 M8x20 Allen screws.
6. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 23 Nm.
7. Plug connectors XM1 and XP1 into motor.
8. Remove safeguards against the robot turning about rotational axis 1.
9. Carry out mastering of axis 1.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

11.1.2 Removal, installation of motor A2

Preconditions

- The link arm is secured (>>> Fig. 11-2).

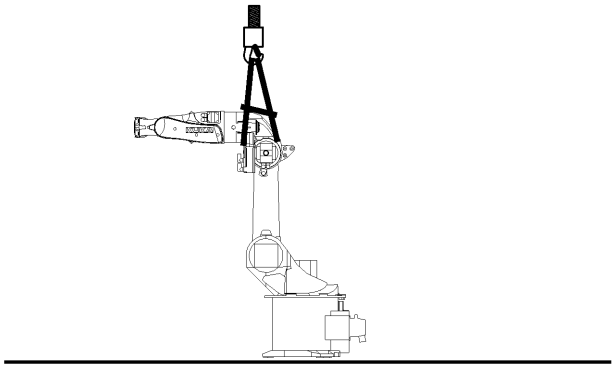


Fig. 11-2: Securing the link arm (schematic)

⚠ WARNING When work is performed on this system, live parts and unintentional robot motions can cause injuries and damage to property. If work is carried out on an operable system, the main switch on the control cabinet must be turned to the OFF position and secured with a padlock to prevent unauthorized persons from switching it on again. Warn all persons concerned before putting the system back into operation.

⚠ WARNING If the motor change is carried out immediately after the robot has stopped operating, the surface temperatures of the motor are liable to be high and could result in burn injuries. Protective gloves must be worn.

⚠ WARNING When removing or installing the motor, care must be taken to avoid injury to hands by crushing. Protective gloves must be worn.

Removal

1. Release and unplug connectors XM2 (>>> Fig. 11-3) and XP2 from motor A2.
2. Slacken 4 Allen screws on the motor.
3. Release motor A2.
4. Remove 4 Allen screws and take off motor A2. The motor must not be tilted while it is being lifted off.
5. If the motor is not to be reinstalled, it must be protected against corrosion before being put into storage.

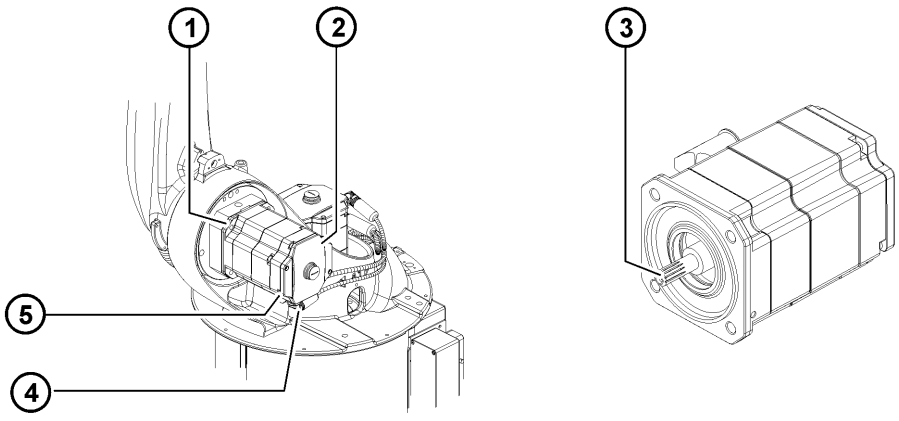


Fig. 11-3: Removal, installation of motor A2

1	Allen screw	4	Connector XP2
2	Motor A2	5	Connector XM2
3	Toothing		

Installation

1. If necessary, remove all protective coatings and oil from the new motor.
2. Clean toothing (>>> Fig. 11-3) of motor and gear unit before installation and apply a thin but continuous coat of Microlube GL 261 grease.

> **⚠ CAUTION** During cleaning, it must be ensured that the toothing of the motor and gear unit is not damaged.
> Damaged parts must be exchanged!

3. Align and insert motor A2 as shown in the illustration . Do not tilt during installation.

> Insertion of motor can be facilitated by turning it gently about its rotational axis.

4. Fasten motor A2 with 4 M8x20 Allen screws.
5. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 23 Nm.
6. Plug connectors XM2 and XP2 into the motor.
7. Remove elements securing the link arm (>>> Fig. 11-2).
8. Carry out mastering of axis 2.

> Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

11.1.3 Removal, installation of motor A3

Precondition

- The arm is secured (>>> Fig. 11-4).

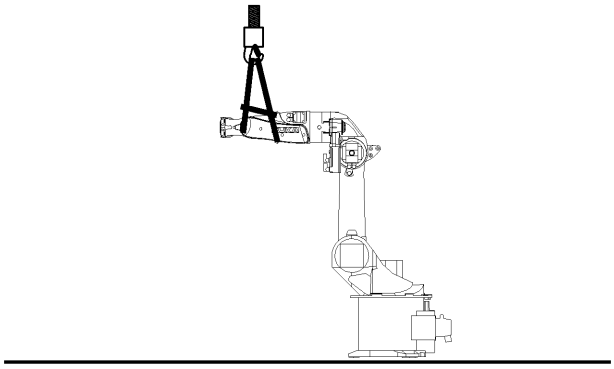


Fig. 11-4: Securing arm (schematic)

> **⚠ WARNING** When work is performed on this system, live parts and unintentional robot motions can cause injuries and damage to property. If work is carried out on an operable system, the main switch on the control cabinet must be turned to the OFF position and secured with a padlock to prevent unauthorized persons from switching it on again.
> Warn all persons concerned before putting the system back into operation.

⚠ WARNING If the motor change is carried out immediately after the robot has stopped operating, the surface temperatures of the motor are liable to be high and could result in burn injuries. Protective gloves must be worn.

⚠ WARNING When removing or installing the motor, care must be taken to avoid injury to hands by crushing. Protective gloves must be worn.

Removal

1. Release and unplug connectors XM3 (>>> Fig. 11-5) and XP3 from motor A3.
2. Slacken 4 Allen screws on motor A3.
3. Release the motor.
4. Remove 4 Allen screws and take off motor A3. The motor must not be tilted while it is being lifted off.
5. If the motor is not to be reinstalled, it must be protected against corrosion before being put into storage.

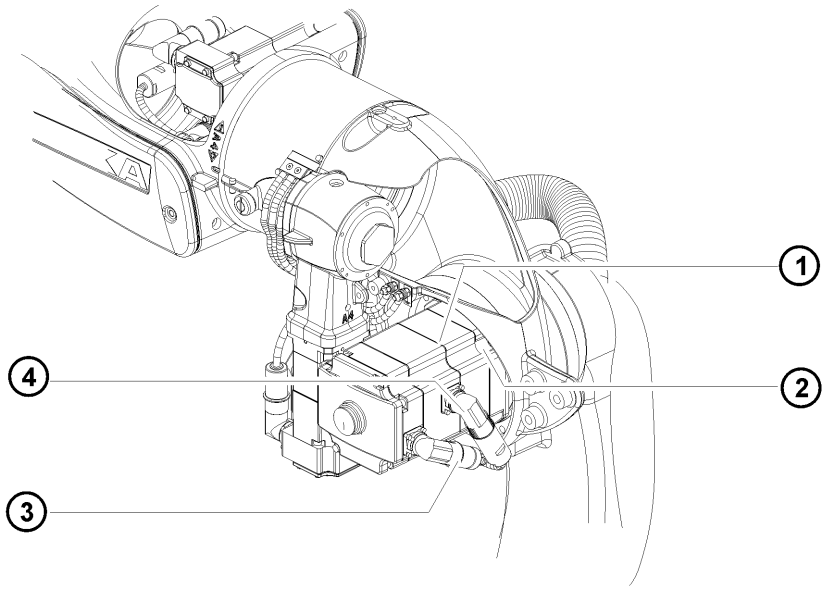


Fig. 11-5: Removing motor A3

1	Motor A3	3	Connector XP3
2	Allen screw	4	Connector XM3

Installation

1. If necessary, remove all protective coatings and oil from the new motor.
2. Clean toothing (>>> Fig. 11-6) of motor and gear unit before installation and apply a thin but continuous coat of Microlube GL 261 grease.

⚠ CAUTION During cleaning, it must be ensured that the toothing of the motor and gear unit is not damaged.
Damaged parts must be exchanged!

3. Align and insert motor A3 as shown in the illustration. Do not tilt during installation.

Insertion of motor can be facilitated by turning it gently about its rotational axis.

4. Fasten motor A3 with 4 M6x20 Allen screws.

5. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 9.5 Nm.
6. Plug connectors XM3 and XP3 into the motor.

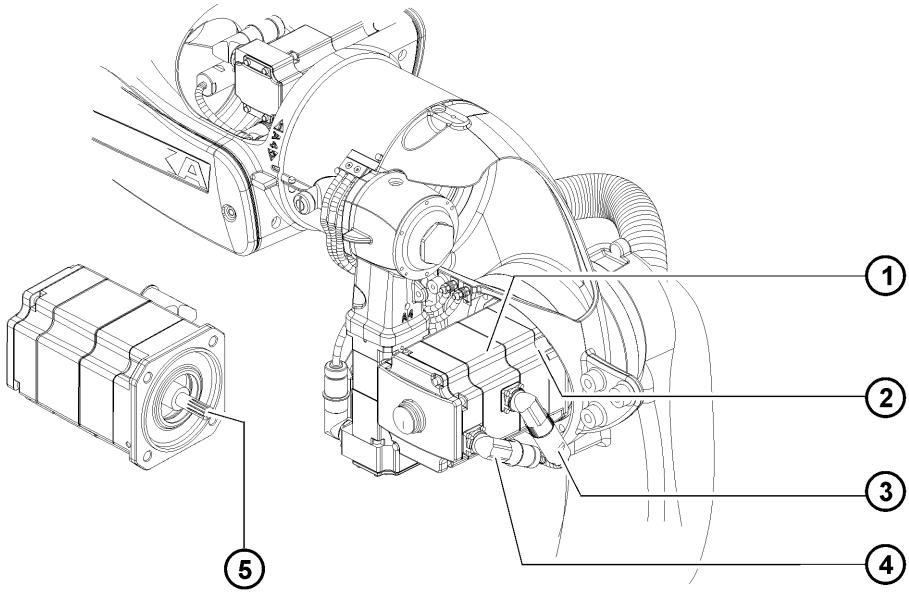


Fig. 11-6: Installing motor A3

1	Motor A3	4	Connector XP3
2	Allen screw	5	Toothing
3	Connector XM3		

7. Remove elements securing the arm (>>> Fig. 11-4).
8. Carry out mastering of axis 3.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

11.1.4 Removal, installation of motor A4

Precondition

- The arm is in the horizontal position.
- The wrist axes and any tooling are secured against rotation.
- All wrist axes should, if possible, be in their zero positions.

WARNING When work is performed on this system, live parts and unintentional robot motions can cause injuries and damage to property. If work is carried out on an operable system, the main switch on the control cabinet must be turned to the OFF position and secured with a padlock to prevent unauthorized persons from switching it on again. Warn all persons concerned before putting the system back into operation.

WARNING If the motor change is carried out immediately after the robot has stopped operating, the surface temperatures of the motor are liable to be high and could result in burn injuries. Protective gloves must be worn.

WARNING When removing or installing the motor, care must be taken to avoid injury to hands by crushing. Protective gloves must be worn.

Removal

1. Release and unplug connectors XM4 and XP4 from motor A4 (>>> Fig. 11-7).
2. Remove 4 Allen screws and conical spring washers, and take off motor A4.
3. If motor A4 is not to be reinstalled, it must be protected against corrosion before being put into storage.

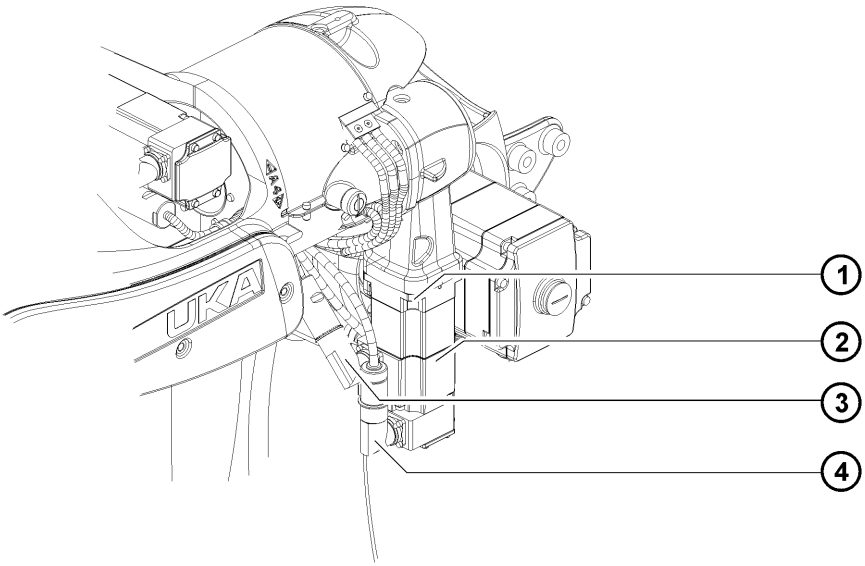


Fig. 11-7: Removing motor A4

1	Allen screw	3	Connector XM4
2	Motor A4	4	Connector XP4

Installation

1. If necessary, remove all protective coatings and oil from the new motor A4.
2. Clean the toothing (>>> Fig. 11-8) and apply a thin but continuous coat of Microlube GL 261.

NOTICE During cleaning, ensure that the toothing is not damaged.

3. Align and insert motor A4 as shown in the illustration. During installation, do not tilt or subject the shaft to axial loads.
4. Fasten motor A4 with 4 M5x16 Allen screws and conical spring washers.
5. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 5.8 Nm.
6. Plug connectors XM4 and XP4 into the motor.

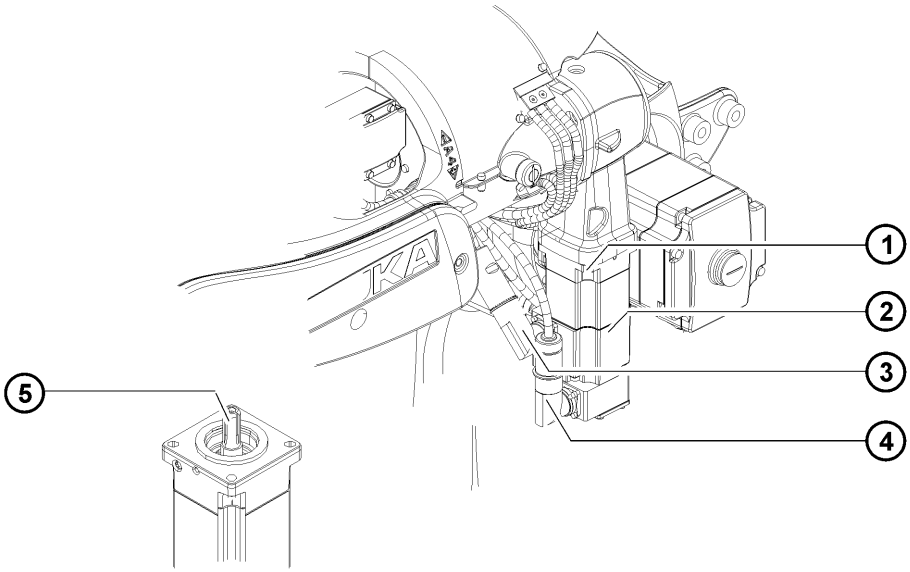


Fig. 11-8: Installing motor A4

1	Allen screw	4	Connector XP4
2	Motor A4	5	Toothing
3	Connector XM4		

7. Remove elements securing the arm and tool.
8. Carry out mastering of axis 6.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

11.1.5 Removal, installation of motor A5

Precondition

- The wrist is in the horizontal position.
- Tools are removed, if possible.
- The wrist axes and any tooling are secured against rotation.
- All axes should, if possible, be in their zero positions.

WARNING When work is performed on this system, live parts and unintentional robot motions can cause injuries and damage to property. If work is carried out on an operable system, the main switch on the control cabinet must be turned to the OFF position and secured with a padlock to prevent unauthorized persons from switching it on again. Warn all persons concerned before putting the system back into operation.

WARNING If the motor change is carried out immediately after the robot has stopped operating, the surface temperatures of the motor are liable to be high and could result in burn injuries. Protective gloves must be worn.

WARNING When removing or installing the motor, care must be taken to avoid injury to hands by crushing. Protective gloves must be worn.

Removal

1. Slacken Allen screw (>>> Fig. 11-9) and nut and unscrew them by a few turns.
2. Remove 3 fillister head screws and take off the cover.

3. Release and unplug connectors XM5 and XP5 from motor A5.
4. Remove 4 Allen screws and conical spring washers and take off motor A5 and toothed belt.
5. If motor A5 is not to be reinstalled, it must be protected against corrosion before being put into storage.

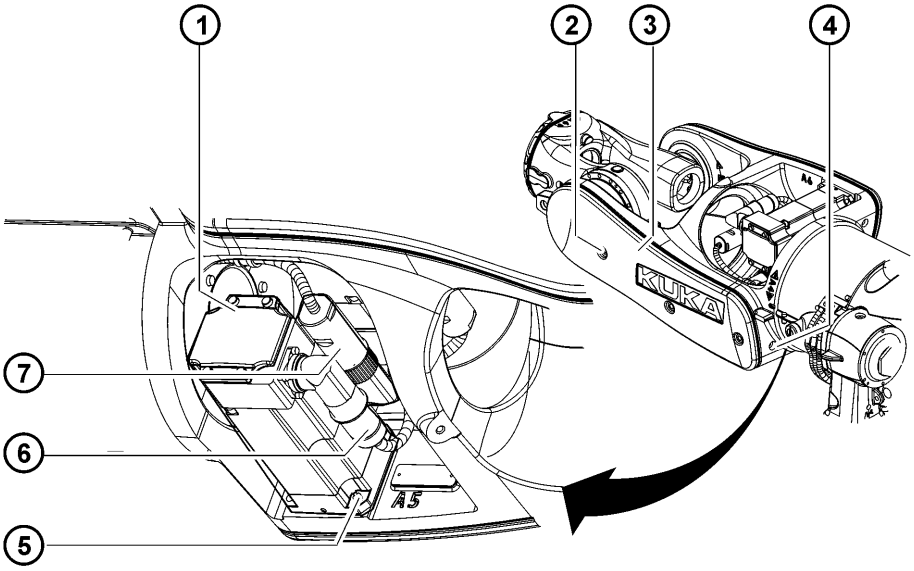


Fig. 11-9: Removal of motor A5

1	Motor A5	5	Allen screws
2	Fillister head screw	6	Connector XP5
3	Cover	7	Connector XM5
4	Allen screw		

6. Remove the Allen screw (>>> Fig. 11-10) and take off the disc.
7. Pull off the toothed belt pinion and bushing.

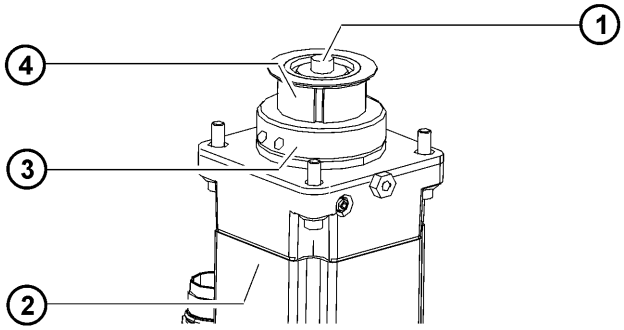


Fig. 11-10: Motor with toothed belt pinion

1	Allen screw	3	Bushing
2	Motor A3	4	Toothed belt pinion

Installation

1. If necessary, remove all protective coatings and oil from the new motor A5 (>>> Fig. 11-11).
2. Clean the toothing and apply a thin but continuous coat of Microlube GL 261.

NOTICE During cleaning, ensure that the toothing is not damaged.

3. Mount the bushing and toothed belt pinion.
4. Insert the disc and M4x12-10.9 Allen screws and tighten with a torque of 3.7 Nm.

