KUKA

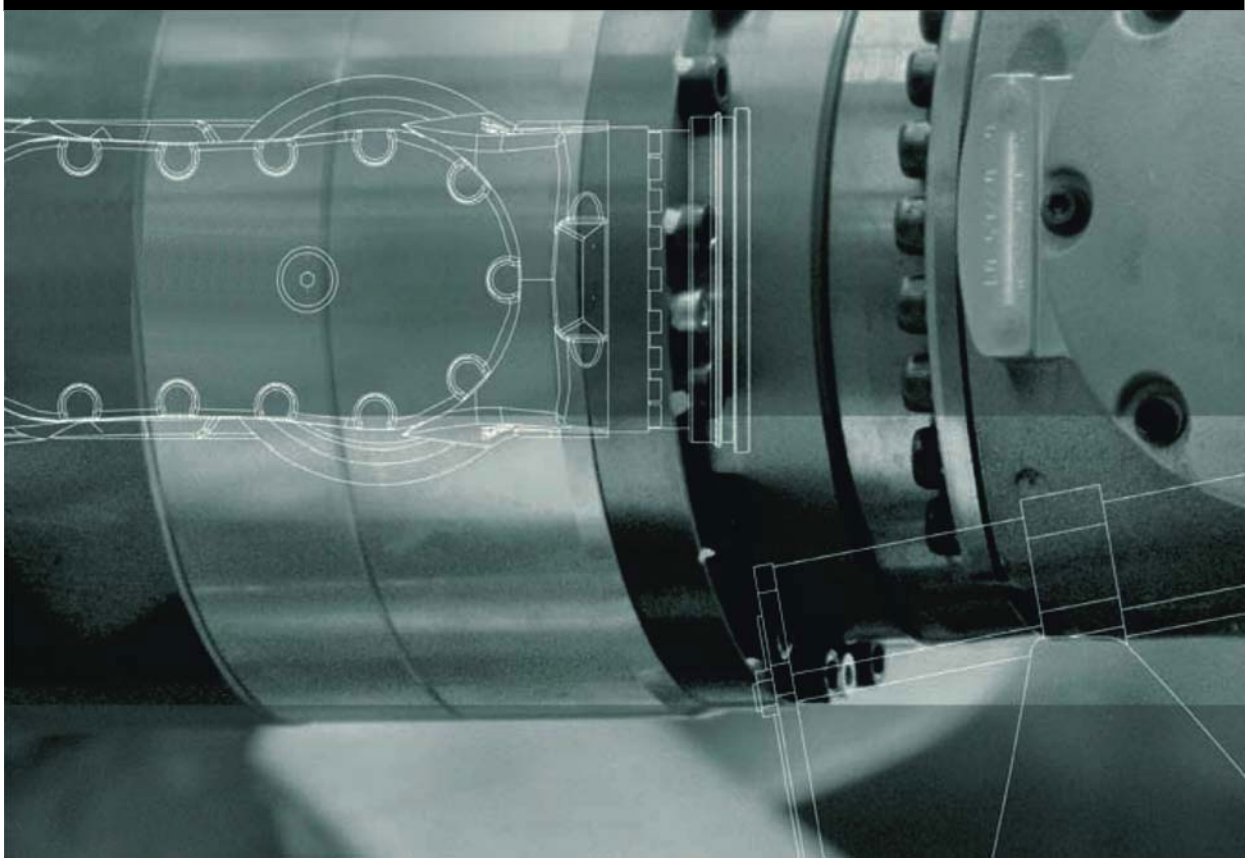
Robots

KUKA Roboter GmbH

KR 500 FORTEC

With F and C Variants

Operating Instructions



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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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Book structure:	BA KR 500 FORTEC V4.1
Version:	BA KR 500 FORTEC V2

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 System Software
- Instructions for 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 notices serve to make your work easier or contain references to further information.

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

1.3 Terms used

Term	Description
Stopping distance	Stopping distance = reaction distance + braking distance The stopping distance is part of the danger zone.
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.
Manipulator	The robot arm and the associated electrical installations

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 misuse and is not allowed. 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.

NOTICE Deviations from the operating conditions specified in the technical data or the use of special functions or applications can lead to premature wear. KUKA Roboter GmbH must be consulted.

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

The robot system consists of the following components:

- Robot
- Robot controller
- smartPAD teach pendant
- Connecting cables
- Software
- Options, accessories

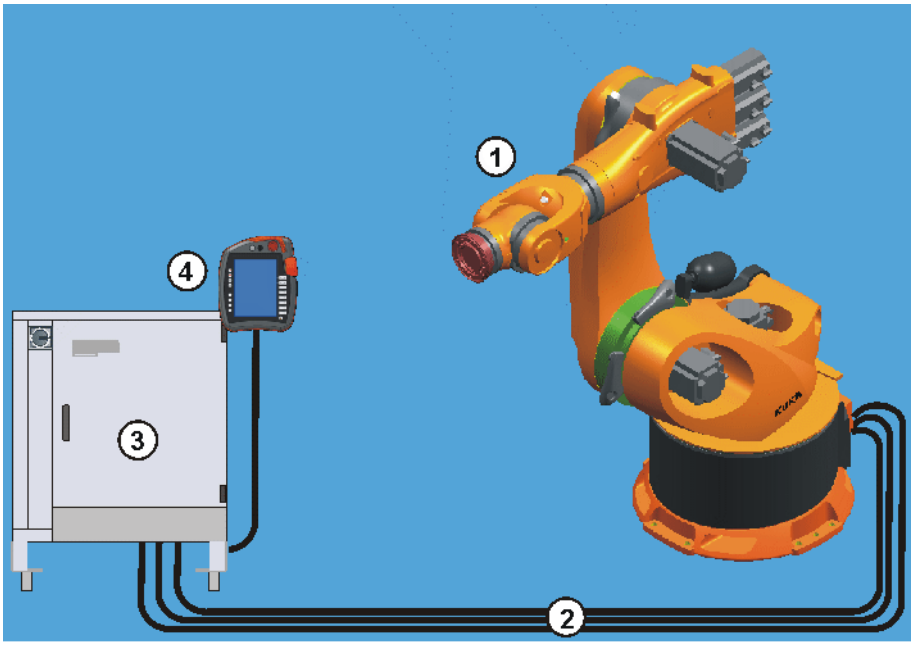

Fig. 3-1: Example of a robot system

1	Robot	3	Robot controller
2	Connecting cables	4	smartPAD teach pendant

3.2 Description of the robot

Overview

The robot is designed as a 6-axis jointed-arm kinematic system. The structural components of the robot are made of light alloy and iron castings. The axes are driven by AC servomotors. A hydropneumatic counterbalancing system is used to equalize the load moment about axis 2.

The robot consists of the following principal components:

- In-line wrist
- Arm
- Link arm
- Rotating column
- Base frame
- Counterbalancing system
- Electrical installations

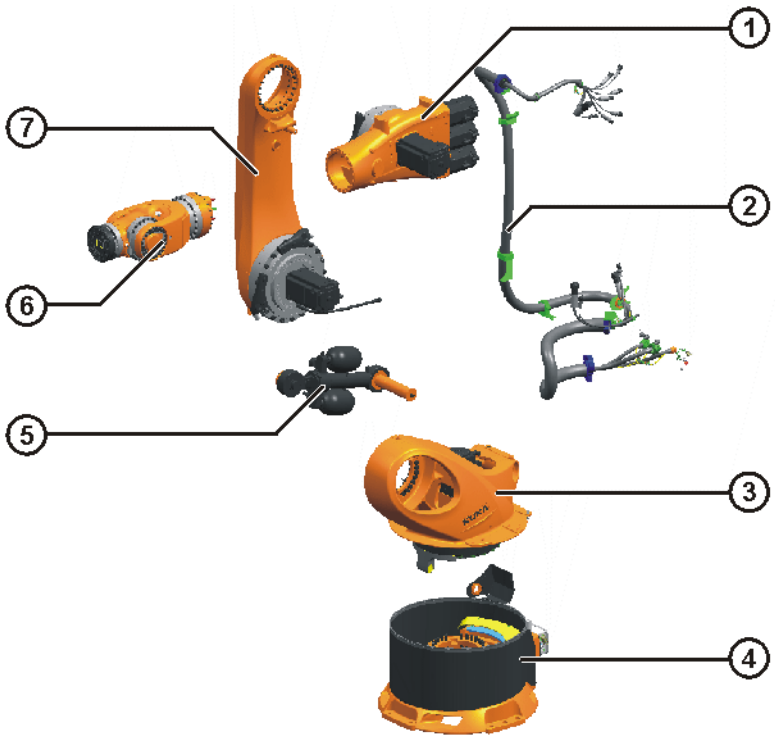

Fig. 3-2: Principal components

1	Arm	5	Counterbalancing system
2	Electrical installations	6	In-line wrist
3	Rotating column	7	Link arm
4	Base frame		

In-line wrist

The robot is fitted with a 3-axis in-line wrist for a rated payload of 500 kg. The in-line wrist comprises axes 4, 5 and 6. It is driven by three AC servomotors installed at the rear end of the arm via drive shafts. The motor unit consists of brushless AC servomotors with a permanent-magnet single-disk brake and hollow-shaft resolver, both integrated. The permanent-magnet single-disk brakes perform a holding function when the servomotor is at rest and contribute to the braking of the respective axis in the event of short-circuit braking (e.g. if one or more of the enabling switches is released while in Test mode). Short-circuit braking must not be used to stop the robot under normal circumstances. The gear units of the in-line wrist are supplied with oil from three separate oil chambers.

If the permissible turning range of a wrist axis is exceeded, the robot is switched off by means of software limit switches. The turning range of A5 is mechanically limited by end stops.

The in-line wrist forms an exchangeable unit with a standardized mechanical interface to the arm.