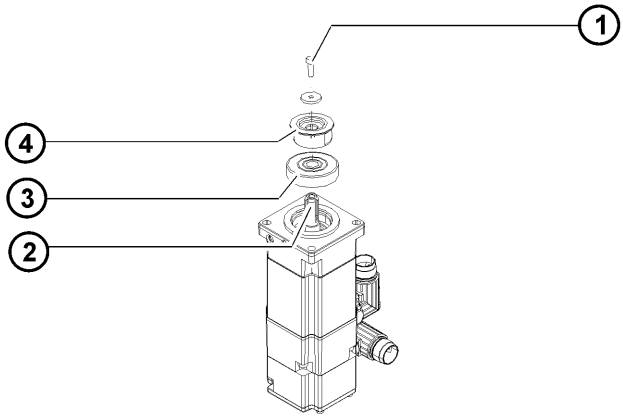


Fig. 11-11: Motor with toothed belt pinion

1	Allen screw	3	Bushing
2	Toothing	4	Toothed belt pinion

5. Align and insert motor A5 (>>> Fig. 11-12) as shown in the illustration. When inserting toothed belts, fit them on the toothed belt pinions. When fitting the toothed belt, it must be ensured that it meshes properly with the toothed belt pinion.
6. Fasten motor A5 with 4 M5x16 Allen screws and conical spring washers.
7. Lightly tighten the 4 Allen screws.
8. Plug connectors XM5 and XP5 into the motor.
9. Insert the Allen screw and nut and tighten them lightly.

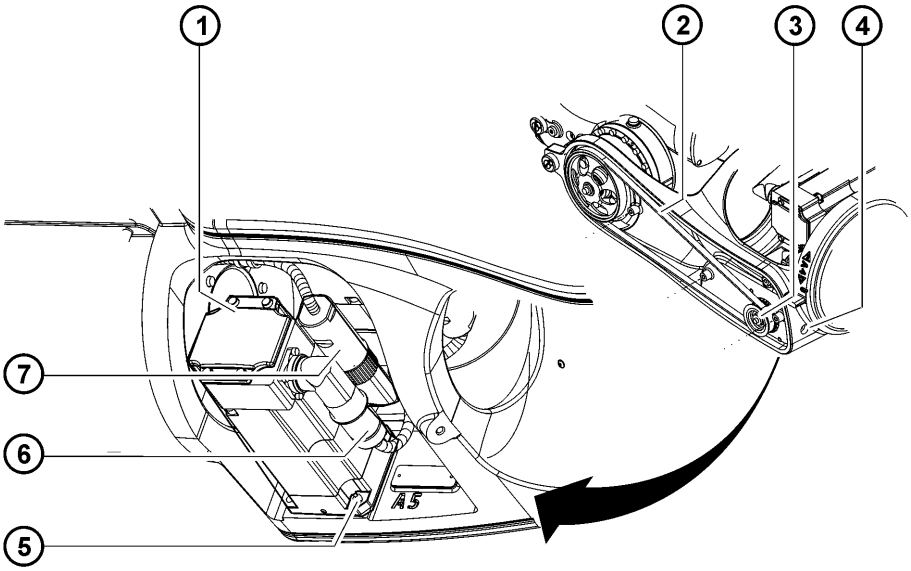


Fig. 11-12: Installation of motor A5

1	Motor A5	5	Allen screws
2	Toothed belt	6	Connector XP5

3	Toothed belt pinion	7	Connector XM5
4	Allen screw		

10. Adjust the toothed belt tension (>>> 10.1.1 "Measuring and adjusting the toothed belt tension on A5" Page 121).
11. Remove elements securing axis 5 against rotation.
12. Carry out mastering of axis 5.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

11.1.6 Removal, installation of motor A6

Precondition

- The wrist is in the horizontal position.
- Tools are removed, if possible.
- The wrist axes and any tooling are secured against rotation.
- All axes should, if possible, be in their zero positions.

WARNING When work is performed on this system, live parts and unintentional robot motions can cause injuries and damage to property. If work is carried out on an operable system, the main switch on the control cabinet must be turned to the OFF position and secured with a padlock to prevent unauthorized persons from switching it on again. Warn all persons concerned before putting the system back into operation.

WARNING If the motor change is carried out immediately after the robot has stopped operating, the surface temperatures of the motor are liable to be high and could result in burn injuries. Protective gloves must be worn.

WARNING When removing or installing the motor, care must be taken to avoid injury to hands by crushing. Protective gloves must be worn.

Removal

1. Slacken Allen screw (>>> Fig. 11-13) and nut and unscrew them by a few turns.
2. Remove 3 fillister head screws and take off the cover.
3. Release and unplug connectors XM6 and XP6 from motor A6.
4. Remove 4 Allen screws together with conical spring washers. Shift motor A6 and take off the toothed belt.

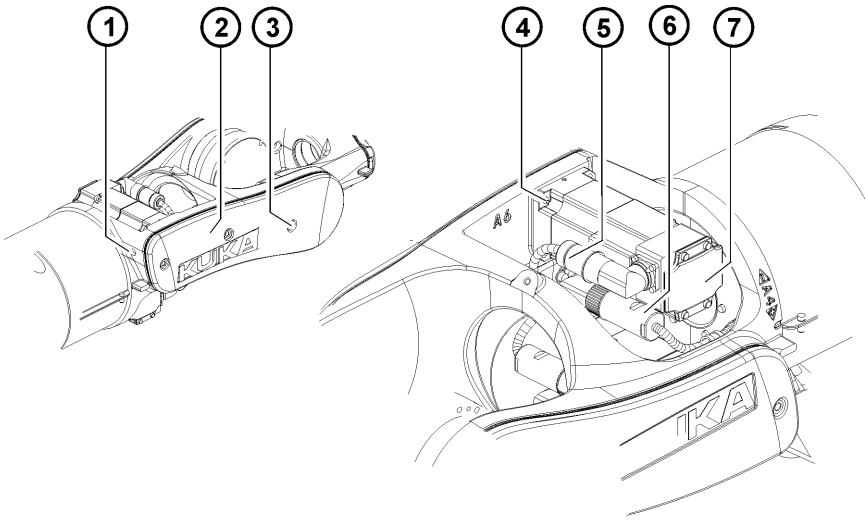


Fig. 11-13: Removing motor A6

1	Allen screw	5	Connector XP6
2	Cover	6	Connector XM6
3	Fillister head screw	7	Motor A6
4	Allen screws		

5. Remove the Allen screw (>>> Fig. 11-14) and take off the disc.
6. Pull off the toothed belt pinion and bushing.
7. If motor A6 is not to be reinstalled, it must be protected against corrosion before being put into storage.

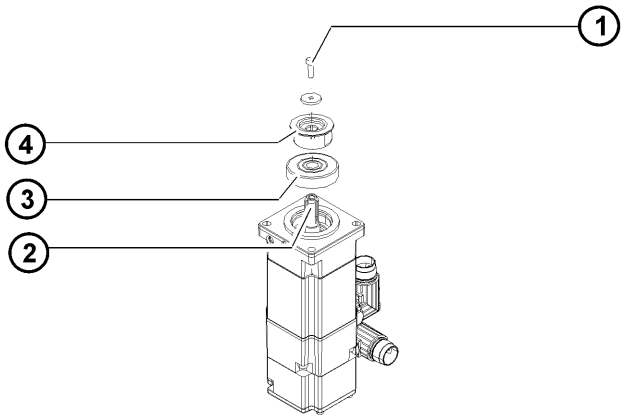


Fig. 11-14: Motor with toothed belt pinion

1	Allen screw	3	Bushing
2	Motor A2	4	Toothed belt pinion

Installation

1. If necessary, remove all protective coatings and oil from the new motor A6 (>>> Fig. 11-15).
2. Clean the toothing and apply a thin but continuous coat of Microlube GL 261.

NOTICE During cleaning, ensure that the toothing is not damaged.

3. Mount the bushing and toothed belt pinion.
4. Insert the disc and M4x12-10.9 Allen screw and tighten with a torque of 3.7 Nm.

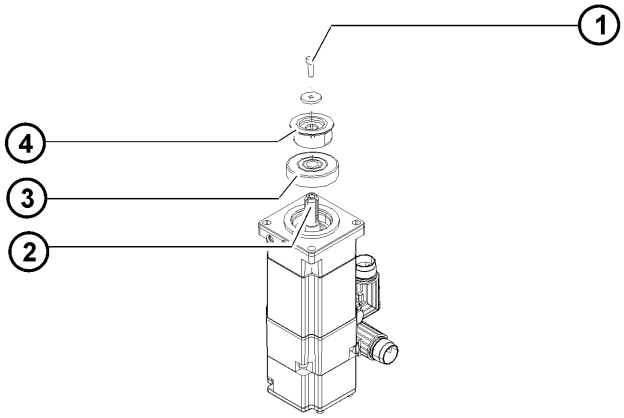


Fig. 11-15: Motor with toothed belt pinion

1	Allen screw	3	Bushing
2	Toothing	4	Toothed belt pinion

5. Align and insert motor A6 (>>> Fig. 11-16) as shown in the illustration. When inserting toothed belts, fit them on the toothed belt pinions (2). When fitting the toothed belt, it must be ensured that it meshes properly with both toothed belt pinions.
6. Fasten motor A6 with 4 M5x16 Allen screws and conical spring washers.
7. Lightly tighten the 4 Allen screws.
8. Plug connectors XM6 and XP6 into the motor.

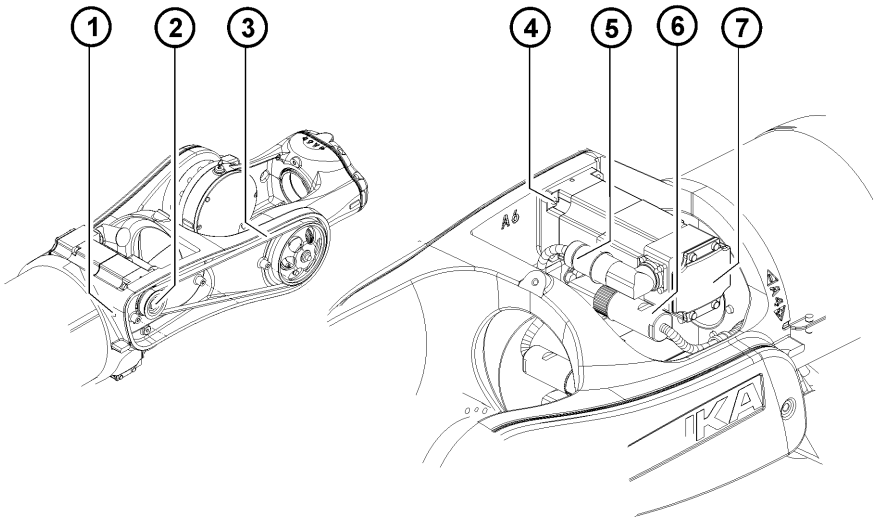


Fig. 11-16: Installing motor A6

1	Allen screw	5	Connector XM6
2	Toothed belt pinion	6	Connector XP6
3	Toothed belt	7	Motor A6
4	Allen screws		

9. Insert the Allen screw and nut and tighten them lightly.
10. Adjust the toothed belt tension (>>> 10.1.2 "Measuring and adjusting the toothed belt tension on A6" Page 122).
11. Remove elements securing axis 6 against rotation.
12. Carry out mastering of axis 6.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

11.1.7 Removal, installation of toothed belt for axis 5

Precondition

- Axis 5 is free from load.
- The arm is positioned horizontally.
- No tools are installed on axis 6.

WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

WARNING If the toothed belt is removed and installed immediately after the robot has stopped operating, surface temperatures are likely to be high and could result in burn injuries.
Protective gloves must be worn.

Procedure

1. Remove 3 fillister head screws (>>> Fig. 11-17) and take off cover and seal.
2. Slacken the Allen screw and nut on the rear of motor A5.
3. Slacken the 4 Allen screws on motor A5 until motor A5 can be shifted.
4. Shift motor A5 and take off the toothed belt.
5. Fit the new toothed belt, making sure that it meshes properly with the toothed belt pulleys.
6. Tighten the Allen screw until the toothed belt is lightly pre-tensioned.
7. Tighten the 4 Allen screws on the motor until motor A5 can only just be shifted.
8. Carry out adjustment of the toothed belt (>>> 10.1.1 "Measuring and adjusting the toothed belt tension on A5" Page 121).

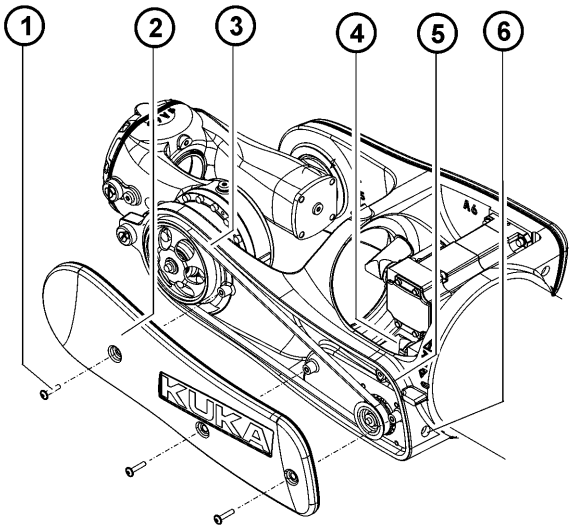


Fig. 11-17: Removal, installation of toothed belt for axis 5

1	Fillister head screws	4	Motor A5
2	Cover	5	Seal
3	Toothed belt	6	Allen screw

9. Carry out mastering of axis 5.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

NOTICE If a new toothed belt is installed, the belt tension must be rechecked after approximately 100 hours of operation and readjusted if necessary.

11.1.8 Removal, installation of toothed belt for axis 6

Precondition

- Axis 6 is free from load.
- The arm is positioned horizontally.
- No tools are installed on axis 6.

WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

WARNING If the toothed belt is removed and installed immediately after the robot has stopped operating, surface temperatures are likely to be high and could result in burn injuries.
Protective gloves must be worn.

Procedure

1. Remove 3 fillister head screws (>>> Fig. 11-18) and take off cover and seal.
2. Slacken the Allen screw and nut on the rear of motor A6.
3. Slacken the 4 Allen screws on motor A6 until motor A6 can be shifted.
4. Shift motor A6 and take off the toothed belt.
5. Fit the new toothed belt, making sure that it meshes properly with the toothed belt pulleys.
6. Tighten the Allen screw until the toothed belt is lightly pre-tensioned.
7. Tighten the 4 Allen screws on the motor until motor A6 can only just be shifted.
8. Carry out adjustment of the toothed belt (>>> 10.1.2 "Measuring and adjusting the toothed belt tension on A6" Page 122).

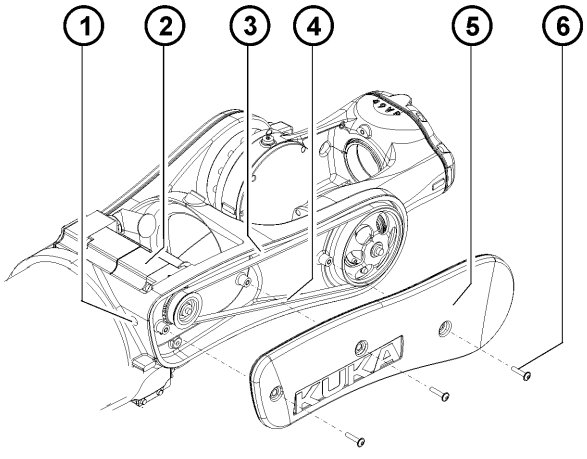


Fig. 11-18: Removal, installation of toothed belt for axis 6

1	Allen screw	4	Toothed belt
2	Motor A6	5	Cover
3	Seal	6	Fillister head screws

9. Carry out mastering of axis 6.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

NOTICE If a new toothed belt is installed, the belt tension must be rechecked after approximately 100 hours of operation and readjusted if necessary.

11.2 Repair, KR 16 L8 arc HW

11.2.1 Exchanging motors A1 to A3

The following overview lists the sections containing the descriptions of the procedure for exchanging the motors on axes 1 to 3 for the KR 16 L8 arc HW:

- Removal, installation of motor A1
  (>>> 11.1.1 "Removal, installation of motor A1" Page 127)
- Removal, installation of motor A2
  (>>> 11.1.2 "Removal, installation of motor A2" Page 128)
- Removal, installation of motor A3
  (>>> 11.1.3 "Removal, installation of motor A3" Page 130)

11.2.2 Removal, installation of motor A4

Precondition

- The arm is in the horizontal position.
- The wrist axes and any tooling are secured against rotation.
- All wrist axes should, if possible, be in their zero positions.

WARNING When work is performed on this system, live parts and unintentional robot motions can cause injuries and damage to property. If work is carried out on an operable system, the main switch on the control cabinet must be turned to the OFF position and secured with a padlock to prevent unauthorized persons from switching it on again. Warn all persons concerned before putting the system back into operation.

WARNING If the motor change is carried out immediately after the robot has stopped operating, the surface temperatures of the motor are liable to be high and could result in burn injuries. Protective gloves must be worn.

WARNING When removing or installing the motor, care must be taken to avoid injury to hands by crushing. Protective gloves must be worn.

Removal

1. Release and unplug connectors XM4 and XP4 from motor A4 (>>> Fig. 11-19).
2. Remove 4 Allen screws and conical spring washers, and take off motor A4.
3. If motor A4 is not to be reinstalled, it must be protected against corrosion before being put into storage.

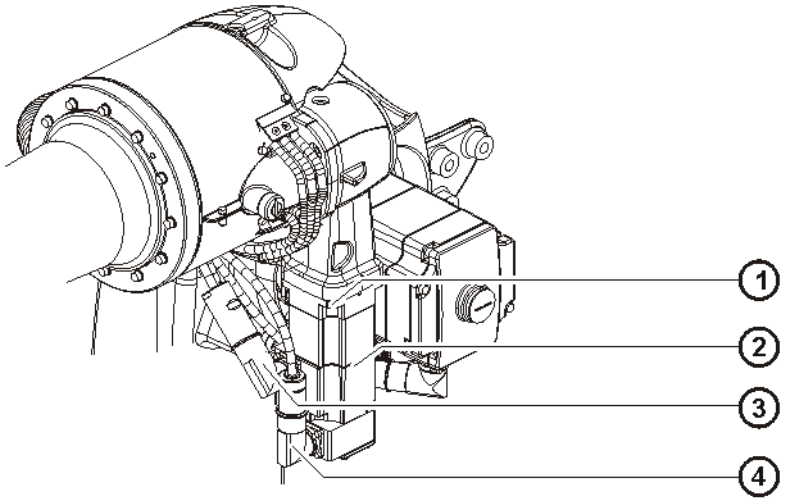


Fig. 11-19: Removing motor A4

1	Allen screw	3	Connector XM4
2	Motor A4	4	Connector XP4

Installation

1. If necessary, remove all protective coatings and oil from the new motor A4.
2. Clean the toothing (>>> Fig. 11-8) and apply a thin but continuous coat of Microlube GL 261.

NOTICE During cleaning, ensure that the toothing is not damaged.

3. Align and insert motor A4 as shown in the illustration. During installation, do not tilt or subject the shaft to axial loads.
4. Fasten motor A4 with 4 M5x16 Allen screws and conical spring washers.
5. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 5.8 Nm.
6. Plug connectors XM4 and XP4 into the motor.

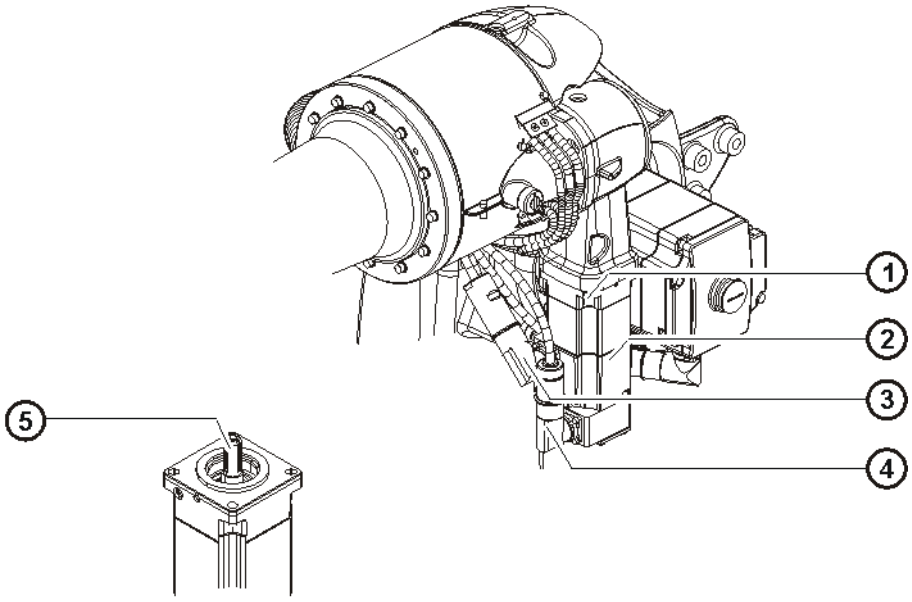


Fig. 11-20: Installing motor A4

1	Allen screw	4	Connector XP4

2 Motor A4
3 Connector XM4
5 Toothing

7. Remove elements securing the arm and tool.
8. Carry out mastering of axis 6.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

11.2.3 Removal, installation of motor A5

Precondition

- The wrist is in the horizontal position.
- Tools are removed, if possible.
- The wrist axes and any tooling are secured against rotation.
- All axes should, if possible, be in their zero positions.

WARNING When work is performed on this system, live parts and unintentional robot motions can cause injuries and damage to property. If work is carried out on an operable system, the main switch on the control cabinet must be turned to the OFF position and secured with a padlock to prevent unauthorized persons from switching it on again. Warn all persons concerned before putting the system back into operation.

WARNING If the motor change is carried out immediately after the robot has stopped operating, the surface temperatures of the motor are liable to be high and could result in burn injuries. Protective gloves must be worn.

WARNING When removing or installing the motor, care must be taken to avoid injury to hands by crushing. Protective gloves must be worn.

Removal

1. Slacken Allen screw (>>> Fig. 11-21) and nut and unscrew them by a few turns.
2. Remove 3 fillister head screws and take off the cover.
3. Release and unplug connectors XM5 and XP5 from motor A5.
4. Remove 4 Allen screws together with conical spring washers. Shift motor A5 and take off the toothed belt.
5. If motor A5 is not to be reinstalled, it must be protected against corrosion before being put into storage.

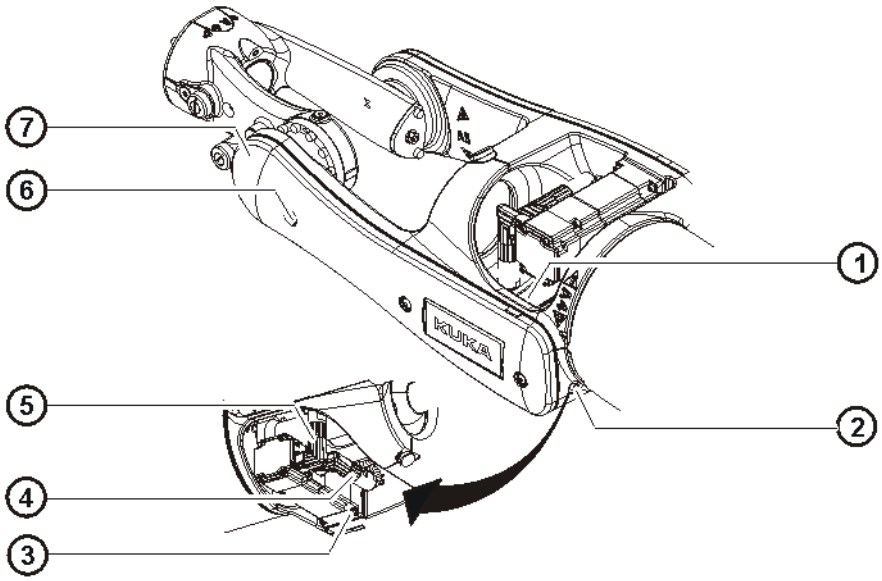


Fig. 11-21: Removal of motor A5

1	Motor A5	5	Connector XP5
2	Allen screw	6	Fillister head screws
3	Allen screws	7	Cover
4	Connector XM5		

6. Remove the Allen screw (>>> Fig. 11-22) and take off the disc.
7. Pull off the toothed belt pinion and bushing.

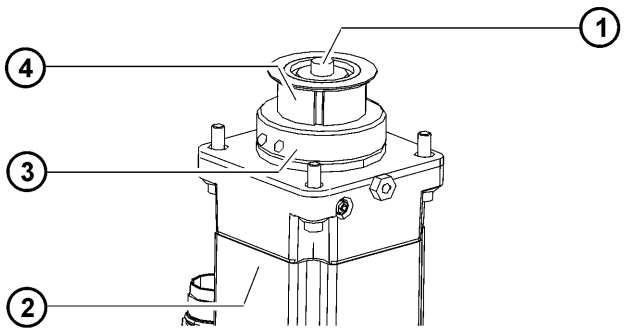


Fig. 11-22: Motor with toothed belt pinion

1	Allen screw	3	Bushing
2	Motor A5	4	Toothed belt pinion

Installation

1. Remove all protective coatings and oil from new motor A5 (>>> Fig. 11-23), if applicable.
2. Clean the toothing and apply a thin but continuous coat of Microlube GL 261.

NOTICE During cleaning, ensure that the toothing is not damaged.

3. Mount the bushing and toothed belt pinion.
4. Insert the disc and M4x12-10.9 Allen screws and tighten with a torque of 3.7 Nm.

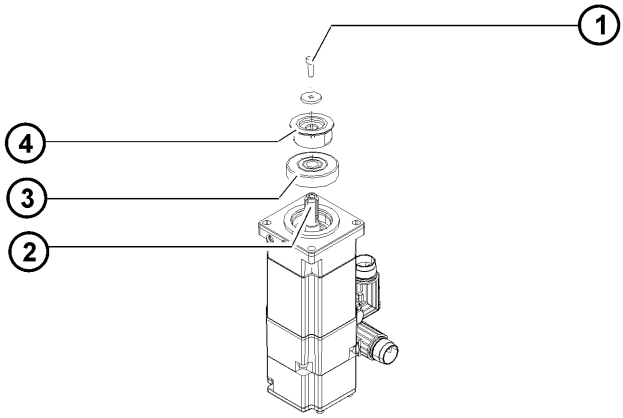


Fig. 11-23: Motor with toothed belt pinion

1	Allen screw	3	Bushing
2	Toothing	4	Toothed belt pinion

5. Align and insert motor A5 (>>> Fig. 11-24) as shown in the illustration. When inserting toothed belts, fit them on the toothed belt pinions. When fitting the toothed belt, it must be ensured that it meshes properly with the toothed belt pinion.
6. Fasten motor A5 with 4 M4x18-8.8 Allen screws and conical spring washers.
7. Lightly tighten the 4 Allen screws.
8. Plug connectors XM5 and XP5 into the motor.
9. Insert the Allen screw and nut and tighten them lightly.

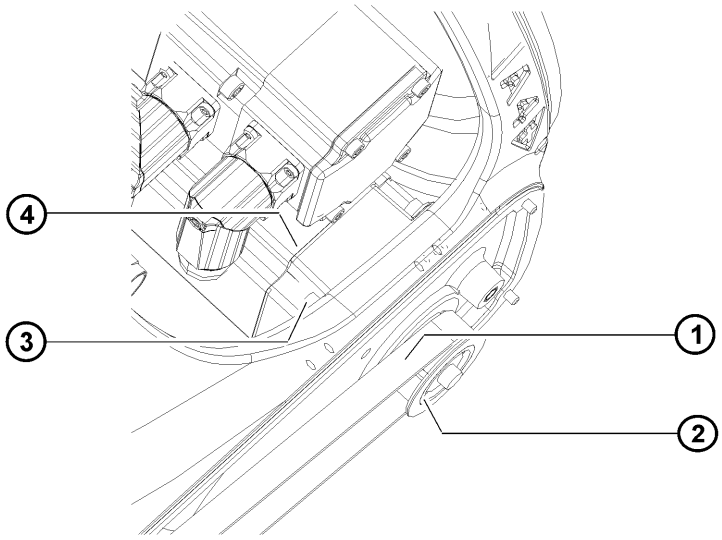


Fig. 11-24: Motor A5 with toothed belts

1	Toothed belt	3	Allen screws
2	Toothed belt pinion	4	Motor A5

10. Adjust the toothed belt tension (>>> 10.2.1 "Measuring and adjusting the toothed belt tension on A5" Page 124).
11. Remove elements securing axis 5.
12. Carry out mastering of axis 5.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

11.2.4 Removal, installation of motor A6

Precondition

- The wrist is in the horizontal position.
- Tools are removed, if possible.
- The wrist axes and any tooling are secured against rotation.
- All axes should, if possible, be in their zero positions.

WARNING When work is performed on this system, live parts and unintentional robot motions can cause injuries and damage to property. If work is carried out on an operable system, the main switch on the control cabinet must be turned to the OFF position and secured with a padlock to prevent unauthorized persons from switching it on again. Warn all persons concerned before putting the system back into operation.

WARNING If the motor change is carried out immediately after the robot has stopped operating, the surface temperatures of the motor are liable to be high and could result in burn injuries. Protective gloves must be worn.

WARNING When removing or installing the motor, care must be taken to avoid injury to hands by crushing. Protective gloves must be worn.

Removal

1. Slacken Allen screw (>>> Fig. 11-25) and nut and unscrew them by a few turns.
2. Remove 3 fillister head screws and take off the cover.
3. Release and unplug connectors XM6 and XP6 from motor A6.
4. Remove 4 Allen screws together with conical spring washers. Shift motor A6 and take off the toothed belt.

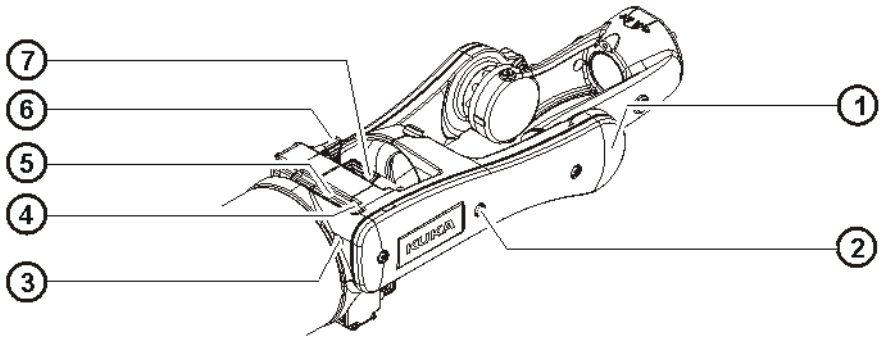


Fig. 11-25: Removing motor A 6

1	Cover	5	Motor A6
2	Fillister head screws	6	Connector XP6
3	Allen screw	7	Connector XM6
4	Allen screws		

5. Remove the Allen screw (>>> Fig. 11-26) and take off the disc.
6. Pull off the toothed belt pinion and bushing.

7. If motor A6 is not to be reinstalled, it must be protected against corrosion before being put into storage.

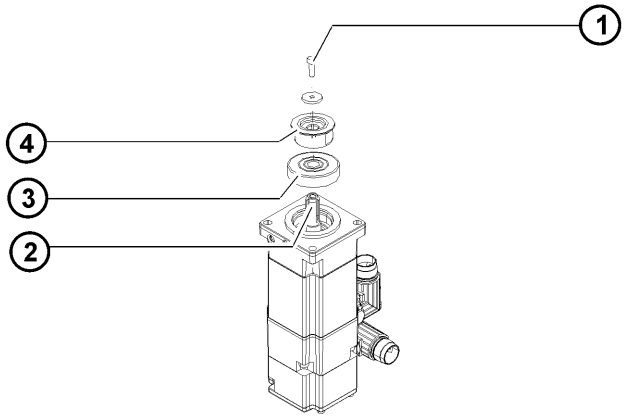


Fig. 11-26: Motor with toothed belt pinion

1	Allen screw	3	Bushing
2	Motor A6	4	Toothed belt pinion

Installation

1. Remove all protective coatings and oil from new motor A6 (>>> Fig. 11-27), if applicable.
2. Clean the toothing and apply a thin but continuous coat of Microlube GL 261.

NOTICE During cleaning, ensure that the toothing is not damaged.

3. Mount the bushing and toothed belt pinion.
4. Insert the disc and M4x12-10.9 Allen screws and tighten with a torque of 3.7 Nm.

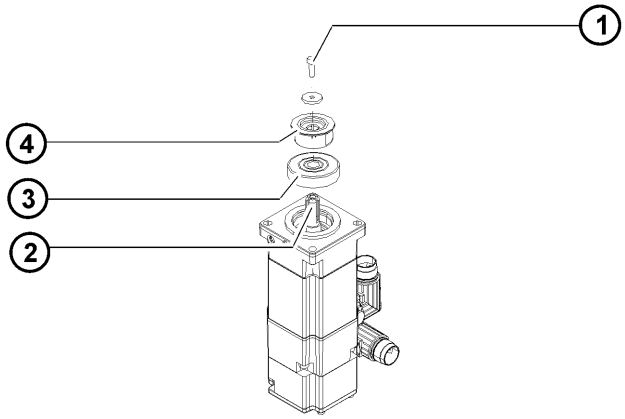


Fig. 11-27: Motor with toothed belt pinion

1	Allen screw	3	Bushing
2	Toothing	4	Toothed belt pinion

5. Align and insert motor A6 (>>> Fig. 11-28) as shown in the illustration. When inserting toothed belts, fit them on the toothed belt pinions. When fitting the toothed belt, it must be ensured that it meshes properly with the toothed belt pinion.
6. Fasten motor A6 with 4 M4x18-8.8 Allen screws and conical spring washers.
7. Lightly tighten the Allen screws.

8. Plug connectors XM6 and XP6 into the motor.

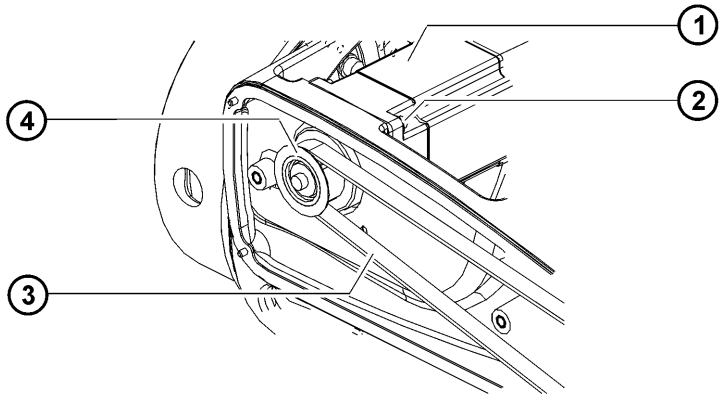


Fig. 11-28: Motor A6 with toothed belt

1	Motor A6	3	Toothed belt
2	Allen screws	4	Toothed belt pinion

9. Insert the Allen screw (>>> Fig. 11-25) and nut and tighten them lightly.
10. Adjust the toothed belt tension (>>> 10.2.1 "Measuring and adjusting the toothed belt tension on A5" Page 124).
11. Remove elements securing axis 6.
12. Carry out mastering of axis 6.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

11.2.5 Removal, installation of toothed belt for axis 5

Precondition

- Axis 5 is free from load.
- The arm is positioned horizontally.
- No tools are installed on axis 6.

WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

WARNING If the toothed belt is removed and installed immediately after the robot has stopped operating, surface temperatures are likely to be high and could result in burn injuries.
Protective gloves must be worn.

Procedure

1. Remove 3 fillister head screws (>>> Fig. 11-29) and take off cover and seal.
2. Slacken the Allen screw and nut on the bottom of motor A5.
3. Slacken the 4 Allen screws on motor A5 until motor A5 can be shifted.
4. Shift motor A5 and take off the toothed belt.
5. Fit the new toothed belt, making sure that it meshes properly with the toothed belt pulleys.
6. Tighten the Allen screw until the toothed belt is lightly pre-tensioned.

7. Tighten the 4 Allen screws on the motor until motor A5 can only just be shifted.
8. Carry out adjustment of the toothed belt (>>> 10.2.1 "Measuring and adjusting the toothed belt tension on A5" Page 124).

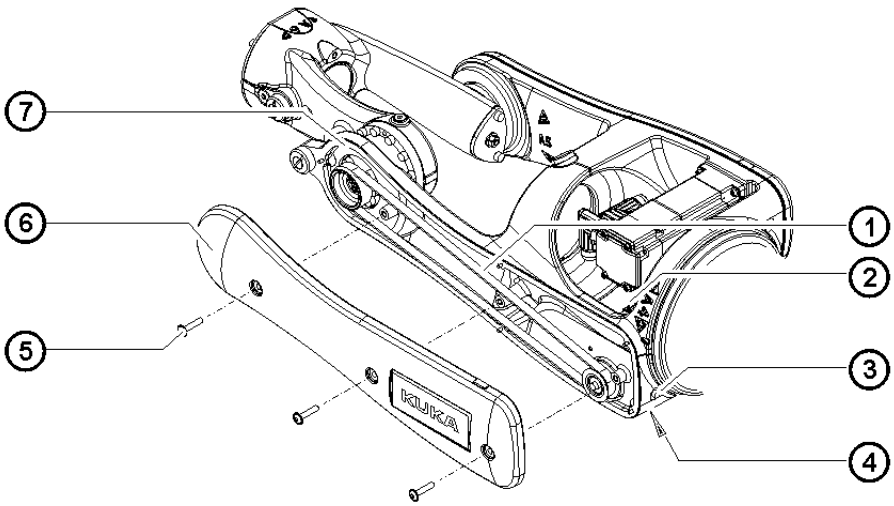


Fig. 11-29: Removal, installation of toothed belt for axis 5

1	Toothed belt	5	Fillister head screws
2	Motor A5	6	Cover
3	Allen screw	7	Seal
4	Nut		

9. Carry out mastering of axis 5.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

NOTICE If a new toothed belt is installed, the belt tension must be rechecked after approximately 100 hours of operation and readjusted if necessary.

11.2.6 Removal, installation of toothed belt for axis 6

Precondition

- Axis 6 is free from load.
- The arm is positioned horizontally.
- No tools are installed on axis 6.

⚠ WARNING Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP device.
Warn all persons concerned before starting to put it back into operation.

⚠ WARNING If the toothed belt is removed and installed immediately after the robot has stopped operating, surface temperatures are likely to be high and could result in burn injuries.
Protective gloves must be worn.

Procedure

1. Remove 3 fillister head screws (>>> Fig. 11-30) and take off cover and seal.
2. Slacken the Allen screw and nut on the bottom of motor A6.
3. Slacken the 4 Allen screws on motor A6 until motor A6 can be shifted.
4. Shift motor A6 and take off the toothed belt.
5. Fit the new toothed belt, making sure that it meshes properly with the toothed belt pulleys.
6. Tighten the Allen screw until the toothed belt is lightly pre-tensioned.
7. Tighten the 4 Allen screws on the motor until motor A6 can only just be shifted.
8. Carry out adjustment of the toothed belt (>>> 10.2.2 "Measuring and adjusting the toothed belt tension on A6" Page 125).

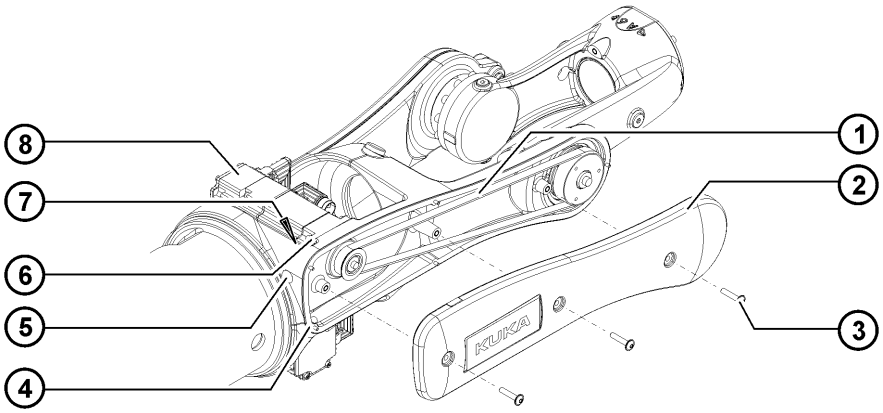


Fig. 11-30: Removal, installation of toothed belt for axis 6

1	Toothed belt	5	Allen screw
2	Cover	6	Allen screws
3	Fillister head screws	7	Nut
4	Seal	8	Motor A6

9. Carry out mastering of axis 6.

Detailed information about mastering is contained in the operating and programming instructions for end users or system integrators.