The assembly also has a gauge mount with a gauge cartridge, through which the mechanical zero of the axis can be determined by means of an electronic probe (accessory) and transferred to the controller.

The in-line wrist variant “F” is available for operating conditions involving greater mechanical and thermal stress.

Arm

The arm is the link between the in-line wrist and the link arm. It houses the motors of the wrist axes A4, A5 and A6, as well as motor A3. The arm is driven by an AC servomotor via a gear unit that is installed between the arm and the link arm. The maximum permissible swivel range is limited by mechanical limit

stops with a buffer function in the positive and negative directions in addition to the software limit switches.

The arm variant “F” is available for operating conditions involving greater mechanical and thermal stress. The arms of the F variants are pressurized to prevent penetration of moisture and dust.

Link arm

The link arm is the assembly located between the arm and the rotating column. It is mounted on one side of the rotating column via a gear unit. The motor unit consists of a brushless AC servomotor with a permanent-magnet single-disk brake and hollow-shaft resolver, both integrated. The permanent-magnet single-disk brake performs a holding function when the servomotor is at rest and contributes to the braking of the respective axis in the event of short-circuit braking (e.g. if one or more of the enabling switches is released while in Test mode). Short-circuit braking must not be used to stop the robot under normal circumstances. During motion about axis 2, the link arm moves about the stationary rotating column. The usable software swivel range is limited by mechanical limit stops with a buffer function in the positive and negative directions in addition to the software limit switches.

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. It is screwed to the base frame via the gear unit of axis 1. Inside the rotating column is a brushless AC servomotor with a permanent-magnet single-disk brake and hollow-shaft resolver, both integrated, for driving axis 1. The permanent-magnet single-disk brake performs a holding function when the servomotor is at rest and contributes to the braking of the respective axis in the event of short-circuit braking (e.g. if one or more of the enabling switches is released while in Test mode). Short-circuit braking must not be used to stop the robot under normal circumstances. The counterbearing for the counterbalancing system is integrated into the rear of the rotating column housing.

Base frame

The base frame is the base of the robot. It is screwed to the mounting base. The interfaces for the electrical installations and the energy supply systems (accessory) are housed in the base frame. The base frame and rotating column are connected via the gear unit of axis 1. The flexible tube for the electrical installations and the energy supply system is accommodated in the base frame.

Counterbalancing system

The counterbalancing system is an assembly installed between the rotating column and the link arm. This assembly minimizes the torques generated about axis 2 when the robot is moving or stationary. A closed, hydropneumatic system is used. The system consists of two accumulators, a hydraulic cylinder with associated hoses, a pressure gauge and a bursting disc as a safety element to protect against overload. The accumulators correspond to category III, fluid group 2, of the Pressure Equipment Directive. Different variants of the counterbalancing system are used for floor and ceiling-mounted robots and for the F variants. The mode of operation is reversed for ceiling-mounted robots, i.e. the piston rod pushes against the link arm.

Electrical installations

The electrical installations are described in Chapter (>>> 10.7 "Description of the electrical installations" Page 178).

Options

The robot can be fitted and operated with various options, e.g. working range limitation. The options are described in separate documentation.

4 Technical data

4.1 Technical data, overview

The technical data for the individual robot types can be found in the following sections:

Robot	Technical data
KR 500 R2830	■ Technical data (>>> 4.2 "Technical data, KR 500 R2830" Page 18) ■ Supplementary loads (>>> 4.9 "Supplementary load" Page 60) ■ Plates and labels (>>> 4.10 "Plates and labels" Page 62) ■ Stopping distances and times (>>> 4.11.3 "Stopping distances and times KR 500 R2830, KR 500 R2830 F, KR 500 R2830 C" Page 65)
KR 500 R2830 F	■ Technical data (>>> 4.3 "Technical data, KR 500 R2830 F" Page 24) ■ Supplementary loads (>>> 4.9 "Supplementary load" Page 60) ■ Plates and labels (>>> 4.10 "Plates and labels" Page 62) ■ Stopping distances and times (>>> 4.11.3 "Stopping distances and times KR 500 R2830, KR 500 R2830 F, KR 500 R2830 C" Page 65)
KR 500 R2830 C	■ Technical data (>>> 4.4 "Technical data, KR 500 R2830 C" Page 30) ■ Supplementary loads (>>> 4.9 "Supplementary load" Page 60) ■ Plates and labels (>>> 4.10 "Plates and labels" Page 62) ■ Stopping distances and times (>>> 4.11.3 "Stopping distances and times KR 500 R2830, KR 500 R2830 F, KR 500 R2830 C" Page 65)
KR 420 R3080	■ Technical data (>>> 4.5 "Technical data, KR 420 R3080" Page 36) ■ Supplementary loads (>>> 4.9 "Supplementary load" Page 60) ■ Plates and labels (>>> 4.10 "Plates and labels" Page 62) ■ Stopping distances and times (>>> 4.11.4 "Stopping distances and times KR 420 R3080, KR 420 R3080 F" Page 70)

Robot	Technical data
KR 420 R3080 F	■ Technical data (>>> 4.6 "Technical data, KR 420 R3080 F" Page 42) ■ Supplementary loads (>>> 4.9 "Supplementary load" Page 60) ■ Plates and labels (>>> 4.10 "Plates and labels" Page 62) ■ Stopping distances and times (>>> 4.11.4 "Stopping distances and times KR 420 R3080, KR 420 R3080 F" Page 70)
KR 340 R3330	■ Technical data (>>> 4.7 "Technical data, KR 340 R3330" Page 48) ■ Supplementary loads (>>> 4.9 "Supplementary load" Page 60) ■ Plates and labels (>>> 4.10 "Plates and labels" Page 62) ■ Stopping distances and times (>>> 4.11.5 "Stopping distances and times KR 340 R3330, KR 340 R3330 F" Page 75)
KR 340 R3330 F	■ Technical data (>>> 4.8 "Technical data, KR 340 R3330 F" Page 54) ■ Supplementary loads (>>> 4.9 "Supplementary load" Page 60) ■ Plates and labels (>>> 4.10 "Plates and labels" Page 62) ■ Stopping distances and times (>>> 4.11.5 "Stopping distances and times KR 340 R3330, KR 340 R3330 F" Page 75)

4.2 Technical data, KR 500 R2830

4.2.1 Basic data, KR 500 R2830

Basic data

	KR 500 R2830
Number of axes	6
Number of controlled axes	6
Work envelope volume	68 m³
Pose repeatability (ISO 9283)	± 0.08 mm
Weight	approx. 2385 kg
Rated payload	500 kg
Maximum reach	2826 mm
Protection rating	IP 65
Protection rating, in-line wrist	IP 65
Sound level	< 75 dB (A)
Mounting position	Floor
Robot footprint	-
Permissible angle of inclination	≤ 5 °

	KR 500 R2830
Default color	Base frame: black (RAL 9005); Moving parts: KUKA orange 2567
Controller	KR C4

Ambient conditions

Humidity class	3k3, DIN EN 60721-3-3
Ambient temperature	
During operation	10 °C to 55 °C (283 K to 328 K)
During storage/transportation	-40 °C to 60 °C (233 K to 333 K)

Connecting cables

Cable designation	Connector designation	Interface with robot
Motor cable	X20.1 - X30.1	Harting connectors at both ends
Motor cable	X20.4 - X30.4	Harting connectors at both ends
Control cable	X21 - X31	HAN 3A EMC at both ends
Ground conductor / equipotential bonding 16 mm^2 (optional)		M8 ring cable lug at both ends

Cable lengths	
Standard	7 m, 15 m, 25 m, 35 m, 50 m

For detailed specifications of the connecting cables, see (>>> 8.6 "Description of the connecting cables" Page 115).

4.2.2 Axis data, KR 500 R2830

Axis data

Range of motion	
A1	±185 °
A2	20 ° / -130 °
A3	144 ° / -100 °
A4	±350 °
A5	±120 °
A6	±350 °
Speed with rated payload	
A1	90 °/s
A2	80 °/s
A3	75 °/s
A4	90 °/s
A5	83 °/s
A6	130 °/s

The direction of motion and the arrangement of the individual axes may be noted from the diagram (>>> Fig. 4-1).

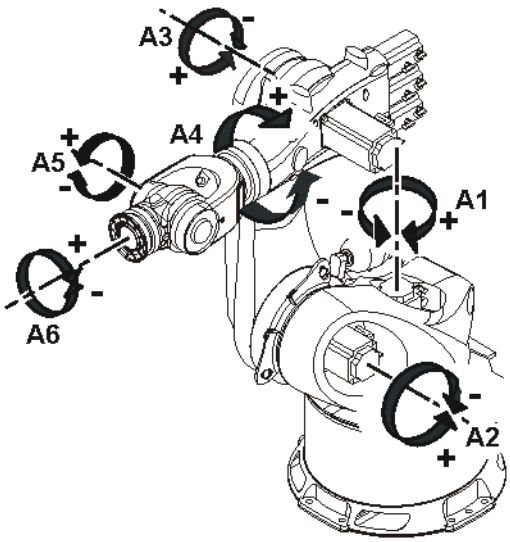

Fig. 4-1: Direction of rotation of robot axes

Working envelope

The diagram (>>> Fig. 4-2) shows the load center of gravity, shape and size of the working envelope.

The reference point for the working envelope is the intersection of axis 4 with axis 5.