NOTICE If a new toothed belt is installed, the belt tension must be rechecked after approximately 100 hours of operation and readjusted if necessary.

11.3 Description of the electrical installations for KR C2

Overview

The electrical installations of the robot consist of:

- Cable set
- Multi-function housing MFH for motor cable
- Control cable junction box, SafeRDC box (only for SafeRobot)

Description

The electrical installations (>>> Fig. 11-31) include all the supply and control cables for the motors of axes 1 to 6. All the connections on the motors are screwed plug-and-socket connections. The assembly consists of the junction boxes for the control cable, the multi-function housing MFH on the push-in

module and the cable set with the flexible tubes. The cable harness for axes 5 and 6 and the cable harness for axis 1 ensure that the cables are guided without strain or kinking throughout the entire motion range of the robot.

The connecting cables are connected to the robot via the MFH for the motor cable, the junction box for the data cable, and via the SafeRDC box in the case of SafeRobot. For SafeRobot, the control cable junction box is replaced by the SafeRDC box.

All junction boxes are installed on the base frame of the robot.

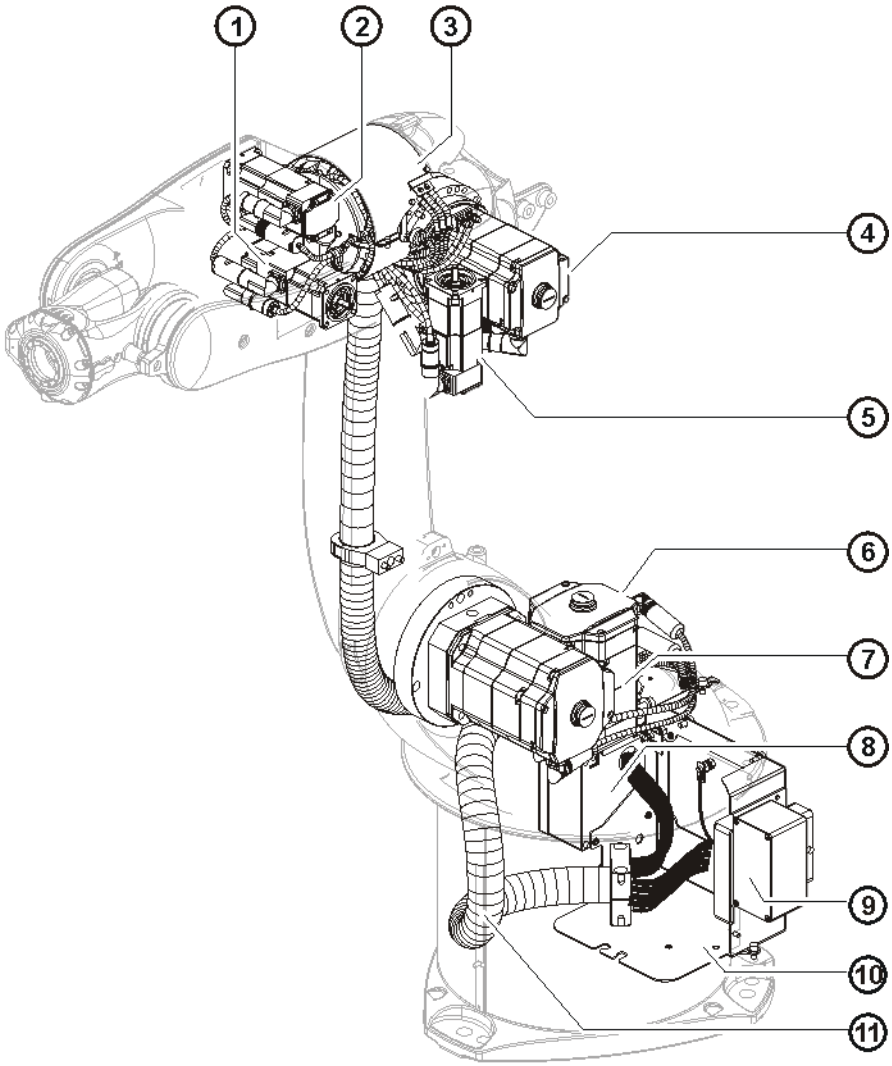


Fig. 11-31: Electrical installations

1 Motor, axis 5
2 Motor, axis 6
3 Wrist axis cable harness
4 Motor, axis 3
5 Motor, axis 4
6 Motor, axis 1
7 Motor, axis 2
8 Control cable junction box
9 MFH

10 Push-in module
11 Axis 1 cable harness

Wiring diagrams The following table provides an overview of the wiring diagrams:

Wiring diagram	Connection	KR 16 arc HW	KR 16 L8 arc HW
		Figure	
A1	XM1	(>>> Fig. 11-32)	
A2	XM2	(>>> Fig. 11-33)	
A3	XM3	(>>> Fig. 11-34)	
A4	XM4	(>>> Fig. 11-35)	
A5	XM5	(>>> Fig. 11-36)	(>>> Fig. 11-37)
A6	XM6	(>>> Fig. 11-38)	(>>> Fig. 11-39)

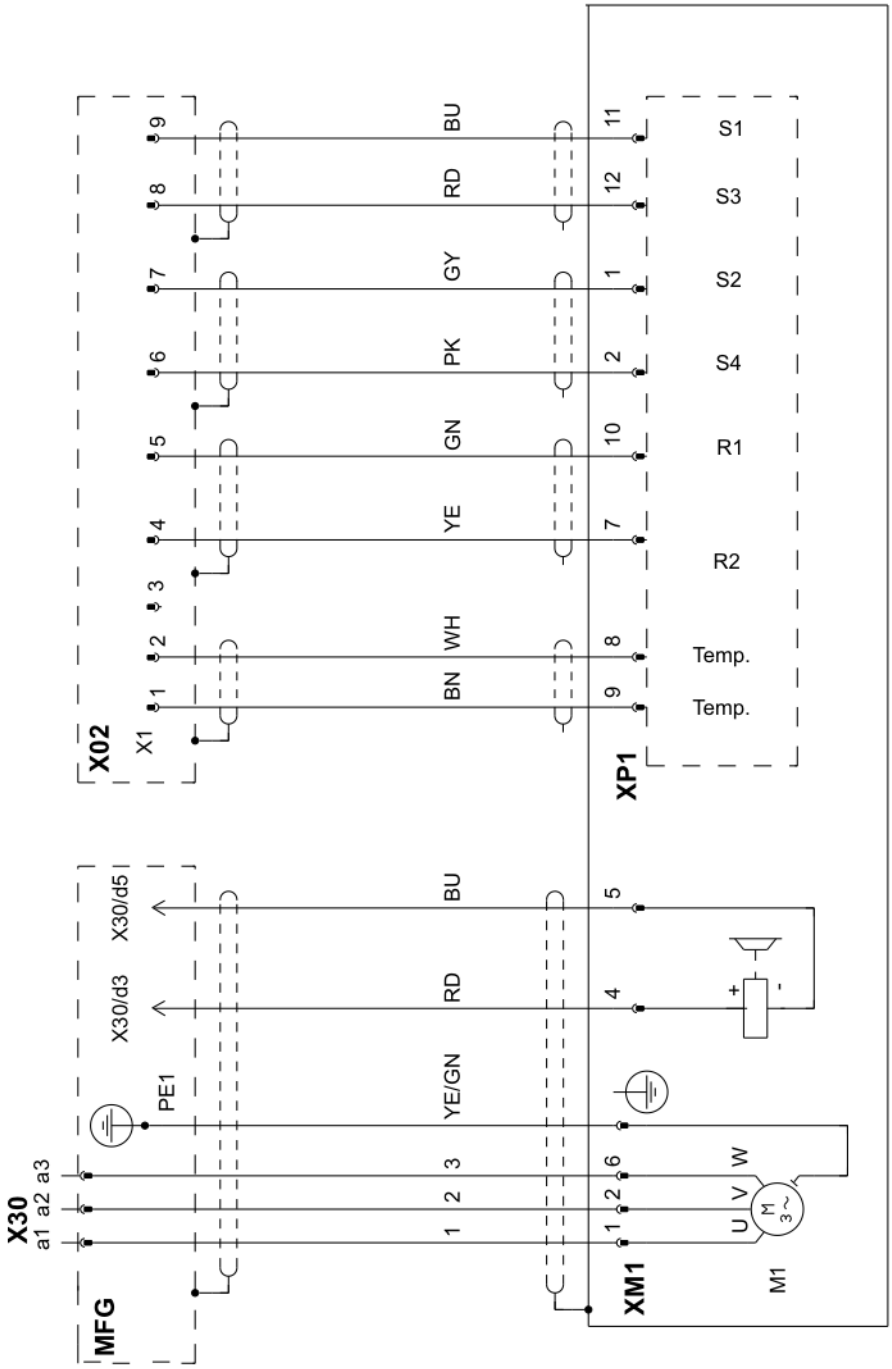


Fig. 11-32: Wiring diagram A1 (KR 16 arc HW, KR 16 L8 arc HW)

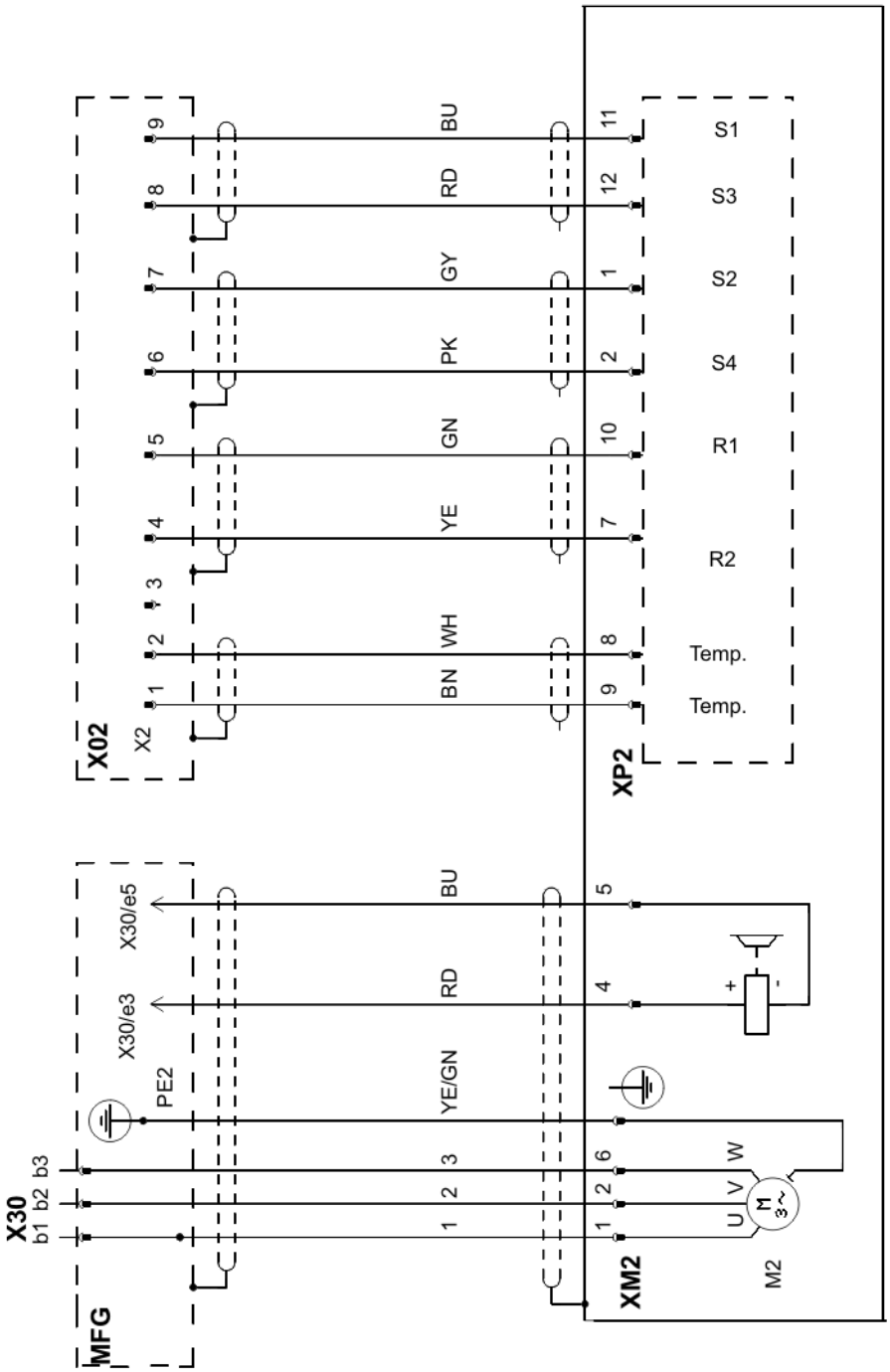


Fig. 11-33: Wiring diagram A2 (KR 16 arc HW, KR 16 L8 arc HW)

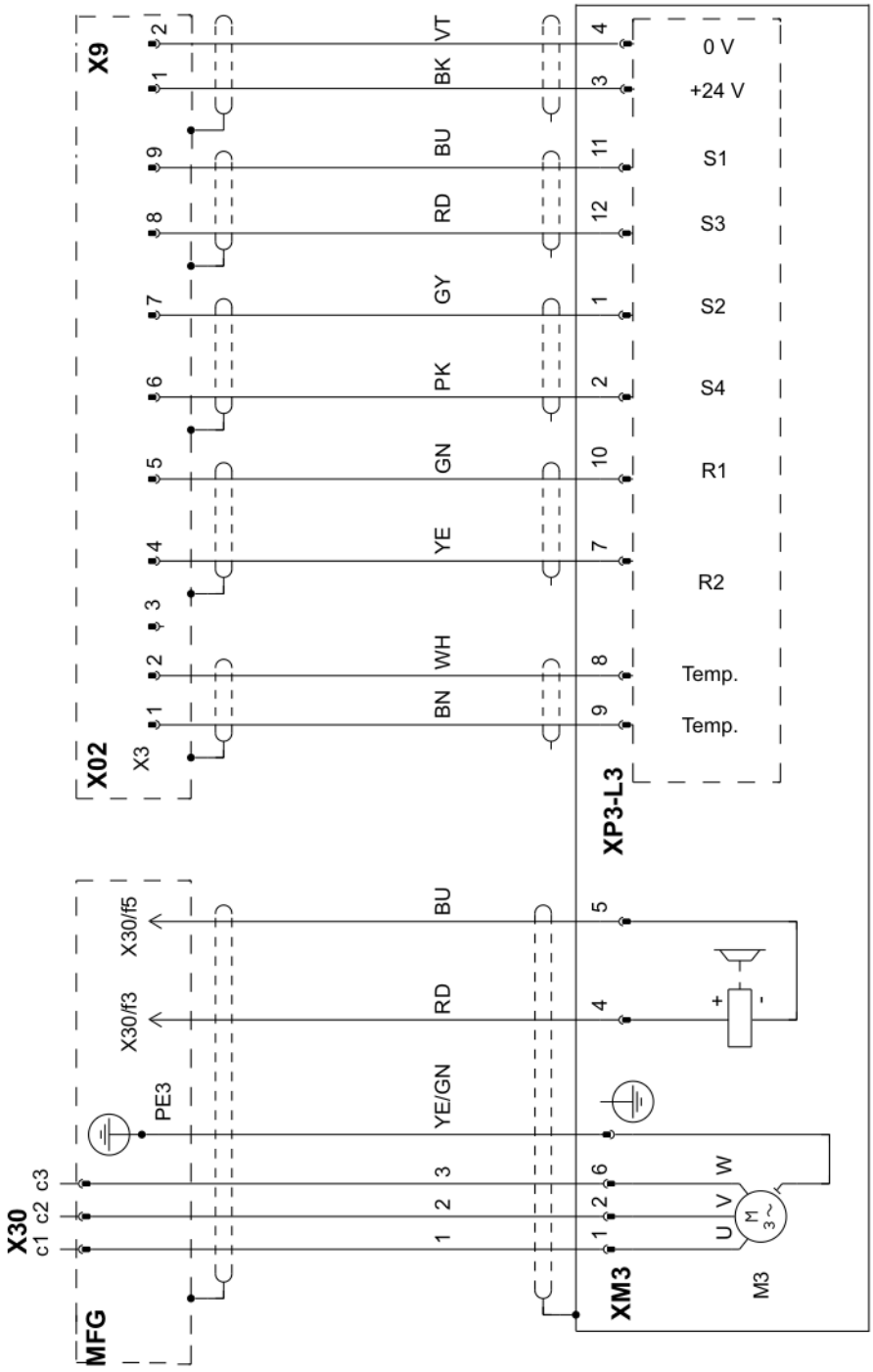


Fig. 11-34: Wiring diagram A3 (KR 16 arc HW, KR 16 L8 arc HW)

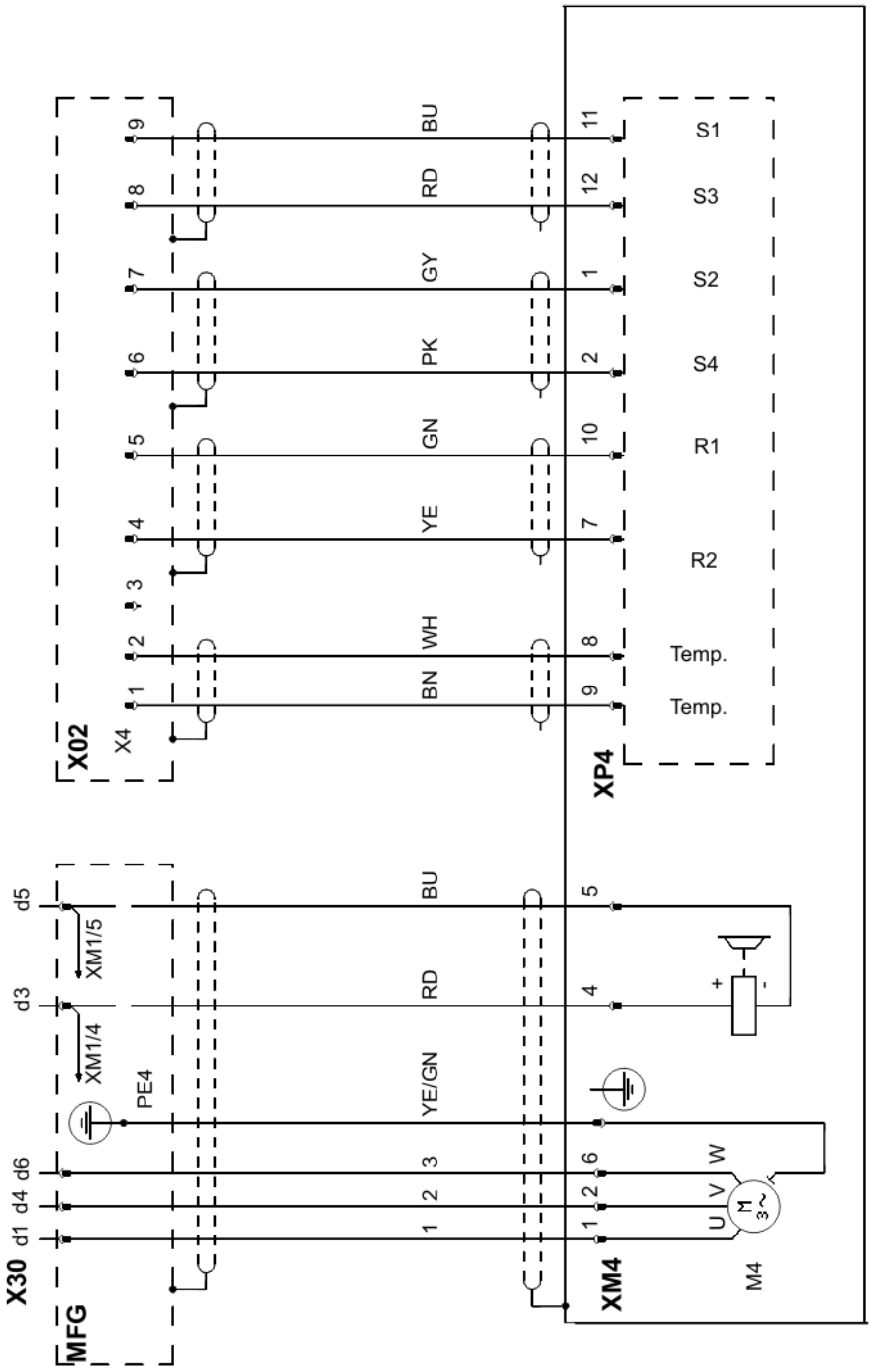


Fig. 11-35: Wiring diagram A4 (KR 16 arc HW, KR 16 L8 arc HW)