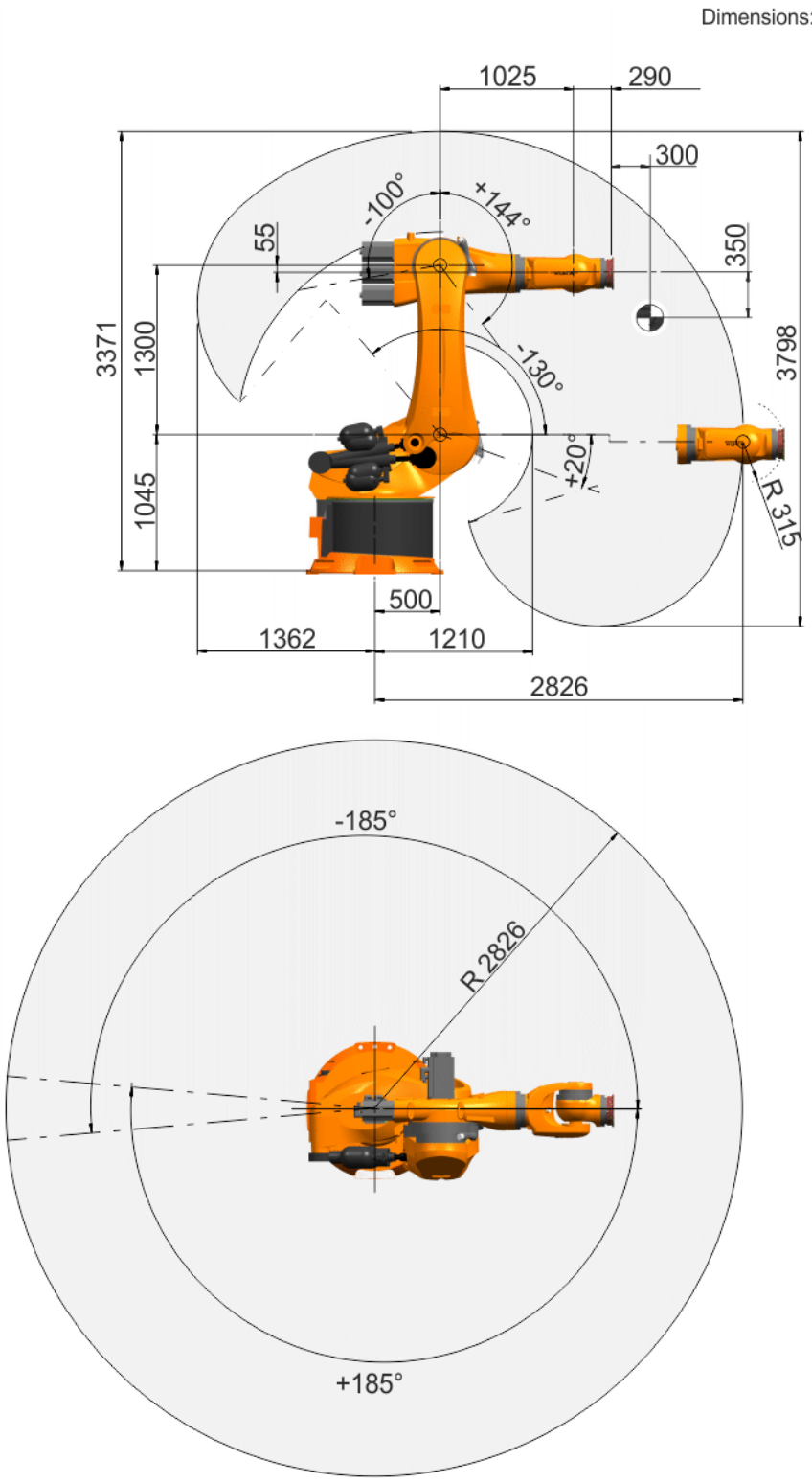

Fig. 4-2: Working envelope KR 500 R2830 (with F variant)

4.2.3 Payloads, KR 500 R2830

Payloads

Rated payload	500 kg
Rated mass moment of inertia	250 kgm²
Rated total load	550 kg
Rated supplementary load, base frame	0 kg

Maximum supplementary load, base frame	0 kg
Rated supplementary load, rotating column	0 kg
Maximum supplementary load, rotating column	400 kg
Rated supplementary load, link arm	0 kg
Maximum supplementary load, link arm	100 kg
Rated supplementary load, arm	50 kg
Maximum supplementary load, arm	100 kg
Nominal distance to load center of gravity	
Lxy	350 mm
Lz	300 mm

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

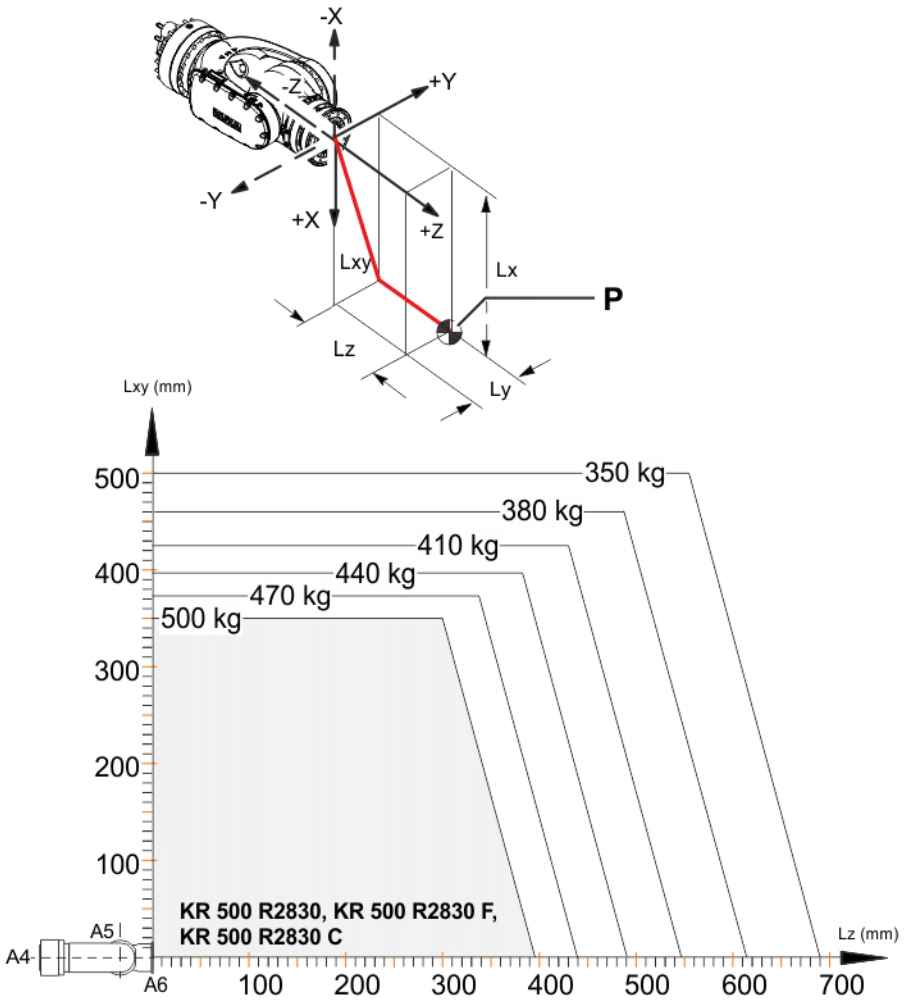

Fig. 4-3: Payload diagram KR 500 R2830 (with F and C variants)

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 the 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!

In-line wrist

In-line wrist type	ZH500-4
Mounting flange	-

Mounting flange

Screw grade	12.9
Screw size	M12
Grip length	1.5 x nominal diameter
Depth of engagement	min. 15 mm, max. 18.5 mm
Locating element	12 ^{H7}

The mounting flange is depicted (>>> Fig. 4-4) with axis 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

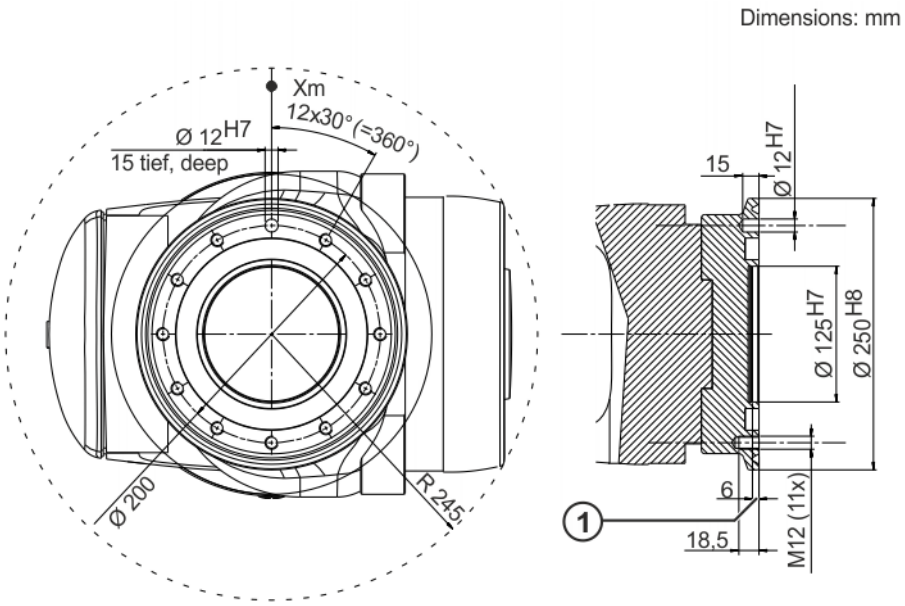

Fig. 4-4: Mounting flange

1 Fitting length

4.2.4 Loads acting on the foundation, KR 500 R2830

Loads acting on the foundation

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

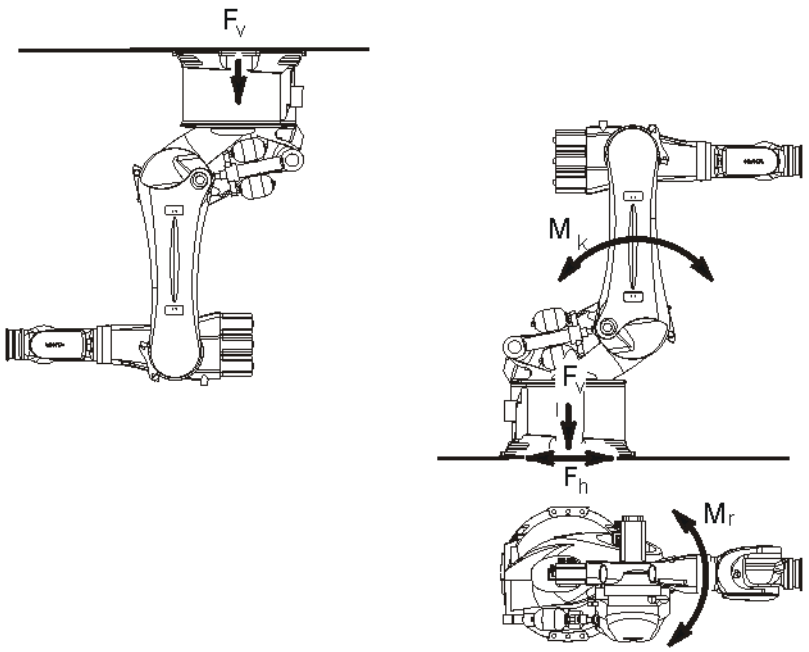

Fig. 4-5: Loads acting on the mounting base

Vertical force	40500 N
Horizontal force	23500 N
Tilting moment	84500 Nm
Torque about axis 1	45500 Nm