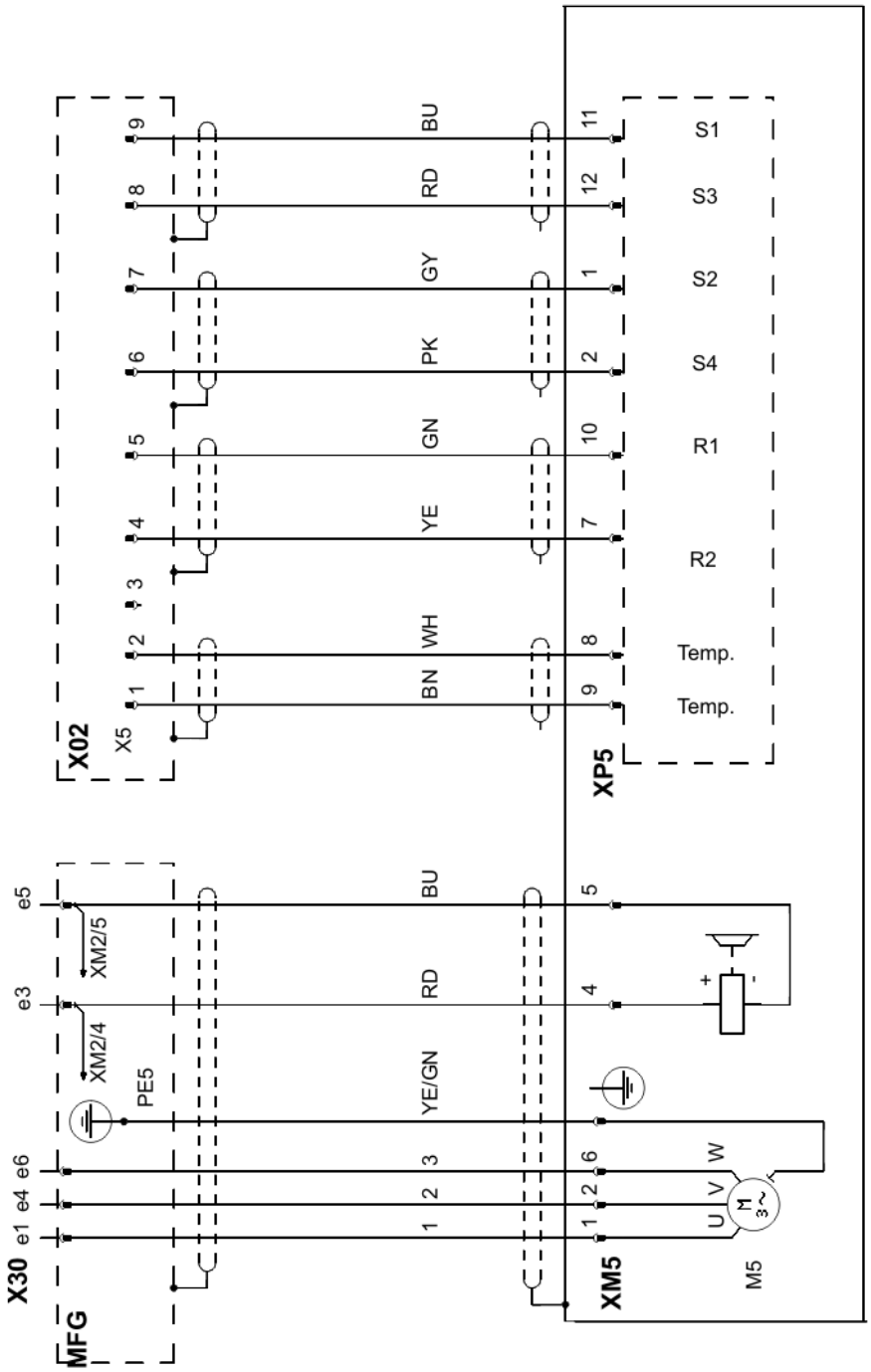


Fig. 11-36: Wiring diagram A5 (KR 16 arc HW)

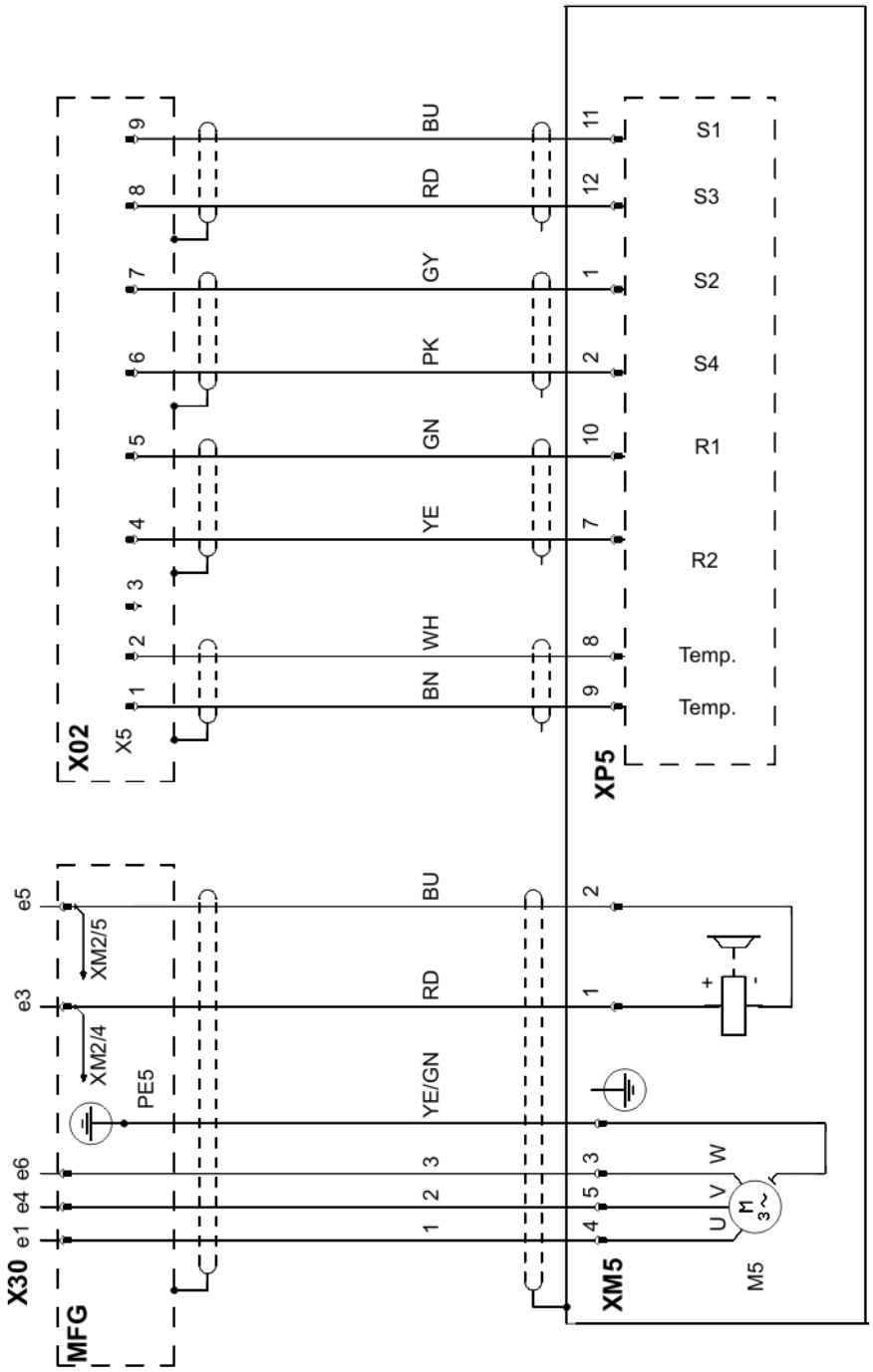


Fig. 11-37: Wiring diagram A5 (KR 16 L8 arc HW)

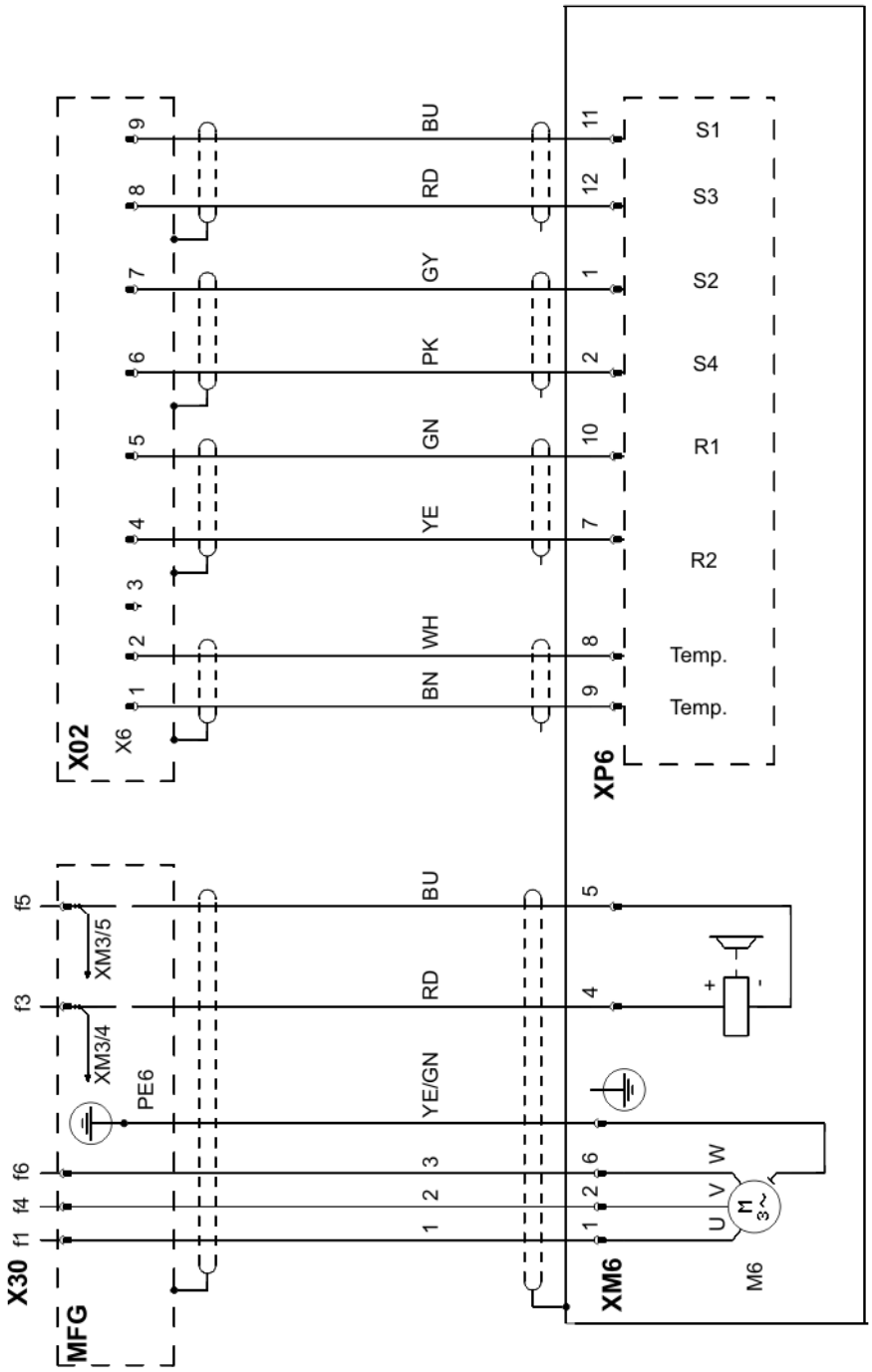


Fig. 11-38: Wiring diagram A6 (KR 16 arc HW)

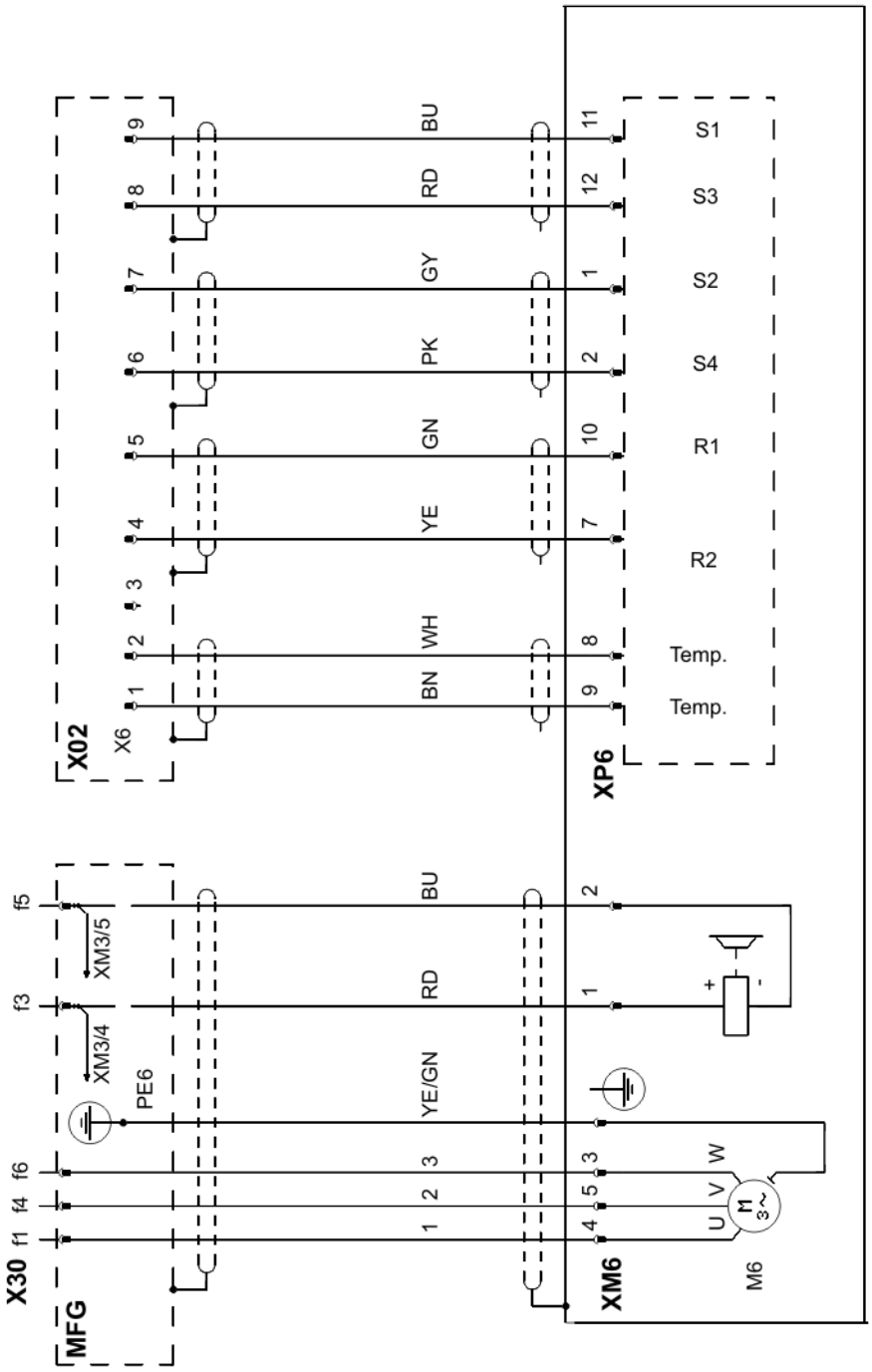


Fig. 11-39: Wiring diagram A6 (KR 16 L8 arc HW)

11.4 Description of the electrical installations (robot) for KR C4

Overview

The electrical installations of the robot consist of:

- Cable set
- Multi-function housing MFH for motor cable
- Junction box for control cable, SafeRDC box

Description

The electrical installations include all the supply and control cables for the motors of axes 1 to 6. All the connections on the motors are screwed plug-and-socket connections. The assembly consists of the cable set, the multi-function housing MFH on the push-in module and the RDC box in the rotating column. The interface for the connecting cables is located at the back of the base frame

on the push-in module. The motor cable X30 and the data cable X31 are connected here via plug-in connections.

The selected cable routing ensures that the cables are guided without strain or kinking throughout the entire motion range of the robot.

The following diagram gives an overview of the installation and routing of the cables on the manipulator.

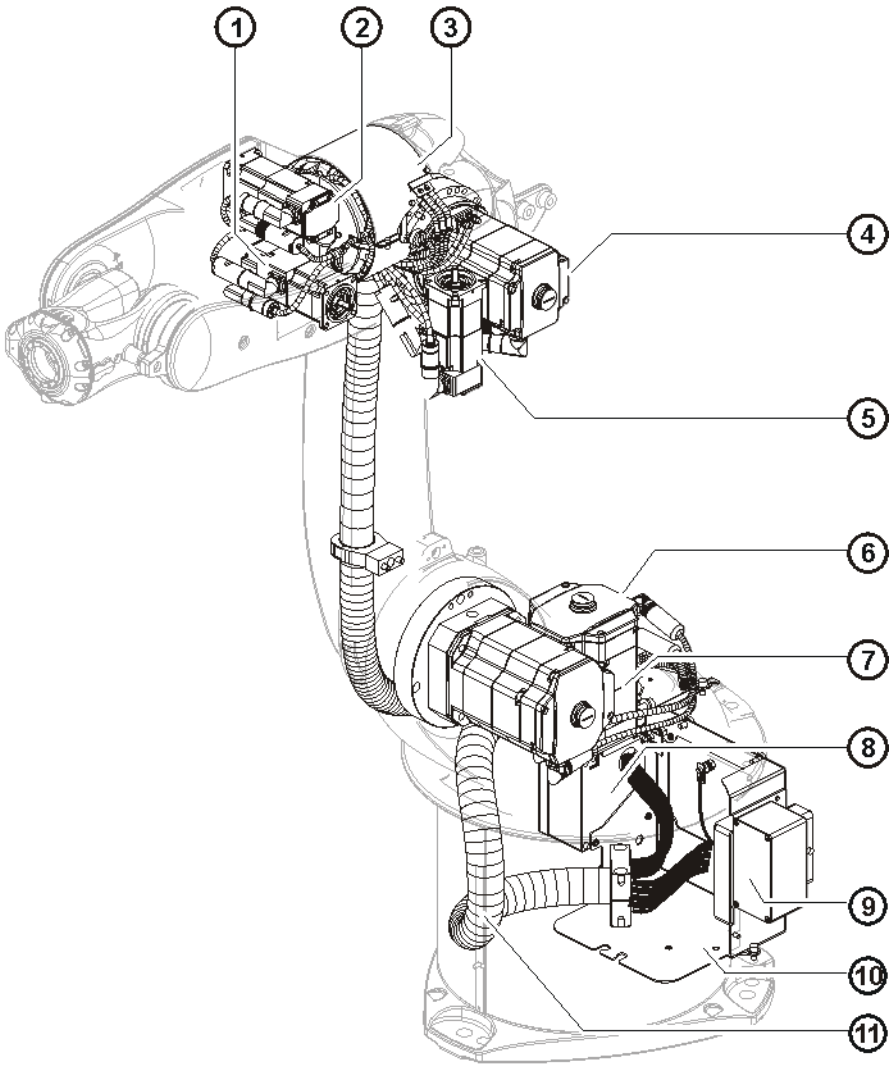


Fig. 11-40: Electrical installations

1 Motor, axis 5
2 Motor, axis 6
3 Wrist axis cable harness
4 Motor, axis 3
5 Motor, axis 4
6 Motor, axis 1
7 Motor, axis 2
8 Control cable junction box
9 MFH
10 Push-in module
11 Axis 1 cable harness