NOTICE The mounting base loads specified in the table are the maximum loads that may occur. They must be referred to when dimensioning the mounting bases and must be adhered to for safety reasons.
The supplementary loads are not taken into consideration in the calculation of the foundation load. These supplementary loads must be taken into consideration for F_v.

4.3 Technical data, KR 500 R2830 F

4.3.1 Basic data, KR 500 R2830 F

Basic data

	KR 500 R2830 F
Number of axes	6
Number of controlled axes	6
Work envelope volume	68 m³
Pose repeatability (ISO 9283)	± 0.08 mm
Weight	approx. 2385 kg
Rated payload	500 kg
Maximum reach	2826 mm
Protection rating	IP 65
Protection rating, in-line wrist	IP 67
Sound level	< 75 dB (A)
Mounting position	Floor
Robot footprint	-
Permissible angle of inclination	≤ 5 °

	KR 500 R2830 F
Default color	Base frame: black (RAL 9005); Moving parts: KUKA orange 2567
Controller	KR C4

Ambient conditions

Humidity class	3k3, DIN EN 60721-3-3
Ambient temperature	
During operation	10 °C to 55 °C (283 K to 328 K)
During storage/transportation	-40 °C to 60 °C (233 K to 333 K)

Foundry robots

Overpressure in the arm	0.01 MPa (0.1 bar)
Compressed air	Free of oil and water
Compressed air supply line	Air line in the cable set
Air consumption	0.1 m^3/h
Air line connection	Quick Star push-in fitting for hose PUN-6x1, blue
Pressure regulator connection	R 1/8", internal thread
Input pressure	0.1 - 1.2 MPa (1 - 12 bar)
Pressure regulator	0.005 - 0.07 MPa (0.05 - 0.7 bar)
Manometer range	0.0 - 0.1 MPa (0.0 - 1.0 bar)
Filter gauge	25 - 30 µm
Thermal loading	10 s/min at 353 K (180 °C)
Resistance	Increased resistance to dust, lubricants, coolants and water vapor.
Special paint finish on wrist	Heat-resistant and heat-reflecting silver paint finish on the in-line wrist.
Special paint finish on the robot	Special paint finish on the entire robot, and an additional protective clear coat.
Other ambient conditions	KUKA Roboter GmbH must be consulted if the robot is to be used under other ambient conditions.

Connecting cables

Cable designation	Connector designation	Interface with robot
Motor cable	X20.1 - X30.1	Harting connectors at both ends
Motor cable	X20.4 - X30.4	Harting connectors at both ends
Control cable	X21 - X31	HAN 3A EMC at both ends
Ground conductor / equipotential bonding 16 mm^2 (optional)		M8 ring cable lug at both ends

Cable lengths	
Standard	7 m, 15 m, 25 m, 35 m, 50 m

For detailed specifications of the connecting cables, see (>>> 8.6 "Description of the connecting cables" Page 115).

4.3.2 Axis data, KR 500 R2830 F

Axis data

Range of motion	
A1	±185 °
A2	20 ° / -130 °
A3	144 ° / -100 °
A4	±350 °
A5	±120 °
A6	±350 °
Speed with rated payload	
A1	90 °/s
A2	80 °/s
A3	75 °/s
A4	90 °/s
A5	83 °/s
A6	130 °/s

The direction of motion and the arrangement of the individual axes may be noted from the diagram (>>> Fig. 4-6).

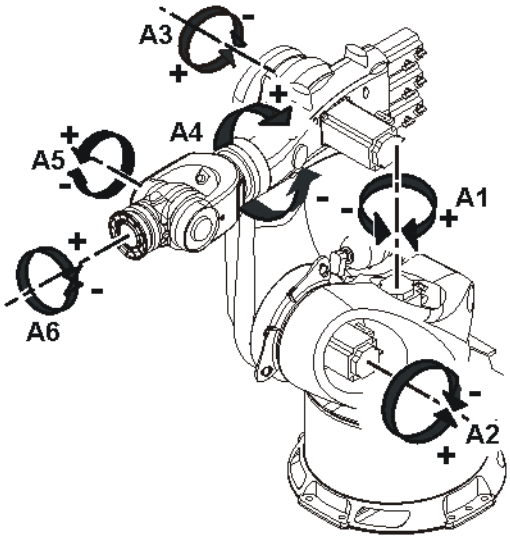

Fig. 4-6: Direction of rotation of robot axes

Working envelope

The diagram (>>> Fig. 4-7) shows the load center of gravity, shape and size of the working envelope.

The reference point for the working envelope is the intersection of axis 4 with axis 5.

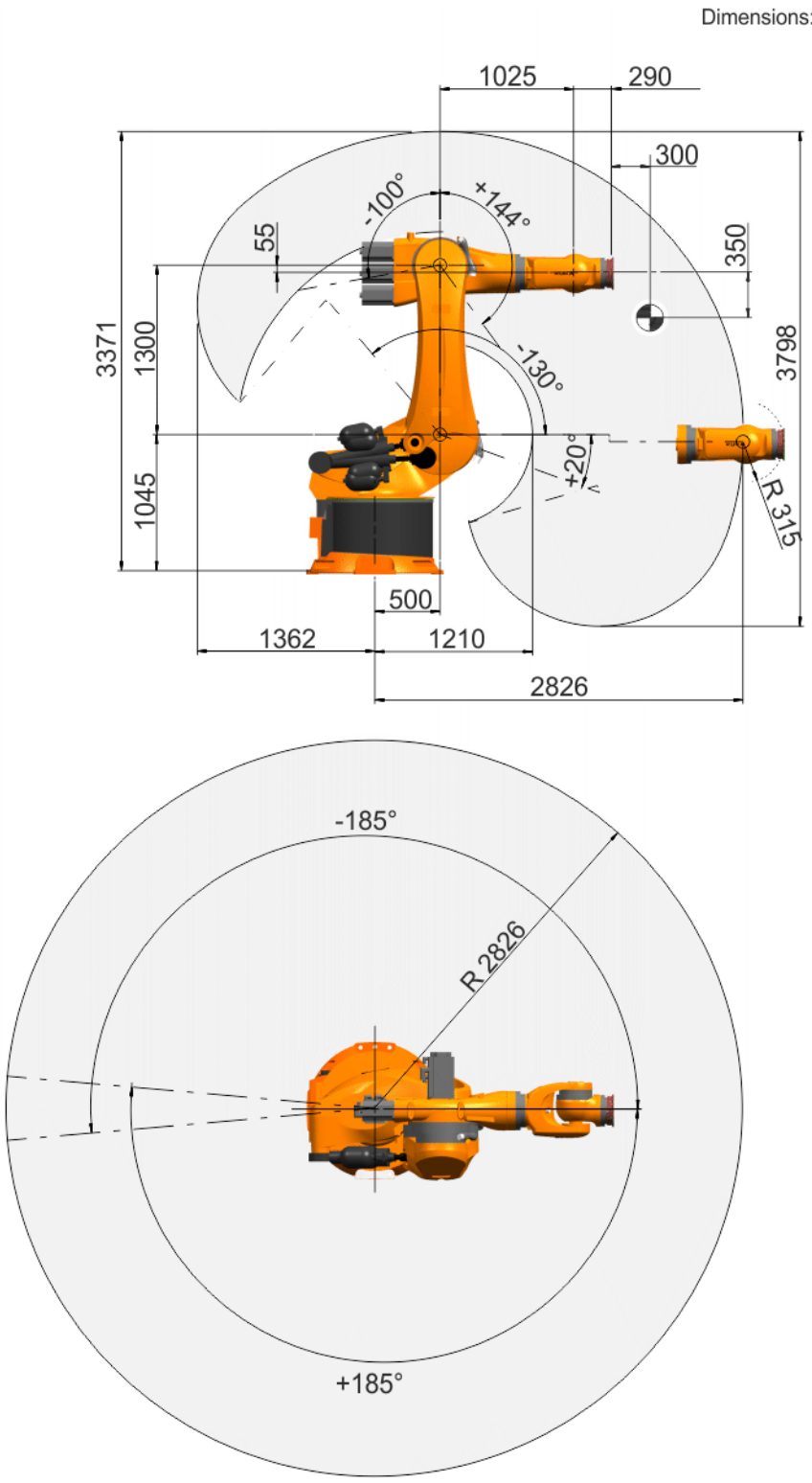

Fig. 4-7: Working envelope KR 500 R2830 (with F variant)