Wiring diagrams The following table provides an overview of the wiring diagrams:

Wiring diagram	Connection	Figure	
		KR 16 arc HW	KR 16 L8 arc HW
A1	XM1	(>>> Fig. 11-41)	
A2	XM2	(>>> Fig. 11-42)	
A3	XM3	(>>> Fig. 11-43)	
A4	XM4	(>>> Fig. 11-44)	
A5	XM5	(>>> Fig. 11-45)	(>>> Fig. 11-46)
A6	XM6	(>>> Fig. 11-47)	(>>> Fig. 11-48)

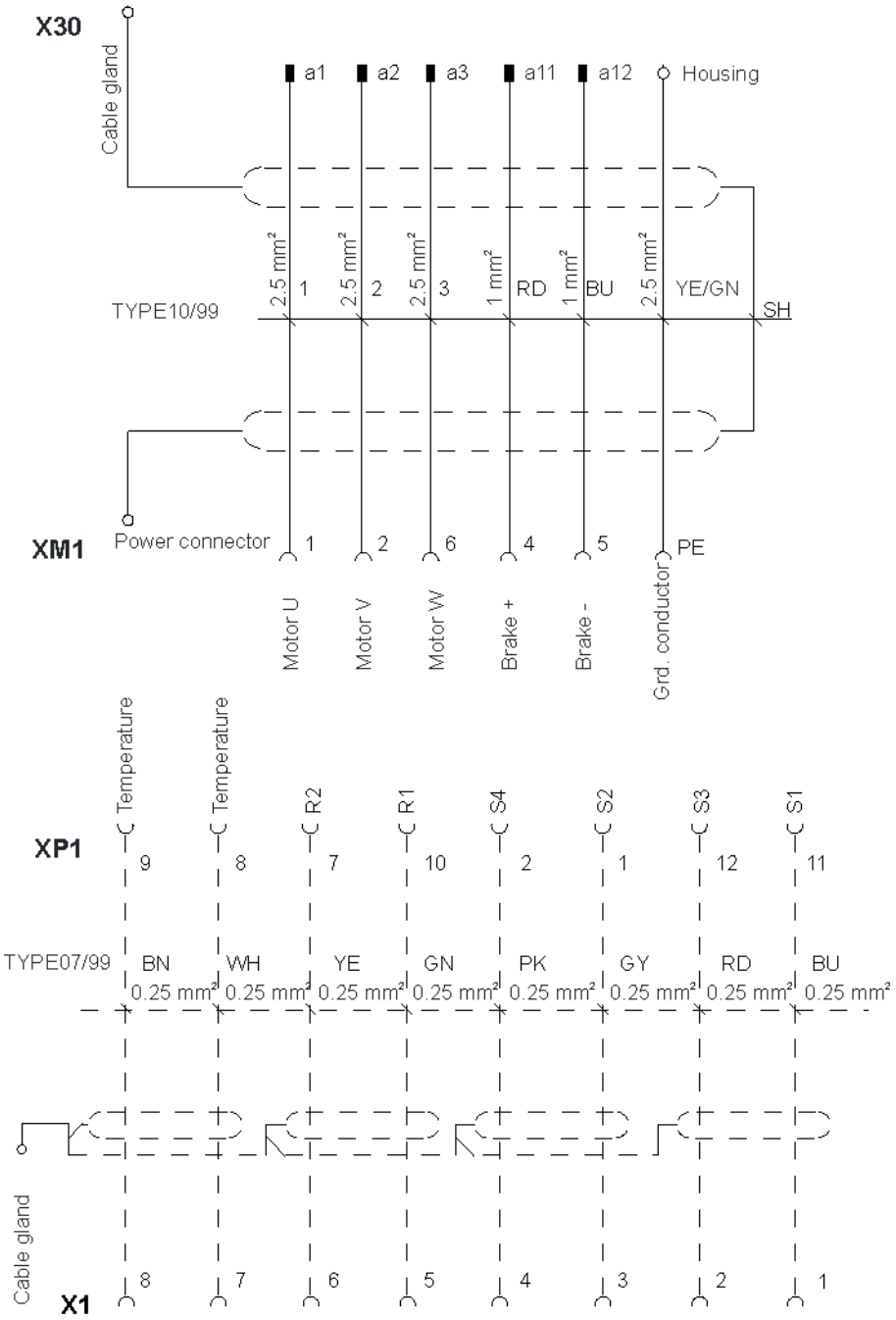


Fig. 11-41: Wiring diagram A1
KR 16 arc HW, KR 16 L8 arc HW
KR 16-3 arc HW, KR 16 L8-3 arc HW

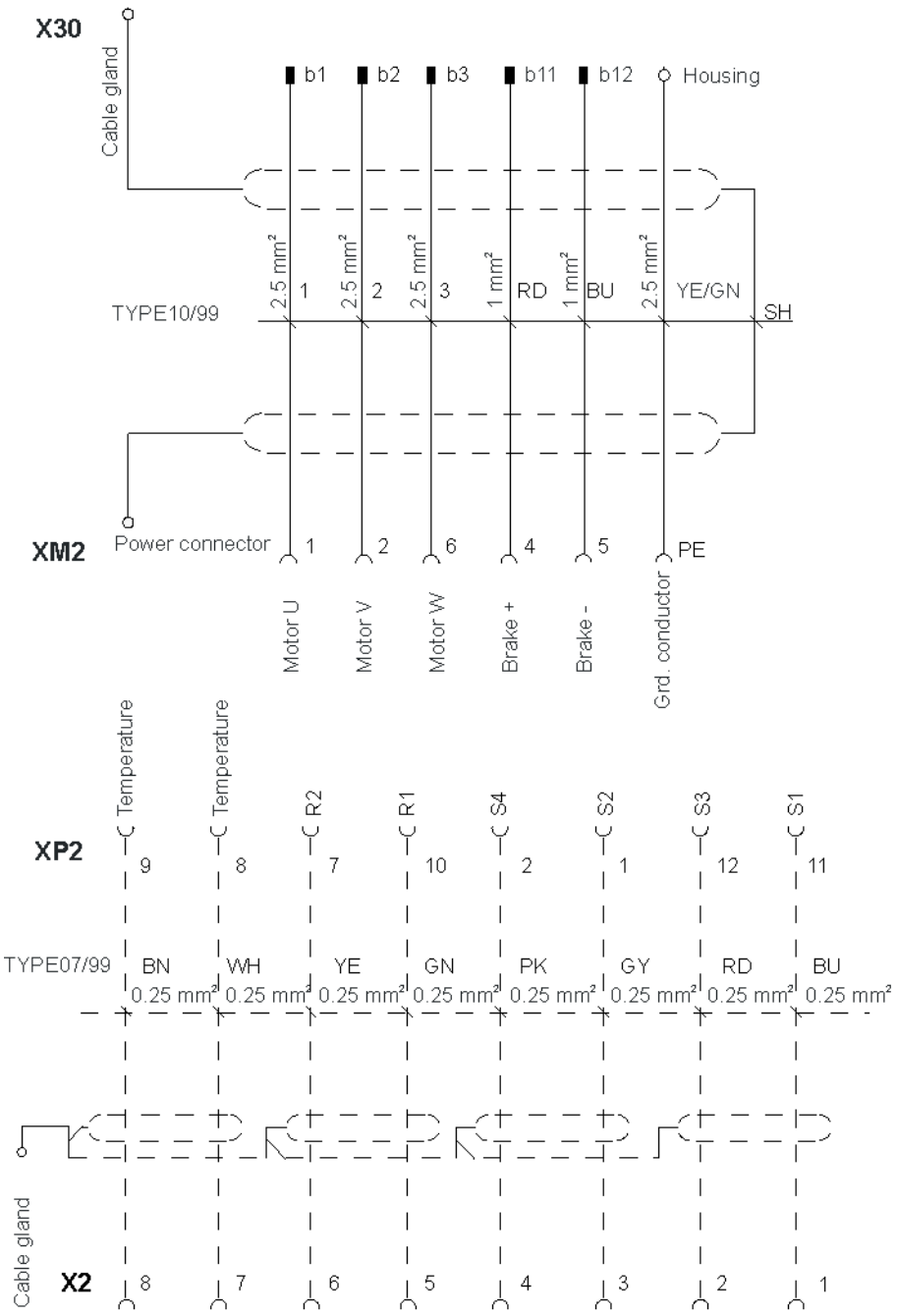


Fig. 11-42: Wiring diagram A2
KR 16 arc HW, KR 16 L8 arc HW
KR 16-3 arc HW, KR 16 L8-3 arc HW

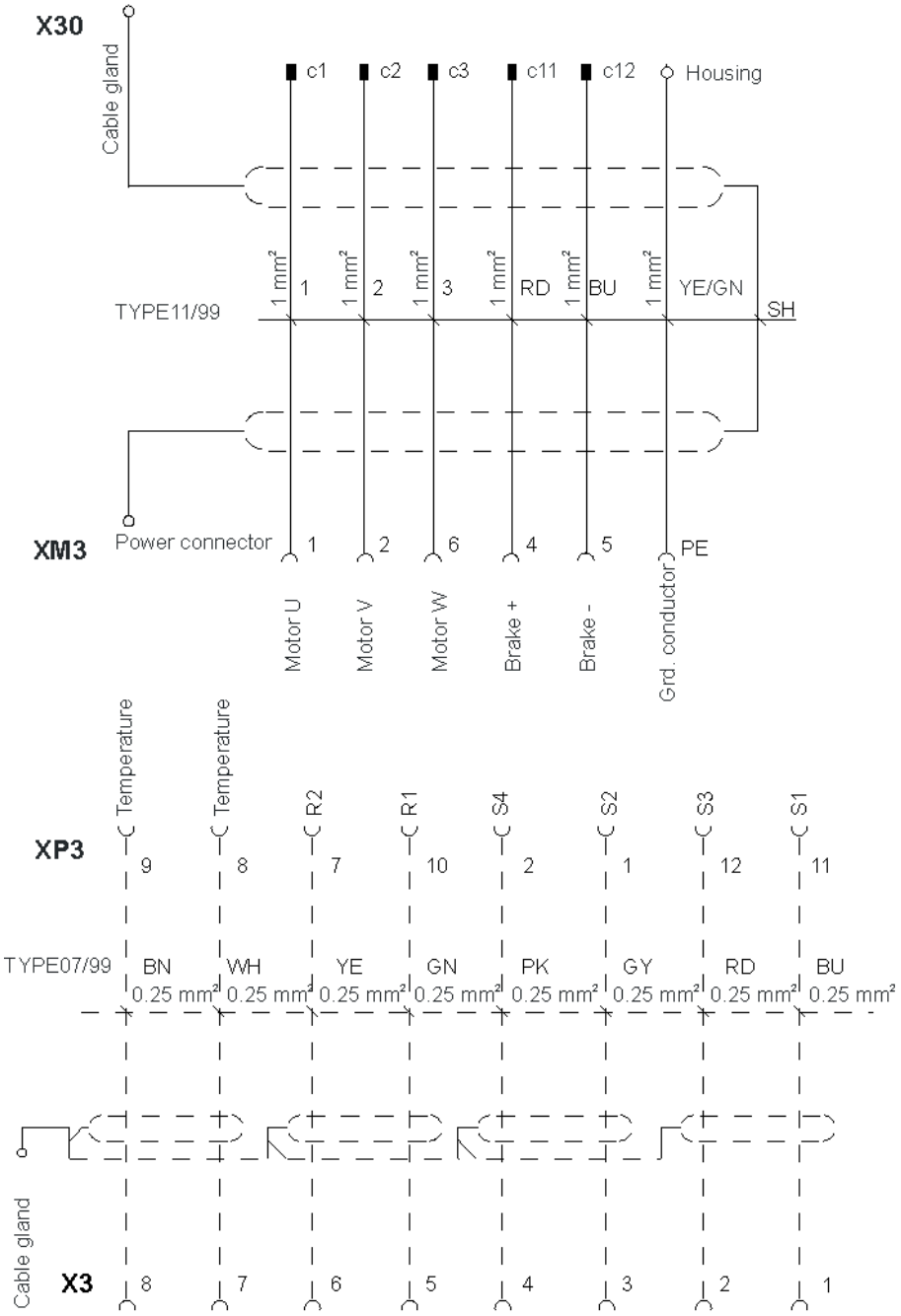


Fig. 11-43: Wiring diagram A3
KR 16 arc HW, KR 16 L8 arc HW
KR 16-3 arc HW, KR 16 L8-3 arc HW

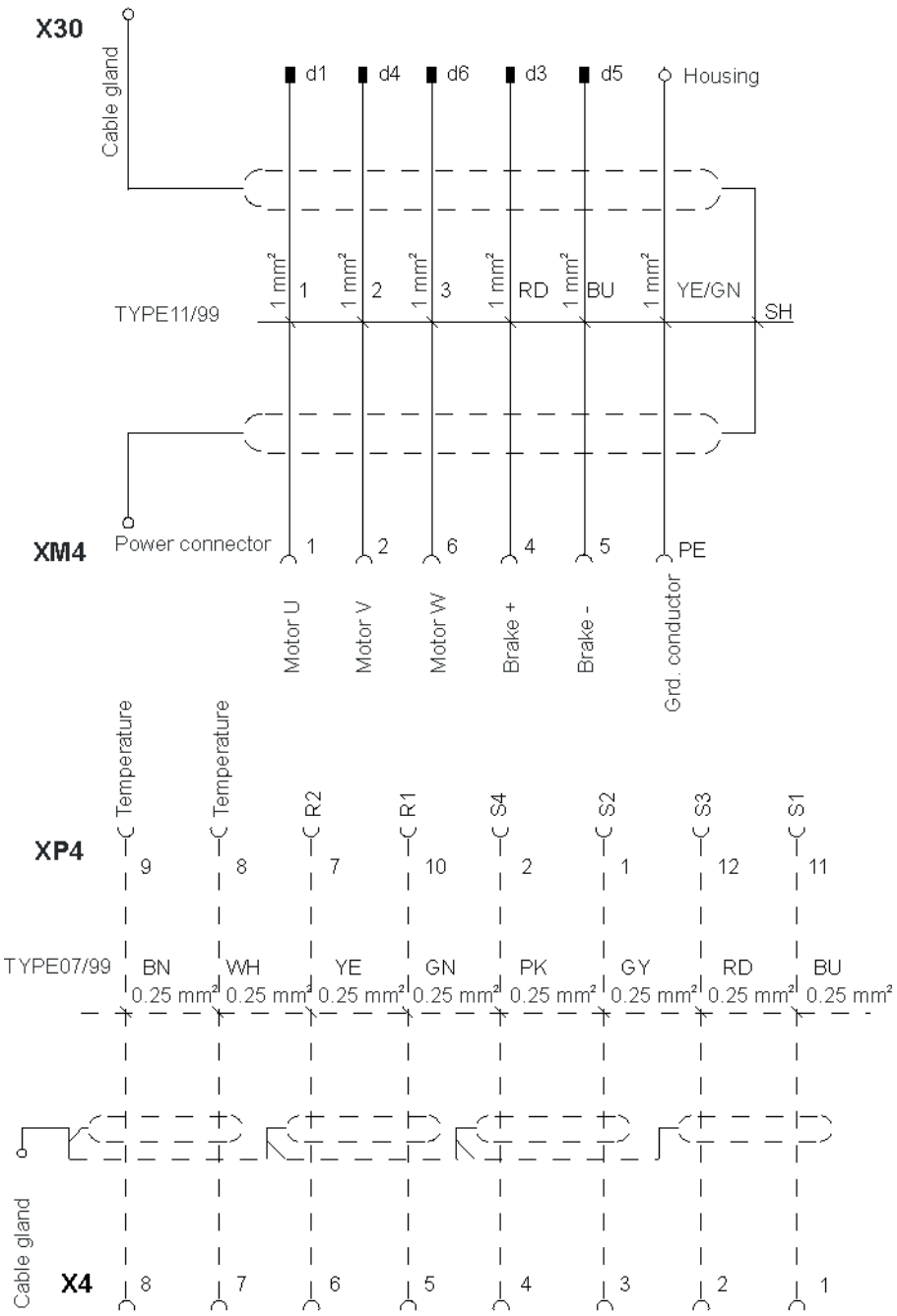


Fig. 11-44: Wiring diagram A4
KR 16 arc HW, KR 16 L8 arc HW
KR 16-3 arc HW, KR 16 L8-3 arc HW

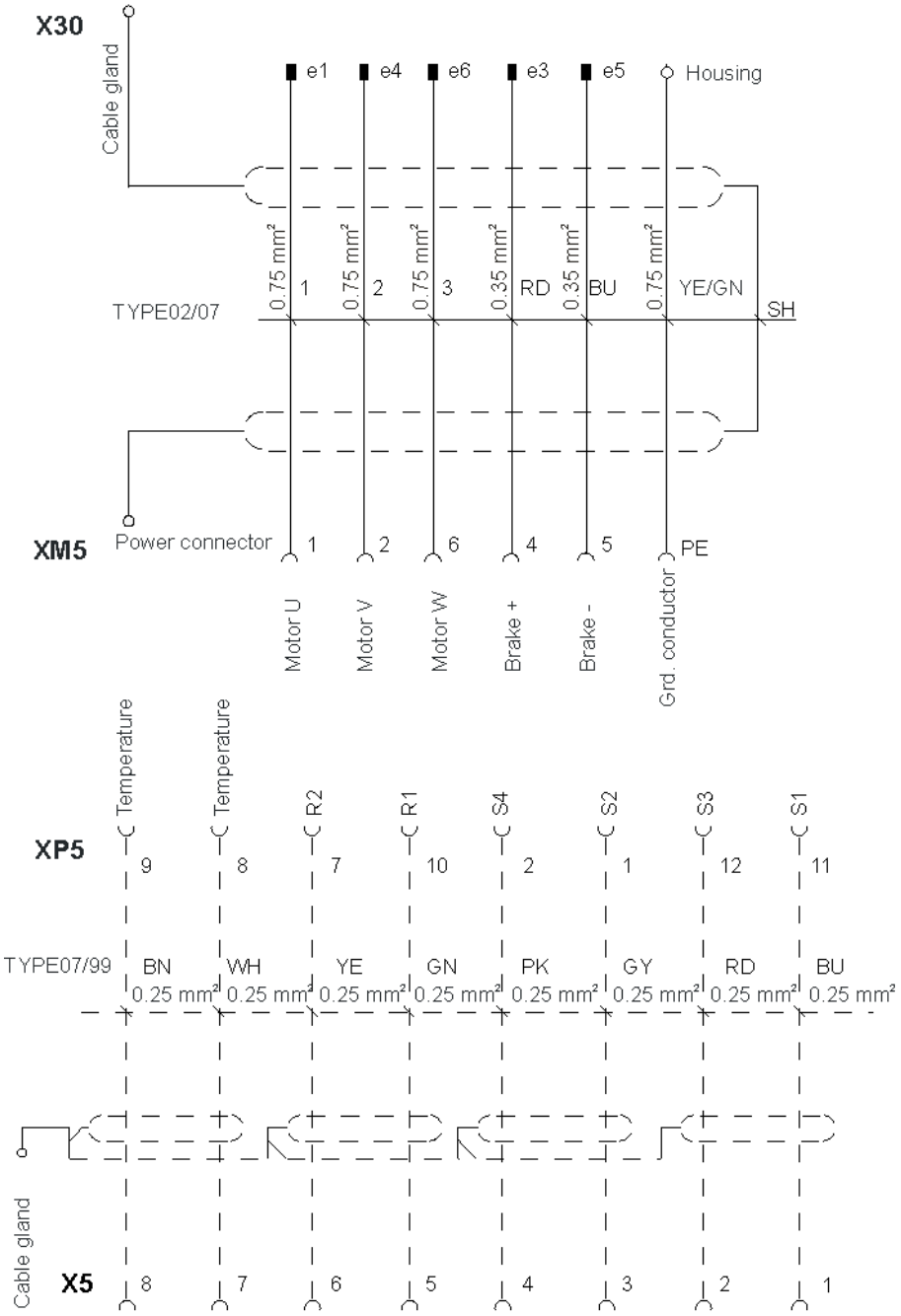


Fig. 11-45: Wiring diagram A5
KR 16 arc HW
KR 16-3 arc HW

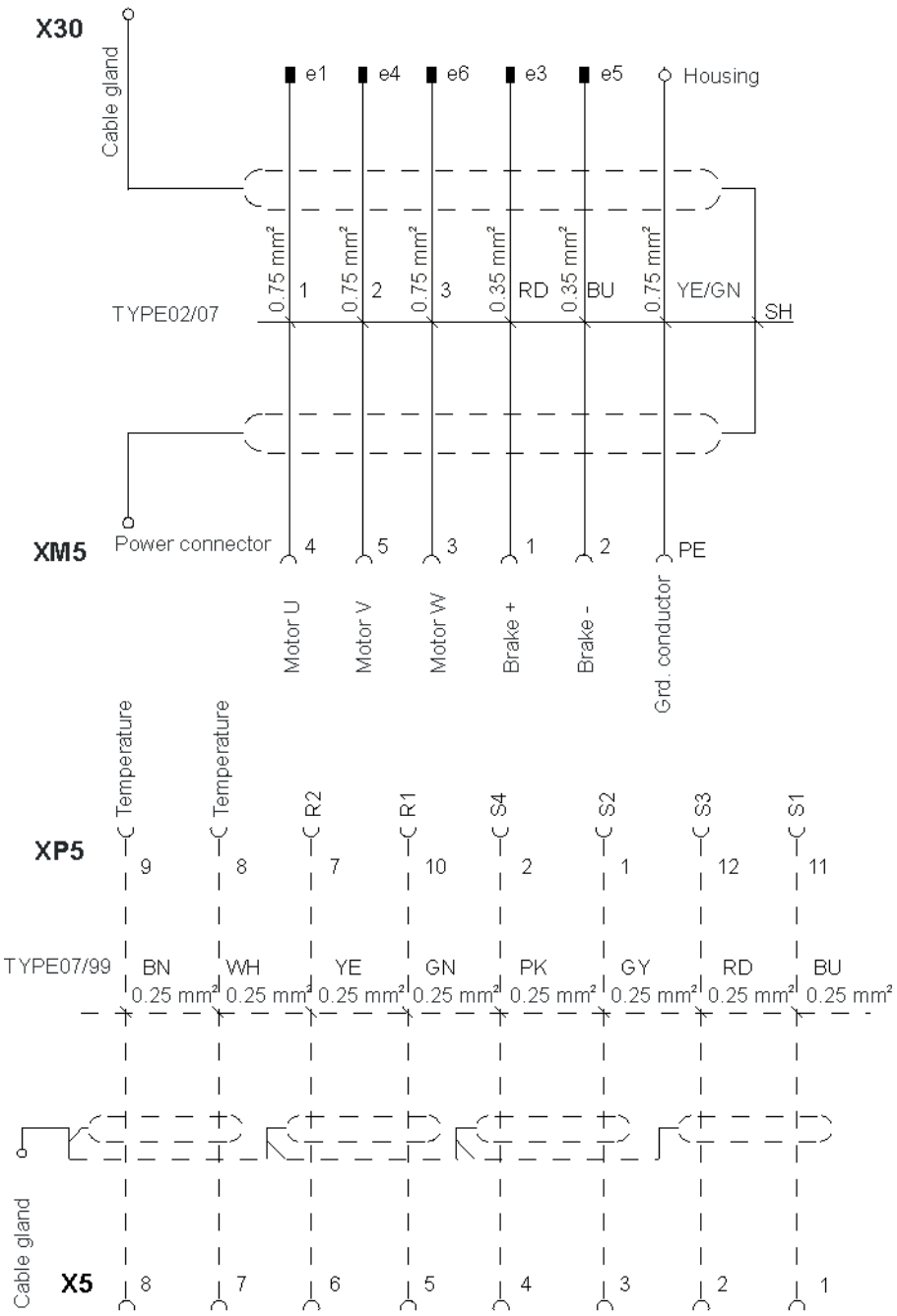


Fig. 11-46: Wiring diagram A5
KR 16 L8 arc HW
KR 16 L8-3 arc HW

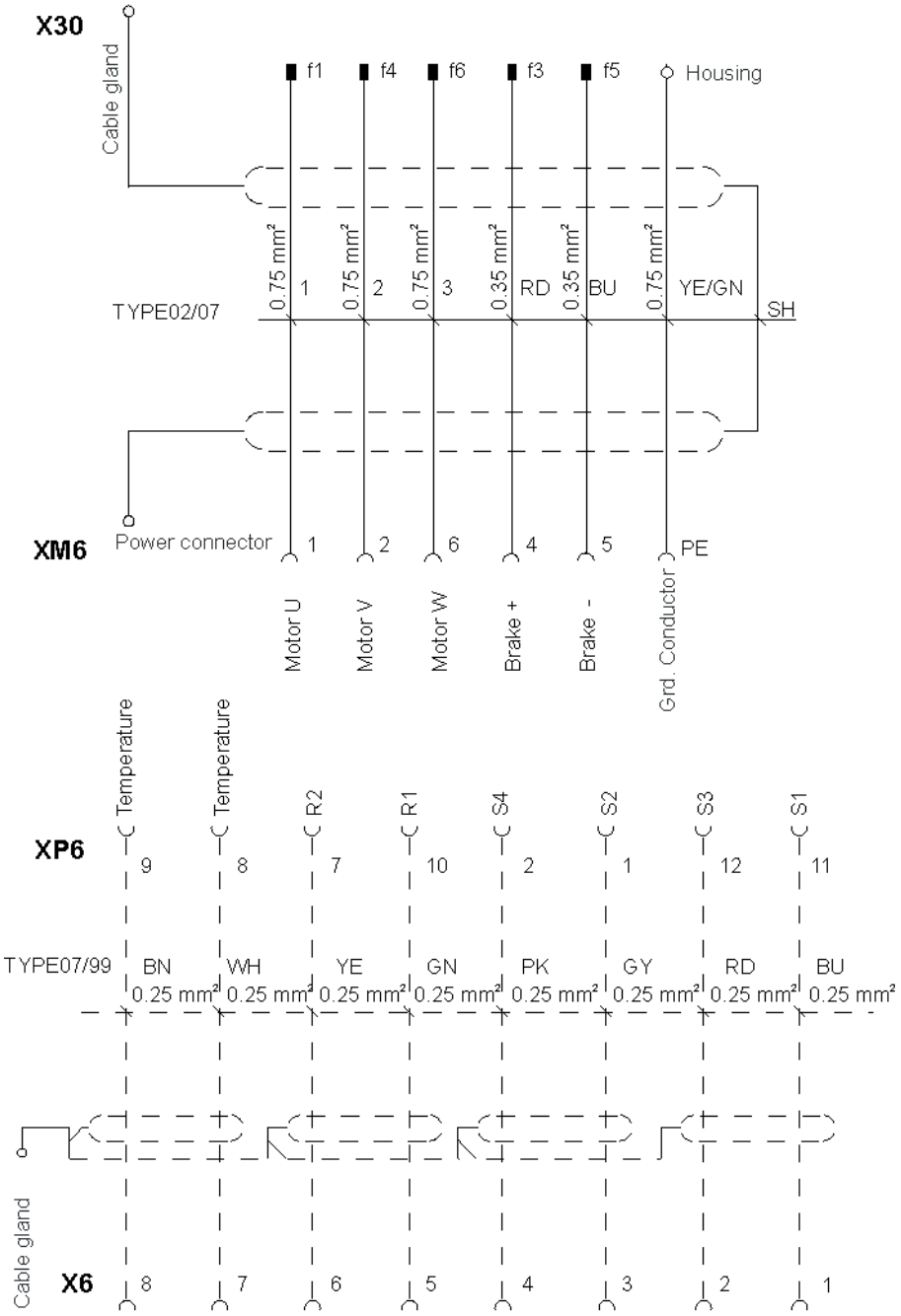


Fig. 11-47: Wiring diagram A6
KR 16 arc HW
KR 16-3 arc HW

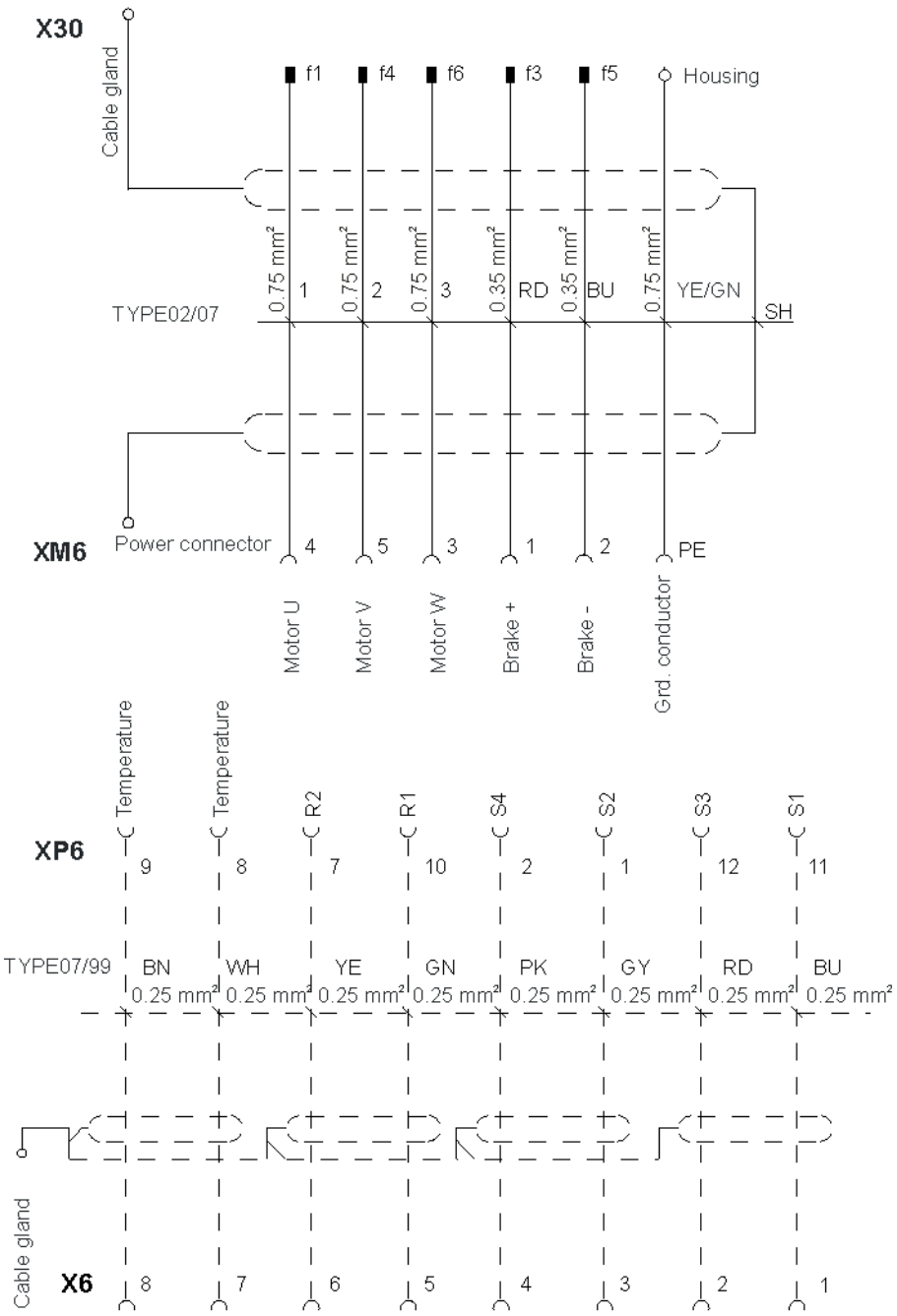


Fig. 11-48: Wiring diagram A6
KR 16 L8 arc HW
KR 16 L8-3 arc HW

12 Decommissioning, storage and disposal

12.1 Decommissioning

Description

This section describes all the work required for decommissioning the robot if the robot is to be removed from the system. After decommissioning, it is prepared for storage or for transportation to a different location.

Following its removal, the robot can be transported by means of transport tackle and crane or by fork lift truck.

Ceiling-mounted robots are removed in the same way. However, ceiling-mounted robots can only be removed and transported by fork lift truck. The removed robot may only be set down in the transport frame.

Preconditions

- The removal site must be accessible with a crane or with a fork lift truck for transportation.
- There is no hazard posed by system components.

Procedure

⚠ WARNING When carrying out the following work, the robot must be moved several times between the individual work steps.
While work is being carried out on the robot, it must always be secured by activating the EMERGENCY STOP device.
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot that is switched on, the robot can only be moved in T1 mode (reduced velocity). It must be possible to stop the robot at any time by activating an EMERGENCY STOP device. Operation must be limited to what is absolutely necessary.
Warn all persons concerned before switching on and moving the robot.

1. Secure the robot.
2. Remove tools and equipment.
3. Mount the fork slots (>>> Fig. 12-1) or 3 eyebolts on the rotating column.
4. Put the robot into operation and move it into the transport position.

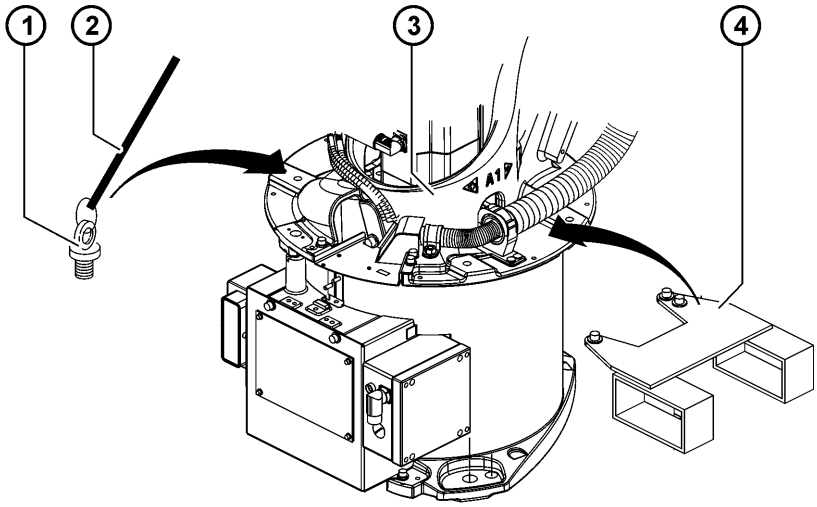


Fig. 12-1: Transporting the robot during removal

1	M12 DIN 580 eyebolt	3	Rotating column
2	Lifting tackle	4	Fork slots

5. Secure the robot again by pressing the E-STOP device.
6. Release and unplug all peripheral connections.

7. Release and unplug the connectors of the motor and data cables (>>> Fig. 12-2).
8. Unscrew hexagon nut from the ground conductor and pull off washers, lock washers and ground conductor.
9. Attach lifting tackle to the robot or prepare the robot for transportation with the fork lift truck.
10. Unscrew and remove the 3 hexagon bolts and conical spring washers.
11. Lift the robot vertically off the mounting surface and transport it away.
    Take care not to damage the two pins when lifting off the robot.

⚠ CAUTION If the robot is caught on the mounting surface, it may come free abruptly, endangering persons and property.
The robot must stand loosely on the mounting surface; completely remove all fastening materials and any adhesives.

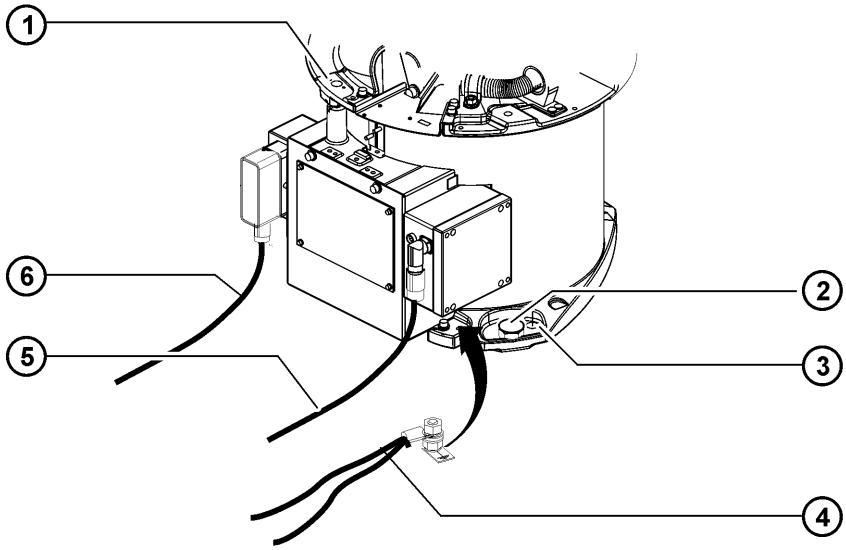


Fig. 12-2: Removing the robot

1	Robot	4	Ground conductor
2	Hexagon bolts	5	Data cable
3	Pin	6	Motor cable

12. Prepare the robot for storage.

12.2 Storage

Description

If the robot is to be put into long-term storage, the following points must be observed:

- The place of storage must be as dry and dust-free as possible.
- Avoid temperature fluctuations.
- Avoid wind and drafts.
- Avoid condensation.
- Use appropriate coverings that cannot detach themselves and which can withstand the expected environmental conditions.
- Do not leave any loose parts on the robot, especially ones that might knock against other parts.
- Do not leave the robot exposed to direct sunlight while in storage.
- Observe and comply with the permissible temperature ranges for storage.

- Select a storage location in which the packaging materials cannot be damaged.

Procedure

1. Remove the robot.
2. Remove tools and equipment.
3. Clean and dry the robot. No dirt or cleaning agent residue may remain on or in the robot.
4. Perform a visual inspection of the robot.
5. Remove any foreign bodies.
6. Remove any corrosion.
7. Attach all covers to the robot and check that the seals are correctly in place.
8. Seal off electrical connections with suitable covers.
9. Seal hose connections by suitable means.
10. Cover the robot with plastic film and seal it at the base frame against dust. If necessary, add a desiccant beneath the sheeting.

12.3 Disposal

When the robot reaches the end of its useful life, it can be removed from the system and dismantled, and the materials can be disposed of properly by type.

The following table provides an overview of the materials used in the robot. All plastic components are marked with a material designation and must be disposed of accordingly.

Material, designation	Subassembly, component	Note
Cast aluminum	Wrist, arm, link arm, rotating column	
Cast steel	Base frame	
ABS	Panels, covers	
Steel	Gear units, screws and washers, metal covers	
	Motors	Dispose of motors without dismantling them.
PUR	Cable sheaths	
ETFE	Flexible tube	
Copper	Cables, wires	
PU	Hoses	
Cable grease	Cabling	See safety data sheet, consumables (>>> 13.2.3 "Safety data sheet for Optitemp RB1 cable grease" Page 186)
Oil	Gear units	See safety data sheet, consumables (>>> 13.2.1 "Safety data sheet for Optigear Synthetic RO 150 oil" Page 175)

Material, designation	Subassembly, component	Note
Lubricating grease	Gear teeth	See safety data sheet, consumables (>>> 13.2.2 "Safety data sheet for Microlube GL 261 lubricating grease" Page 182)
PA	Hinged clamps, slide plates	
NBR	O-rings	
PE	End stop buffer	
	Stops	
FKM (fluorocarbon rubber)	Shaft sealing rings	

13 Appendix

13.1 Tightening torque

Tightening torque

The following tightening torques are valid for screws and nuts where no other specifications are given.

	Strength class		
Screw size	8.8	10.9	12.9
M1.6	0.17 Nm	0.24 Nm	0.28 Nm
M2	0.35 Nm	0.48 Nm	0.56 Nm
M2.5	0.68 Nm	0.93 Nm	1.10 Nm
M3	1.2 Nm	1.6 Nm	2.0 Nm
M4	2.8 Nm	3.7 Nm	4.4 Nm
M5	5.6 Nm	7.5 Nm	9.0 Nm
M6	9.5 Nm	12.5 Nm	15.0 Nm
M8	23.0 Nm	31.0 Nm	36.0 Nm
M10	45.0 Nm	60.0 Nm	70.0 Nm
M12	78.0 Nm	104.0 Nm	125.0 Nm
M14	125.0 Nm	165.0 Nm	195.0 Nm
M16	195.0 Nm	250.0 Nm	305.0 Nm
M20	370.0 Nm	500.0 Nm	600.0 Nm
M24	640.0 Nm	860.0 Nm	1030.0 Nm
M30	1330.0 Nm	1700.0 Nm	2000.0 Nm

Tighten M5 domed cap nuts with a torque of 4.2 Nm.