4.3.3 Payloads, KR 500 R2830 F

Payloads

Rated payload	500 kg
Rated mass moment of inertia	250 kgm²
Rated total load	550 kg
Rated supplementary load, base frame	0 kg

Maximum supplementary load, base frame	0 kg
Rated supplementary load, rotating column	0 kg
Maximum supplementary load, rotating column	400 kg
Rated supplementary load, link arm	0 kg
Maximum supplementary load, link arm	100 kg
Rated supplementary load, arm	50 kg
Maximum supplementary load, arm	100 kg
Nominal distance to load center of gravity	
Lxy	350 mm
Lz	300 mm

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

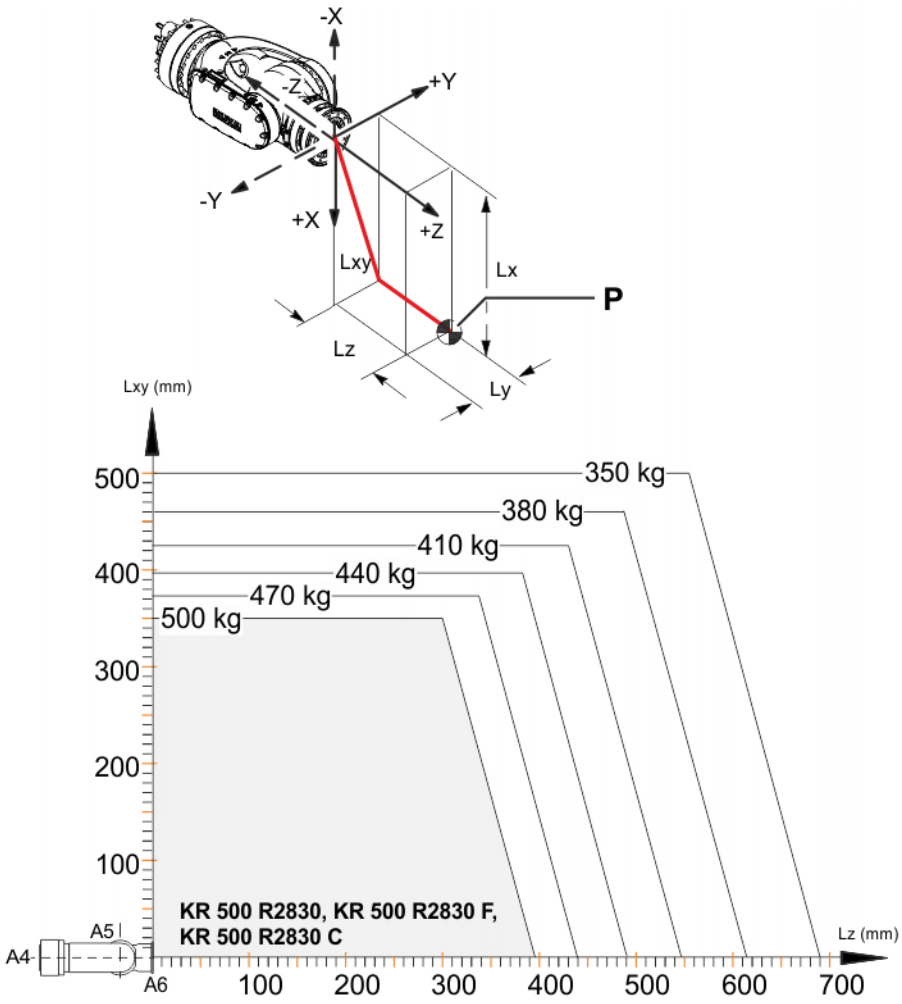

Fig. 4-8: Payload diagram KR 500 R2830 (with F and C variants)

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 the 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!

In-line wrist

In-line wrist type	ZH500-4F
Mounting flange	-

Mounting flange

Screw grade	12.9
Screw size	M12
Grip length	1.5 x nominal diameter
Depth of engagement	min. 15 mm, max. 18.5 mm
Locating element	12 ^{H7}

The mounting flange is depicted (>>> Fig. 4-9) with axis 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

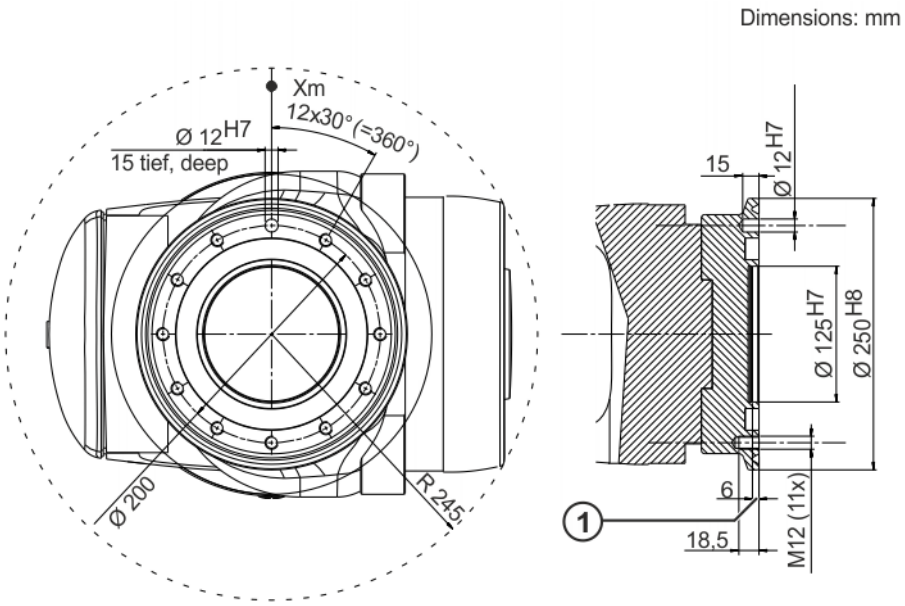

Fig. 4-9: Mounting flange

1 Fitting length

4.3.4 Loads acting on the foundation, KR 500 R2830 F

Loads acting on the foundation

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

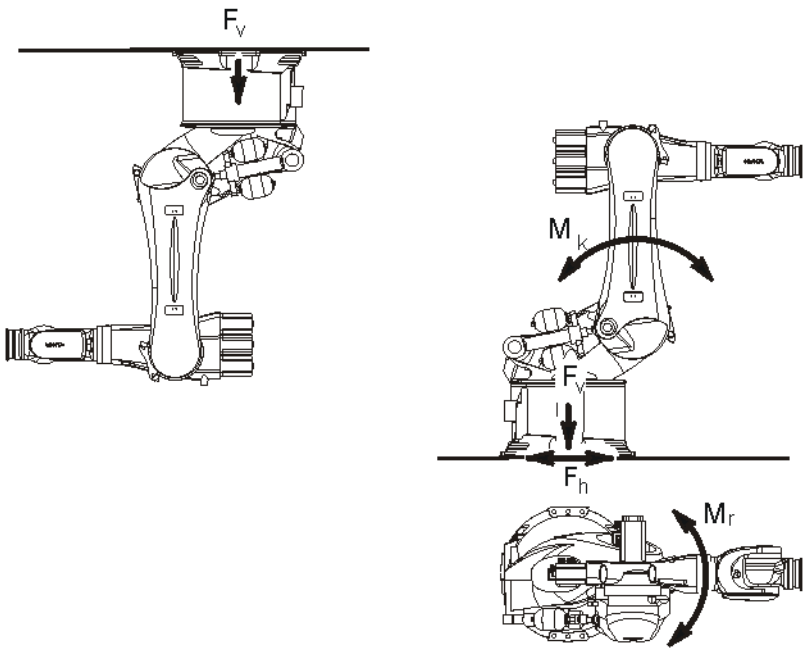

Fig. 4-10: Loads acting on the mounting base

Vertical force	40500 N
Horizontal force	23500 N
Tilting moment	84500 Nm
Torque about axis 1	45500 Nm

NOTICE The mounting base loads specified in the table are the maximum loads that may occur. They must be referred to when dimensioning the mounting bases and must be adhered to for safety reasons.
The supplementary loads are not taken into consideration in the calculation of the foundation load. These supplementary loads must be taken into consideration for F_V.

4.4 Technical data, KR 500 R2830 C

4.4.1 Basic data, KR 500 R2830 C

Basic data

	KR 500 R2830 C
Number of axes	6
Number of controlled axes	6
Work envelope volume	51 m³
Pose repeatability (ISO 9283)	± 0.08 mm
Weight	approx. 2385 kg
Rated payload	500 kg
Maximum reach	2485 mm
Protection rating	IP 65
Protection rating, in-line wrist	IP 65
Sound level	< 75 dB (A)
Mounting position	Ceiling
Robot footprint	-
Permissible angle of inclination	≤ 0 °

	KR 500 R2830 C
Default color	Base frame: black (RAL 9005); Moving parts: KUKA orange 2567
Controller	KR C4

Ambient conditions

Humidity class	3k3, DIN EN 60721-3-3
Ambient temperature	
During operation	10 °C to 55 °C (283 K to 328 K)
During storage/transportation	-40 °C to 60 °C (233 K to 333 K)

Connecting cables

Cable designation	Connector designation	Interface with robot
Motor cable	X20.1 - X30.1	Harting connectors at both ends
Motor cable	X20.4 - X30.4	Harting connectors at both ends
Control cable	X21 - X31	HAN 3A EMC at both ends
Ground conductor / equipotential bonding 16 mm^2 (optional)		M8 ring cable lug at both ends

Cable lengths	
Standard	7 m, 15 m, 25 m, 35 m, 50 m

For detailed specifications of the connecting cables, see (>>> 8.6 "Description of the connecting cables" Page 115).

4.4.2 Axis data, KR 500 R2830 C

Axis data

Range of motion	
A1	±185 °
A2	20 ° / -130 °
A3	144 ° / -100 °
A4	±350 °
A5	±120 °
A6	±350 °
Speed with rated payload	
A1	90 °/s
A2	80 °/s
A3	75 °/s
A4	90 °/s
A5	83 °/s
A6	130 °/s

The direction of motion and the arrangement of the individual axes may be noted from the diagram (>>> Fig. 4-11).

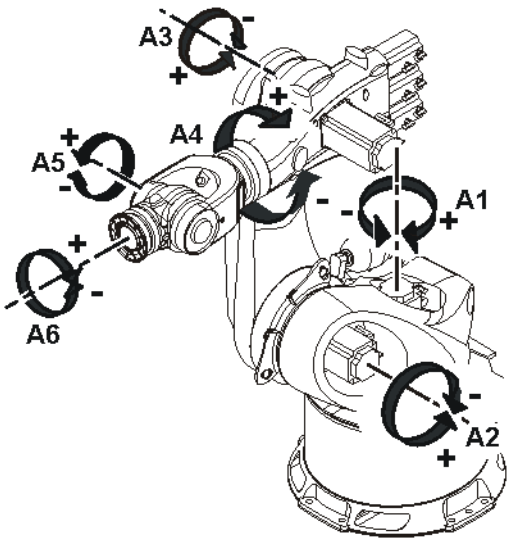

Fig. 4-11: Direction of rotation of robot axes

Working envelope

The diagram (>>> Fig. 4-12) shows the load center of gravity, shape and size of the working envelope.

The reference point for the working envelope is the intersection of axis 4 with axis 5.

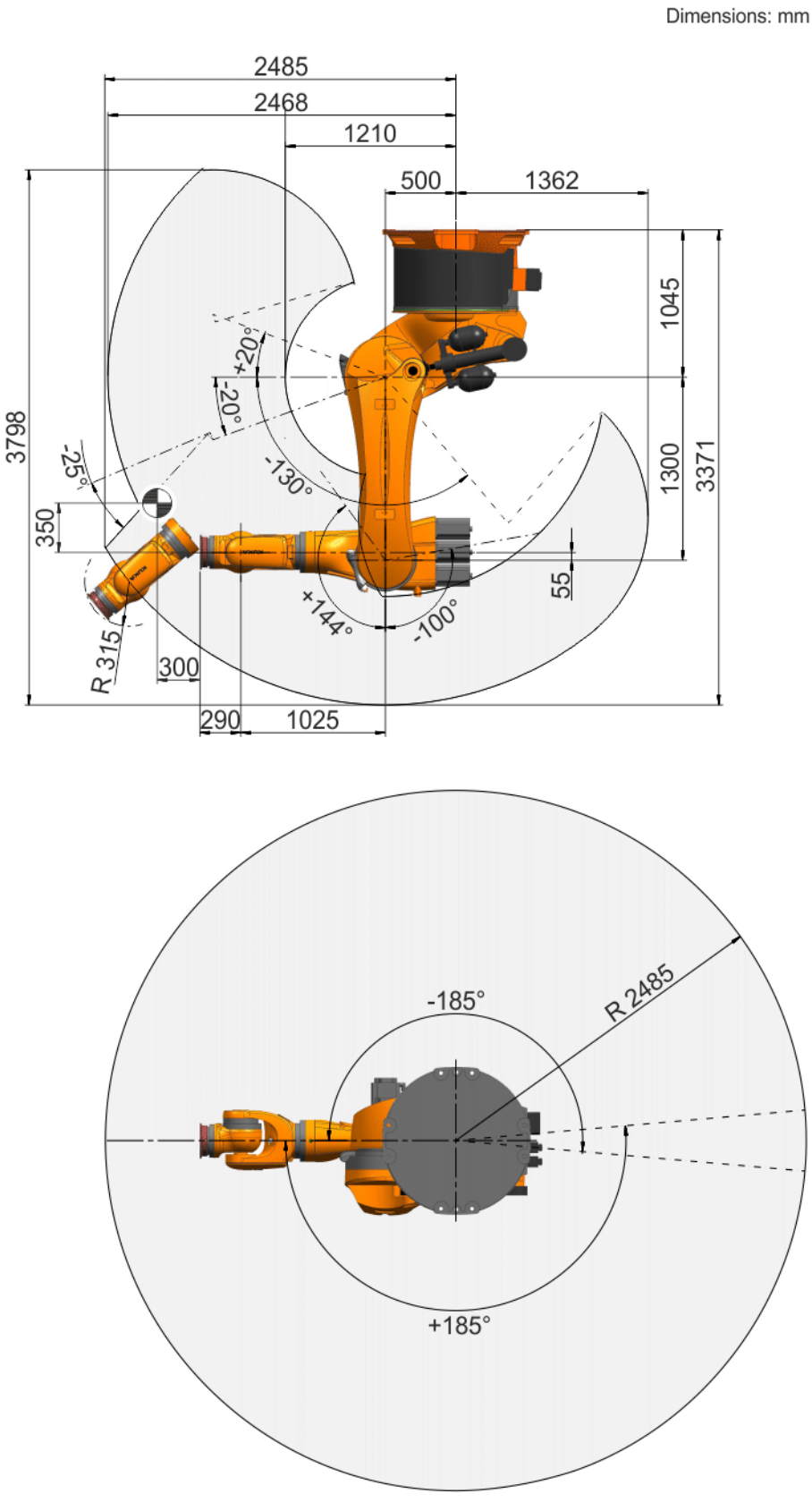

Fig. 4-12: Working envelope KR 500 R2830 C

4.4.3 Payloads, KR 500 R2830 C

Payloads

Rated payload	500 kg
Rated mass moment of inertia	250 kgm²

Rated total load	550 kg
Rated supplementary load, base frame	0 kg
Maximum supplementary load, base frame	0 kg
Rated supplementary load, rotating column	0 kg
Maximum supplementary load, rotating column	50 kg
Rated supplementary load, link arm	0 kg
Maximum supplementary load, link arm	50 kg
Rated supplementary load, arm	50 kg
Maximum supplementary load, arm	50 kg
Nominal distance to load center of gravity	
Lxy	350 mm
Lz	300 mm

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

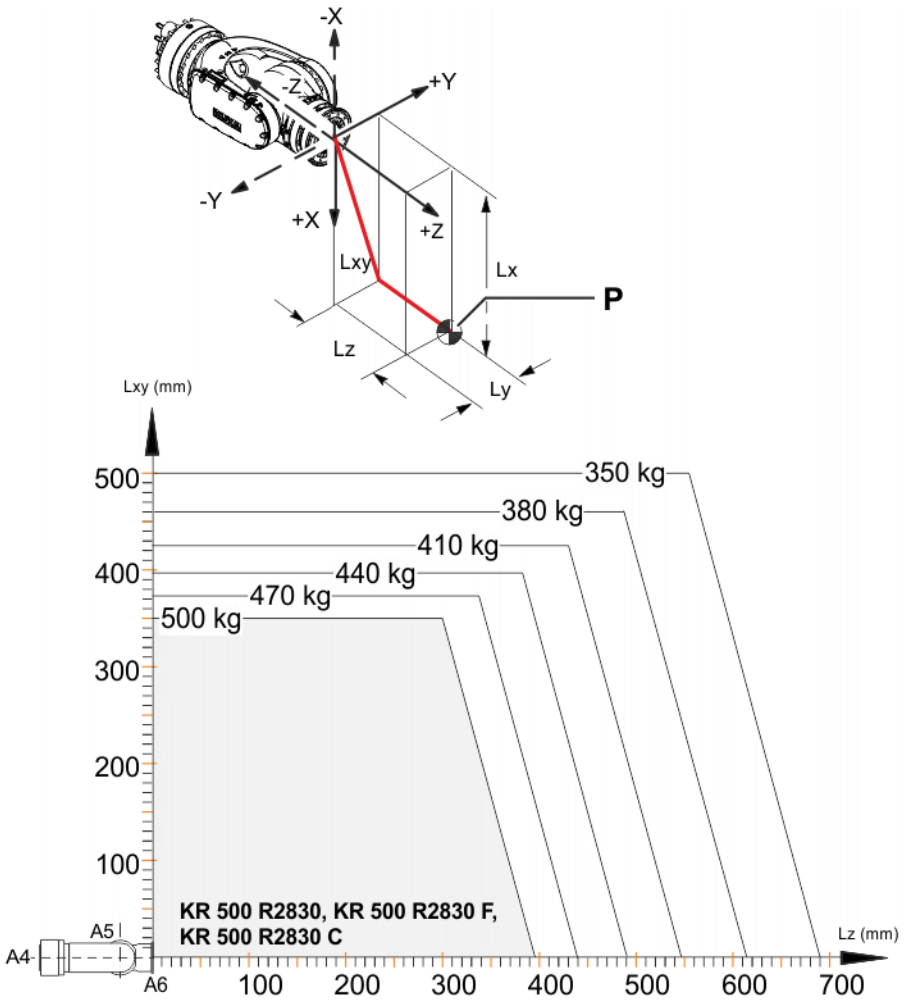

Fig. 4-13: Payload diagram KR 500 R2830 (with F and C variants)

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 the 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!