13.2 Safety data sheets

13.2.1 Safety data sheet for Optigear Synthetic RO 150 oil

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

13.2.1.1 Designation of substance/formulation and manufacturer

Name of substance/preparation	
Trade name:	**Optigear Synthetic RO 150**
SDS no.:	465036
Historical SDS no.:	DE-05254, FR-465036, SK-5254
Use of substance or	Lubricant
Formulation:	For specific instructions for use, see the corresponding technical data sheet or contact a company representative.

Manufacturer designation	
Company:	**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

Manufacturer designation	
Emergency hotline:	Carechem: +44 (0)208 762 8322
e-mail address:	MSDSadvice@bp.com

13.2.1.2 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 (>>> 13.2.1.11 "Toxicological information" Page 180) and (>>> 13.2.1.12 "Ecological information" Page 180) contain more detailed information on health hazards, symptoms and environmental risks.

13.2.1.3 Composition / Information about the components

Chemical characterization:	Synthetic lubricant and additives.

Chemical description	CAS no.	%	EINECS / ELINCS	Classification
Dithiocarbamic acid, dibutyl ester, 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 (>>> 13.2.1.16 "Other information" Page 181) for the full text of the above R-phrases.

The occupational exposure limit values, where available, are specified in Section (>>> 13.2.1.8 "Exposure limits and personal protective equipment" Page 178).

13.2.1.4 First aid measures

Contact with eyes:	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 unless explicitly directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this product have been swallowed, call a physician immediately.
Notes to physician:	Treatment should in general be symptomic and directed at relieving any effects. Note regarding high-pressure applications. Injection into the skin due to contact with a product under high pressure constitutes a major medical emergency. Within a few hours the tissue swells up and becomes discolored and extremely painful, with severe subcutaneous necrosis. Surgical treatment is absolutely imperative. Comprehensive opening of the wound and the tissue beneath it is necessary in order to reduce tissue loss and to prevent or limit lasting damage. The high pressure can cause the product to penetrate extensive areas of tissue layers.

13.2.1.5 Fire-fighting measures

Suitable extinguishing agents:	In the event of a fire: use water spray (mist), foam, dry chemicals or CO2. 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.

13.2.1.6 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 (>>> 13.2.1.8 "Exposure limits and personal protective equipment" Page 178)).
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 (>>> 13.2.1.13 "Disposal information" Page 180)). Disposal should be entrusted to a recognized waste disposal company. Contaminated absorbents can be just as dangerous as spilled material. Note: See (>>> 13.2.1.1 "Designation of substance/formulation and manufacturer" Page 175) for contact in emergencies and (>>> 13.2.1.13 "Disposal information" Page 180) 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.

13.2.1.7 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

13.2.1.8 Exposure limits and personal protective equipment

Ingredient name ACGIH TLVs:	**Limit values to be monitored acc. to ACGIH (USA)**
Base oil – unspecified	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.

Protective measures	
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.

13.2.1.9 Physical and chemical properties

General information / appearance	
Physical state:	Liquid.
Color:	Green.
Odor:	Light.

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.

13.2.1.10 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.

13.2.1.11 Toxicological information

Chronic toxicity:	
Chronic effects:	No particular effects or risks known.

Effects and symptoms	
Eyes:	May cause mild eye irritation.
Skin:	Prolonged or repeated contact can dry out the skin and lead to irritation and/or dermatitis.
Inhalation:	Vapors and spray mist may cause irritation of the mucous membranes of the nose and throat.
Ingestion:	Ingestion may cause gastrointestinal irritation and diarrhea.

13.2.1.12 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.

13.2.1.13 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 06* Synthetic machine oils, gear oils and lubricating oils.

Use of the product for purposes other than those specified and/or impurities can necessitate the use of a different waste code number for the waste producer.

Packaging	
European Waste Catalog (EWC):	15 01 10* Packaging containing the residue of hazardous materials or contaminated by hazardous materials.

13.2.1.14 Transport information

Classification:	Not hazardous as defined by the transport regulations (ADR/RID, ADNR, IMDG, ICAO/IATA).

13.2.1.15 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.
Classification acc. to the German Administrative Regulation on the Classification of Substances Hazardous to Water into Water Hazard Classes (VwVwS):	1, Annex no. 4.

13.2.1.16 Other information

List of R-phrases referred to in Section (>>> 13.2.1.11 "Toxicological information" Page 180) and Section (>>> 13.2.1.3 "Composition / Information about the components" Page 176)	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:	L31/08/2007.
Created 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 given 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 user's obligation to evaluate and use this product safely and to comply with all applicable laws and regulations. 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.

13.2.2 Safety data sheet for Microlube GL 261 lubricating grease

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

13.2.2.1 Designation of substance/formulation and manufacturer

Name of substance/preparation	
Trade name:	**Microlube GL 261**
Article no.:	020195
Use:	Lubricating grease

Manufacturer designation	
Company:	**Klüber Lubrication München AG**
Address:	Geisenhausenerstr. 7
Postal code:	D-81379 München
Country:	Germany
Telephone:	+49 (0)89 7876 0
Fax:	+49 (0)89 7876 333
Information center:	Material Compliance Management
Emergency hotline:	+49 (0)89 7876-700

13.2.2.2 Composition / Information about the components

Chemical characterization:	Mineral oil, lithium special soap, UV indicator

Hazardous components:	This product contains no dangerous components above the legally defined limit values.

13.2.2.3 Possible hazards

The preparation is **NOT** classified as hazardous in accordance with Directive 1999/45/EC in its altered and adapted version.

Physical / chemical hazards:	Not classified as dangerous.
Human health hazards:	May irritate eyes and skin.
Environmental hazards:	Unlikely to be harmful to aquatic organisms.

Effects and symptoms	
Eyes:	May cause mild eye irritation.
Skin:	Can dry out the skin and lead to irritation and/or dermatitis. Allergic reactions are possible in the worst case.
Inhalation:	Inhalation of oil mist or vapors at elevated temperatures may cause respiratory irritation.
Ingestion:	Ingestion may cause gastrointestinal irritation (e.g. diarrhea).

13.2.2.4 First aid measures

Contact with eyes:	Rinse eyes immediately with plenty of water for several 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.
Notes to physician:	Treatment should in general be symptomic and directed at relieving any effects. Note regarding high-pressure applications. Injection into the skin due to contact with a product under high pressure constitutes a major medical emergency. Within a few hours the tissue swells up and becomes discolored and extremely painful, with severe subcutaneous necrosis. Surgical treatment is absolutely imperative. Comprehensive opening of the wound and the tissue beneath it is necessary in order to reduce tissue loss and to prevent or limit lasting damage. The high pressure can cause the product to penetrate extensive areas of tissue layers.

13.2.2.5 Fire-fighting measures

Suitable extinguishing agents:	In the event of a fire: use water spray (mist), foam, dry chemicals or CO2.
Unsuitable extinguishing agents:	**Do not** use water jets.
Special instructions for extinguishing work:	Contaminated extinguishing water must be collected separately and prevented from entering the drainage system.
Hazardous decomposition products:	Decomposition products include various oxides (e.g. carbon oxides).
Unusual fire/explosion hazards:	This product is not inherently explosive in accordance with the applicable rules.

Special fire-fighting measures:	-
Protection of fire-fighters:	Fire-fighters must wear self-contained positive pressure breathing apparatus (SCBA) and full protective gear.

13.2.2.6 Measures after unintended release

Personal safety precautions:	In case of spillage, isolate the hazard area. Avoid contact with the hazardous substance and avoid inhaling vapors. Ensure adequate ventilation. Where there is insufficient ventilation, wear suitable respiratory equipment. Use suitable protective equipment.
Environmental protection measures:	Prevent the product from entering the drainage system, surface waters and soil. Notify the competent authorities, if required.
Large spills:	Stop the leak if you can do so without risk. Remove container from spill area. Flush spilled material into a wastewater treatment plant. Contain spilled material using a non-combustible absorbent (e.g. sand, soil, vermiculite, diatomaceous earth) and collect in the containers provided. Disposal should be entrusted to a recognized waste disposal company. Contaminated absorbents can be just as dangerous.
Small spills:	Stop the leak if you can do so without risk. Remove container from spill area. Dilute with water and mop up, or add absorbent material and place the substance in a suitable container for disposal. Disposal should be entrusted to a recognized waste disposal company.

13.2.2.7 Handling and storage

Handling:	Prevent contact with skin or clothing. 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.
Unsuitable:	Avoid prolonged exposure to increased temperatures.

VCI storage class:	11

13.2.2.8 Exposure limits and personal protective equipment

Threshold limit values (TLV):	No occupational exposure threshold limit values have been assigned for this product.

Protective measures	
Limitation and monitoring of exposure in the workplace:	Provide exhaust ventilation or other engineering controls.
Hygiene measures:	Wash hands, forearms and face thoroughly after handling chemical products.
Respiratory protection:	Sufficient ventilation is recommended in industry. If ventilation is insufficient, respiratory protection is useful.
Hand protection:	Wear chemical-resistant gloves (recommended: nitrile gloves) if prolonged or repeated contact is likely.
Eye protection:	Protective goggles with side shields to guard against splashing.
Skin and body:	Wear appropriate clothing to avoid prolonged skin contact.

13.2.2.9 Physical and chemical properties

Physical state:	Paste
Color:	Tan
Odor:	Specific
Flash point:	-
Drop point:	>220 °C (DIN ISO 2176)
Density:	<1,000 kg/m^3 (<1 g/cm^3) at 20 °C
Solubility:	Insoluble in water

13.2.2.10 Stability and reactivity

Incompatible with various substances:	Reactive or incompatible with oxidizing materials.
Hazardous polymerization:	The product is stable. No hazardous polymerization occurs under normal conditions.
Hazardous decomposition products:	Decomposition products may include various oxides (e.g. carbon oxides). No hazardous decomposition products should be formed under normal conditions of storage and use.

13.2.2.11 Toxicological information

Chronic effects:	No particular effects or risks known.
Effects on eyes:	May cause mild eye irritation.
Effects on skin:	Prolonged or repeated contact can dry out the skin and lead to irritation and/or dermatitis. Allergic reactions are possible in the worst case.
Effect if inhaled:	Vapors and aerosols may cause irritation of the mucous membranes of the nose and throat.
Effect if ingested:	May cause nausea, vomiting and diarrhea.

13.2.2.12 Ecological information

Persistence / degradability:	The product can be separated by mechanical means.
Mobility:	The product is insoluble in water.
Environmental hazards:	Prevent from entering wastewater and soil.

13.2.2.13 Disposal information

Disposal information	
Disposal information / waste specifications:	Spilled and leaked product must be prevented from coming into contact with soil and surface waters. Observe local, regional and national regulations. Use only approved transporters, recyclers, treatment, storage or disposal facilities. If necessary, disposal should be entrusted to a recognized waste disposal company.

Hazardous waste
On the basis of the supplier's current state of knowledge, this product is not considered as hazardous waste as defined by EU directive 91/689/EC.

13.2.2.14 Transport information

Classification:	Not hazardous as defined by the transport regulations (ADR/ RID, ADNR, IMDG, ICAO/IATA).

13.2.2.15 Regulations

EU regulations:	EC Directives 1999/45/EC and 67/548/EEC.

Classification acc. to the German Administrative Regulation on the Classification of Substances Hazardous to Water into Water Hazard Classes (VwVwS):	1, low hazard to waters, Annex 4

13.2.2.16 Other information

Notes for the reader
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.

13.2.3 Safety data sheet for Optitemp RB1 cable grease

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

13.2.3.1 Designation of substance/formulation and manufacturer

Name of substance/preparation	
Trade name:	**Optitemp RB1**
SDS no.:	455577
Use:	Lubricant

Manufacturer designation	
Company:	**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

13.2.3.2 Composition / Information about the components

Chemical characterization:	Synthetic lubricant and additives. Thickeners.

Hazardous components:	This product contains no dangerous components above the legally defined limit values.

13.2.3.3 Possible hazards

The preparation is **NOT** classified as hazardous in accordance with Directive 1999/45/EC in its altered and adapted version.

Physical / chemical hazards:	Not classified as dangerous.
Human health hazards:	May irritate eyes and skin.
Environmental hazards:	Unlikely to be harmful to aquatic organisms.

Effects and symptoms	
Eyes:	May cause mild eye irritation.
Skin:	Can dry out the skin and lead to irritation and/or dermatitis. Allergic reactions are possible in the worst case.
Inhalation:	Inhalation of oil mist or vapors at elevated temperatures may cause respiratory irritation.
Ingestion:	Ingestion may cause gastrointestinal irritation (e.g. diarrhea).

13.2.3.4 First aid measures

Contact with eyes:	Rinse eyes immediately with plenty of water for several 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.
Notes to physician:	Treatment should in general be symptomic and directed at relieving any effects. Note regarding high-pressure applications. Injection into the skin due to contact with a product under high pressure constitutes a major medical emergency. Within a few hours the tissue swells up and becomes discolored and extremely painful, with severe subcutaneous necrosis. Surgical treatment is absolutely imperative. Comprehensive opening of the wound and the tissue beneath it is necessary in order to reduce tissue loss and to prevent or limit lasting damage. The high pressure can cause the product to penetrate extensive areas of tissue layers.

13.2.3.5 Fire-fighting measures

Suitable extinguishing agents:	In the event of a fire: use water spray (mist), foam, dry chemicals or CO2.
Unsuitable extinguishing agents:	**Do not** use water jets.
Special instructions for extinguishing work:	Contaminated extinguishing water must be collected separately and prevented from entering the drainage system.
Hazardous decomposition products:	Decomposition products include various oxides (e.g. carbon oxides).
Unusual fire/explosion hazards:	This product is not inherently explosive in accordance with the applicable rules.
Special fire-fighting measures:	-
Protection of fire-fighters:	Fire-fighters must wear self-contained positive pressure breathing apparatus (SCBA) and full protective gear.

13.2.3.6 Measures after unintended release

Personal safety precautions:	In case of spillage, isolate the hazard area. Avoid contact with the hazardous substance and avoid inhaling vapors. Ensure adequate ventilation. Where there is insufficient ventilation, wear suitable respiratory equipment. Use suitable protective equipment.
Environmental protection measures:	Prevent the product from entering the drainage system, surface waters and soil. Notify the competent authorities, if required.
Large spills:	Stop the leak if you can do so without risk. Remove container from spill area. Flush spilled material into a wastewater treatment plant. Contain spilled material using a non-combustible absorbent (e.g. sand, soil, vermiculite, diatomaceous earth) and collect in the containers provided. Disposal should be entrusted to a recognized waste disposal company. Contaminated absorbents can be just as dangerous.
Small spills:	Stop the leak if you can do so without risk. Remove container from spill area. Dilute with water and mop up, or add absorbent material and place the substance in a suitable container for disposal. Disposal should be entrusted to a recognized waste disposal company.

13.2.3.7 Handling and storage

Handling:	Prevent contact with skin or clothing. 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.
Unsuitable:	Avoid prolonged exposure to increased temperatures.

VCI storage class:	11

13.2.3.8 Exposure limits and personal protective equipment

Threshold limit values (TLV):	No occupational exposure threshold limit values have been assigned for this product.

Protective measures	
Limitation and monitoring of exposure in the workplace:	Provide exhaust ventilation or other engineering controls.
Hygiene measures:	Wash hands, forearms and face thoroughly after handling chemical products.
Respiratory protection:	Sufficient ventilation is recommended in industry. If ventilation is insufficient, respiratory protection is useful.
Hand protection:	Wear chemical-resistant gloves (recommended: nitrile gloves) if prolonged or repeated contact is likely.
Eye protection:	Protective goggles with side shields to guard against splashing.
Skin and body:	Wear appropriate clothing to avoid prolonged skin contact.

13.2.3.9 Physical and chemical properties

Physical state:	Paste
Color:	Light beige
Odor:	Slight
Flash point:	Closed cup: >150 °C
Vapor pressure:	<0.01 kPa (<0.075 mm Hg) at 20 °C
Penetration number (0.1 mm)	280 at 25 °C
Melting point/range:	192 °C
Drop point:	>180 °C
Density:	<1000 kg/m^3 (<1 g/cm^3) at 20 °C
Solubility:	Insoluble in water

13.2.3.10 Stability and reactivity

Incompatible with various substances:	Reactive or incompatible with oxidizing materials.
Hazardous polymerization:	The product is stable. No hazardous polymerization occurs under normal conditions.
Hazardous decomposition products:	Decomposition products may include various oxides (e.g. carbon oxides). No hazardous decomposition products should be formed under normal conditions of storage and use.

13.2.3.11 Toxicological information

Chronic effects:	No particular effects or risks known.
Effects on eyes:	May cause mild eye irritation.
Effects on skin:	Prolonged or repeated contact can dry out the skin and lead to irritation and/or dermatitis. Allergic reactions are possible in the worst case.
Effect if inhaled:	Vapors and aerosols may cause irritation of the mucous membranes of the nose and throat.
Effect if ingested:	May cause nausea, vomiting and diarrhea.

13.2.3.12 Ecological information

Persistence / degradability:	Biodegradable.

Mobility:	The product is non-volatile. Insoluble in water.
Environmental hazards:	Not classified as dangerous.

13.2.3.13 Disposal information

Disposal information	
Disposal information / waste specifications:	Spilled and leaked product must be prevented from coming into contact with soil and surface waters. Observe local, regional and national regulations. Use only approved transporters, recyclers, treatment, storage or disposal facilities. If necessary, disposal should be entrusted to a recognized waste disposal company.

Unused product	
European Waste Catalog (EWC):	Waste code 12 01 12: Used waxes and greases

Packaging	
European Waste Catalog (EWC):	Waste code 15 01 10: Packaging containing the residue of hazardous materials or contaminated by hazardous materials.

Use of the product for purposes other than those specified and/or impurities can necessitate the use of a different waste code number for the waste producer.

Hazardous waste
On the basis of the supplier's current state of knowledge, this product is not considered as hazardous waste as defined by EU directive 91/689/EC.

13.2.3.14 Transport information

Classification:	Not hazardous as defined by the transport regulations (ADR/RID, ADNR, IMDG, ICAO/IATA).

13.2.3.15 Regulations

EU regulations:	EC Directives 1999/45/EC and 67/548/EEC.

Labeling requirements	
Risk (R) phrases:	This product is not classified according to the Dangerous Substances Order / EU regulations.
Additional warning labels:	Contains acetic acid, (4-nonylphenoxyl). Can cause allergic reactions.

Miscellaneous provisions	
Inventories:	**European inventory:** All components are listed or exempted. **US inventory (TSCA 8b):** All components are listed or exempted. **Australian inventory (AICS):** At least one component is not listed. **Canadian inventory:** At least one component is not listed. **Inventory of Existing Chemical Substances in China (IECSC):** At least one component is not listed. **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.
Classification acc. to the German Administrative Regulation on the Classification of Substances Hazardous to Water into Water Hazard Classes (VwVwS):	1, Annex no. 4

13.2.3.16 Other information

Notes for the reader
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.

14 KUKA Service

14.1 Requesting support

Introduction

The KUKA Roboter GmbH documentation offers information on operation and provides assistance with troubleshooting. For further assistance, please contact your local KUKA subsidiary.

Information

The following information is required for processing a support request:

- Model and serial number of the robot
- Model and serial number of the controller
- Model and serial number of the linear unit (if applicable)
- Model and serial number of the energy supply system (if applicable)
- Version of the KUKA System Software
- Optional software or modifications
- Archive of the software

  For KUKA System Software V8: instead of a conventional archive, generate the special data package for fault analysis (via **KrcDiag**).
- Application used
- Any external axes used
- Description of the problem, duration and frequency of the fault

14.2 KUKA Customer Support

Availability

KUKA Customer Support is available in many countries. Please do not hesitate to contact us if you have any questions.

Argentina

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