In-line wrist

In-line wrist type	ZH500-4
Mounting flange	-

Mounting flange

Screw grade	12.9
Screw size	M12
Grip length	1.5 x nominal diameter
Depth of engagement	min. 15 mm, max. 18.5 mm
Locating element	12 ^{H7}

The mounting flange is depicted (>>> Fig. 4-14) with axis 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

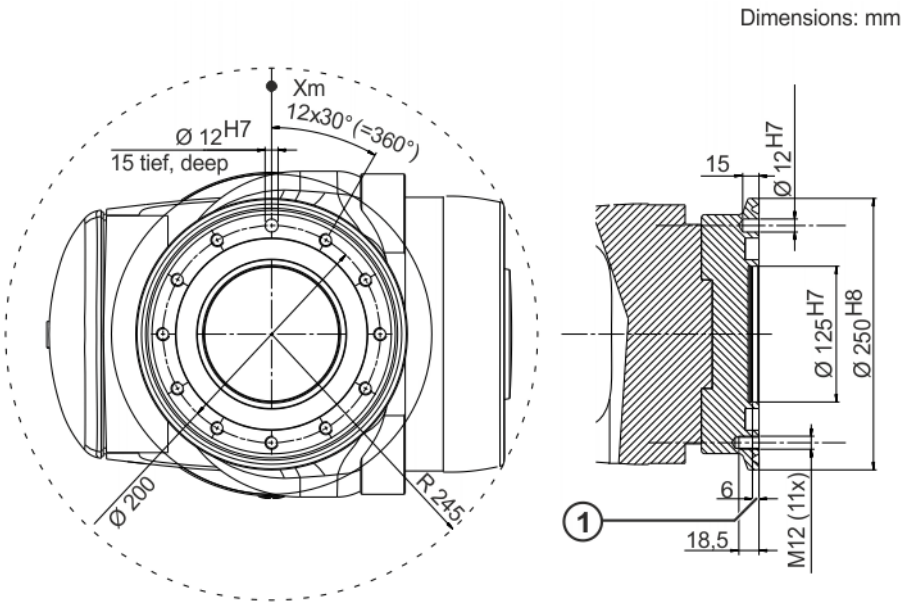

Fig. 4-14: Mounting flange

1 Fitting length

4.4.4 Loads acting on the foundation, KR 500 R2830 C

Loads acting on the foundation

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

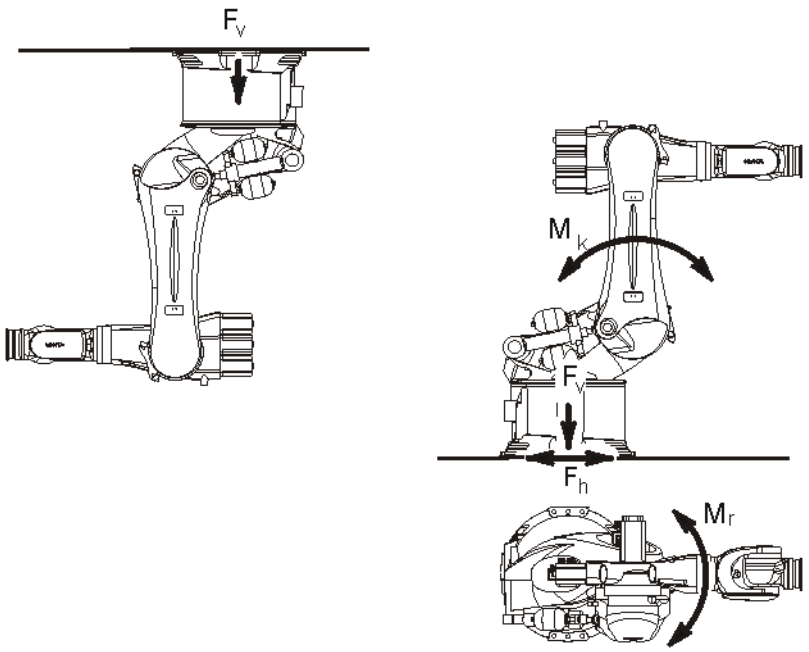

Fig. 4-15: Loads acting on the mounting base

Vertical force	40500 N
Horizontal force	23500 N
Tilting moment	84500 Nm
Torque about axis 1	45500 Nm

NOTICE The mounting base loads specified in the table are the maximum loads that may occur. They must be referred to when dimensioning the mounting bases and must be adhered to for safety reasons.
The supplementary loads are not taken into consideration in the calculation of the foundation load. These supplementary loads must be taken into consideration for F_V.

4.5 Technical data, KR 420 R3080

4.5.1 Basic data, KR 420 R3080

Basic data

	KR 420 R3080
Number of axes	6
Number of controlled axes	6
Work envelope volume	88 m³
Pose repeatability (ISO 9283)	± 0.08 mm
Weight	approx. 2415 kg
Rated payload	420 kg
Maximum reach	3076 mm
Protection rating	IP 65
Protection rating, in-line wrist	IP 65
Sound level	< 75 dB (A)
Mounting position	Floor
Robot footprint	-
Permissible angle of inclination	≤ 5 °

	KR 420 R3080
Default color	Base frame: black (RAL 9005); Moving parts: KUKA orange 2567
Controller	KR C4

Ambient conditions

Humidity class	3k3, DIN EN 60721-3-3
Ambient temperature	
During operation	10 °C to 55 °C (283 K to 328 K)
During storage/transportation	-40 °C to 60 °C (233 K to 333 K)

Connecting cables

Cable designation	Connector designation	Interface with robot
Motor cable	X20.1 - X30.1	Harting connectors at both ends
Motor cable	X20.4 - X30.4	Harting connectors at both ends
Control cable	X21 - X31	HAN 3A EMC at both ends
Ground conductor / equipotential bonding 16 mm^2 (optional)		M8 ring cable lug at both ends

Cable lengths	
Standard	7 m, 15 m, 25 m, 35 m, 50 m

For detailed specifications of the connecting cables, see (>>> 8.6 "Description of the connecting cables" Page 115).

4.5.2 Axis data, KR 420 R3080

Axis data

Range of motion	
A1	±185 °
A2	20 ° / -130 °
A3	144 ° / -100 °
A4	±350 °
A5	±120 °
A6	±350 °
Speed with rated payload	
A1	90 °/s
A2	80 °/s
A3	75 °/s
A4	90 °/s
A5	83 °/s
A6	130 °/s

The direction of motion and the arrangement of the individual axes may be noted from the diagram (>>> Fig. 4-16).

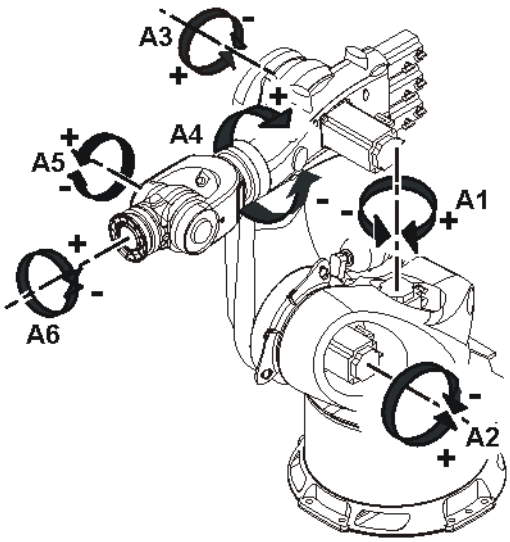

Fig. 4-16: Direction of rotation of robot axes

Working envelope

The diagram (>>> Fig. 4-17) shows the load center of gravity, shape and size of the working envelope.

The reference point for the working envelope is the intersection of axis 4 with axis 5.

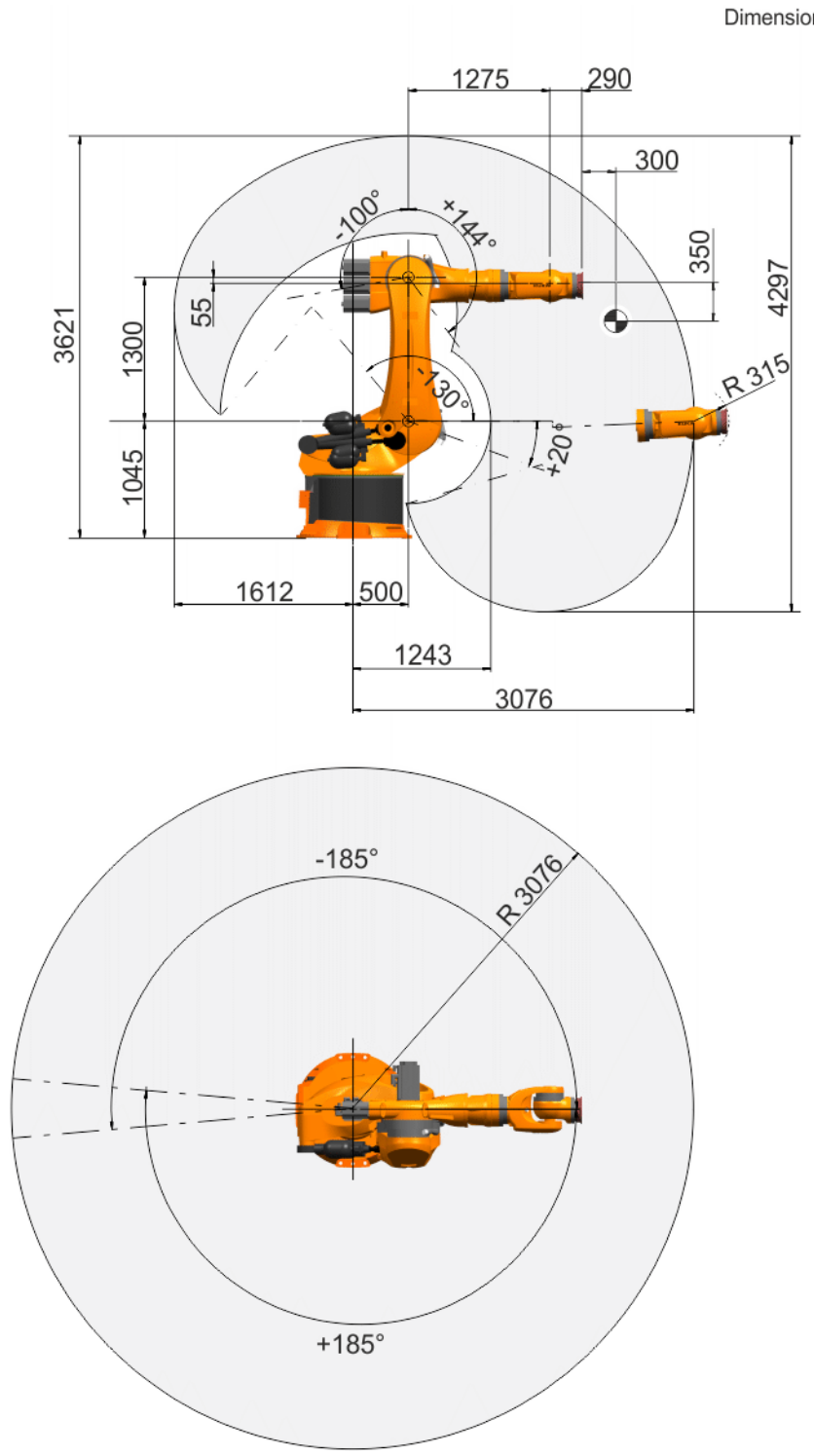

Fig. 4-17: Working envelope KR 420 R3080 (with F variant)

4.5.3 Payloads, KR 420 R3080

Payloads

Rated payload	420 kg
Rated mass moment of inertia	210 kgm²
Rated total load	470 kg
Rated supplementary load, base frame	0 kg

Maximum supplementary load, base frame	0 kg
Rated supplementary load, rotating column	0 kg
Maximum supplementary load, rotating column	400 kg
Rated supplementary load, link arm	0 kg
Maximum supplementary load, link arm	100 kg
Rated supplementary load, arm	50 kg
Maximum supplementary load, arm	100 kg
Nominal distance to load center of gravity	
Lxy	350 mm
Lz	300 mm

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

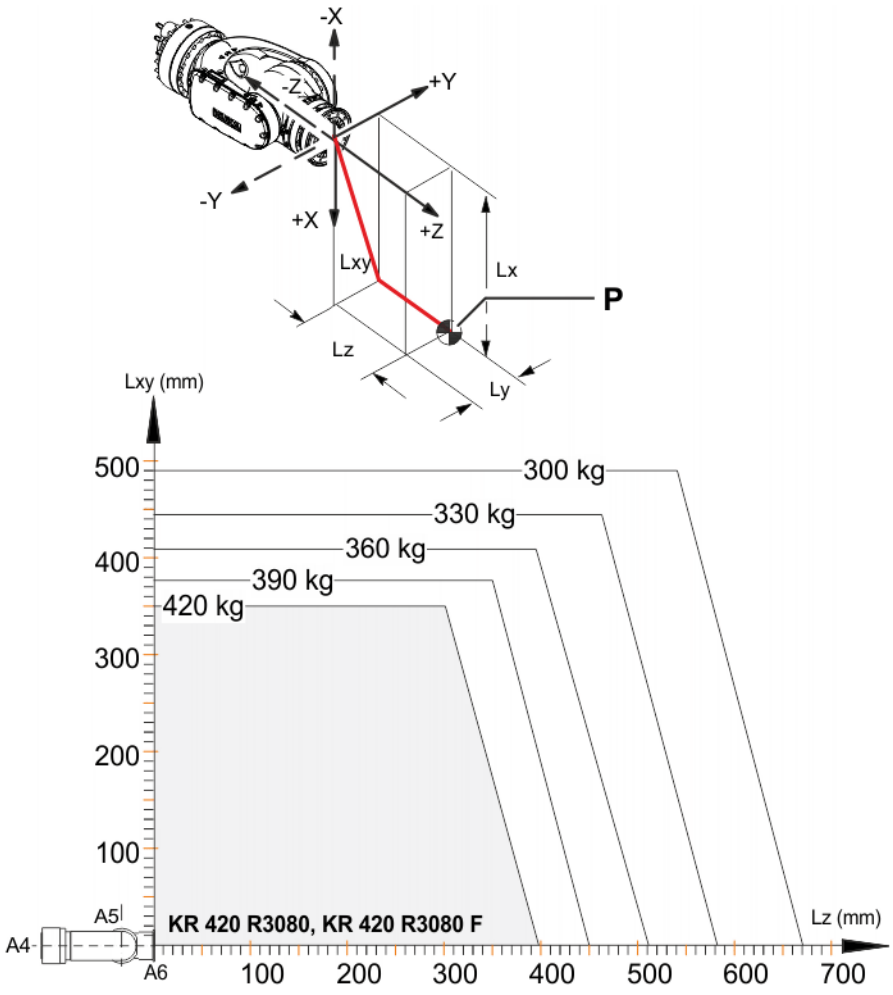

Fig. 4-18: Payload diagram KR 420 R3080 (with F variant)

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 the 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!

In-line wrist

In-line wrist type	ZH500-4
Mounting flange	-

Mounting flange

Screw grade	12.9
Screw size	M12
Grip length	1.5 x nominal diameter
Depth of engagement	min. 15 mm, max. 18.5 mm
Locating element	12 ^{H7}

The mounting flange is depicted (>>> Fig. 4-19) with axis 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

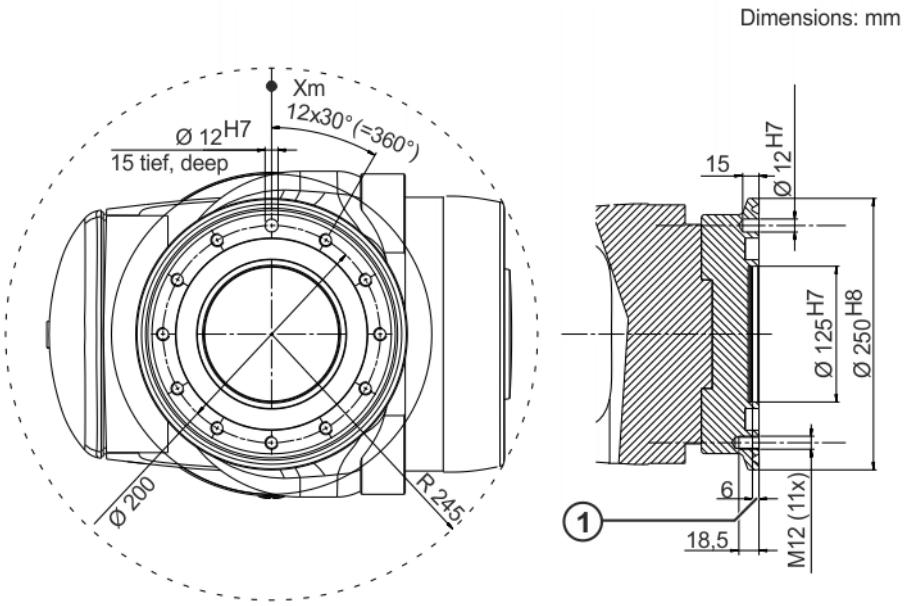

Fig. 4-19: Mounting flange

1 Fitting length

4.5.4 Loads acting on the foundation, KR 420 R3080

Loads acting on the foundation

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

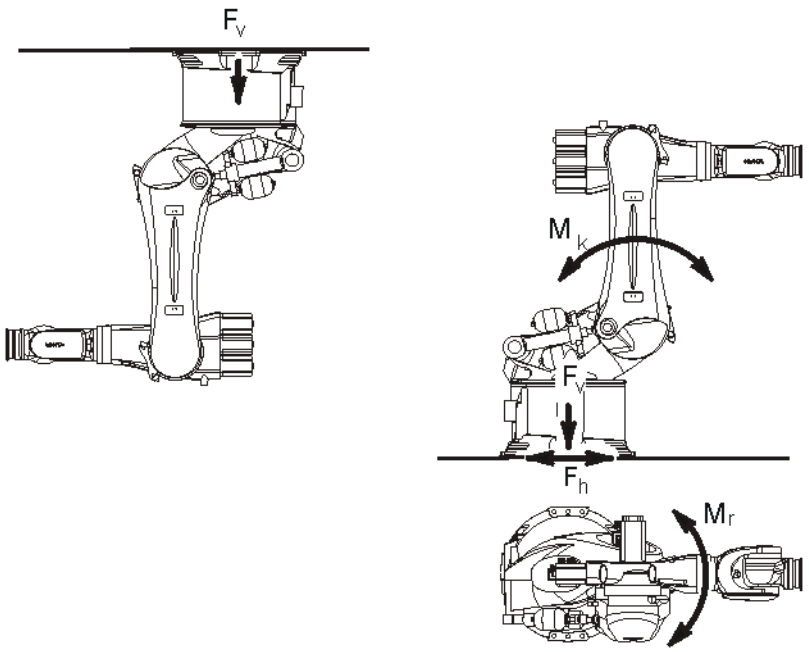

Fig. 4-20: Loads acting on the mounting base

Vertical force	40500 N
Horizontal force	23500 N
Tilting moment	84500 Nm
Torque about axis 1	45500 Nm

NOTICE The mounting base loads specified in the table are the maximum loads that may occur. They must be referred to when dimensioning the mounting bases and must be adhered to for safety reasons.
The supplementary loads are not taken into consideration in the calculation of the foundation load. These supplementary loads must be taken into consideration for F_V.

4.6 Technical data, KR 420 R3080 F

4.6.1 Basic data, KR 420 R3080 F

Basic data

	KR 420 R3080 F
Number of axes	6
Number of controlled axes	6
Work envelope volume	88 m³
Pose repeatability (ISO 9283)	± 0.08 mm
Weight	approx. 2415 kg
Rated payload	420 kg
Maximum reach	3076 mm
Protection rating	IP 65
Protection rating, in-line wrist	IP 67
Sound level	< 75 dB (A)
Mounting position	Floor
Robot footprint	-
Permissible angle of inclination	≤ 5 °

	KR 420 R3080 F
Default color	Base frame: black (RAL 9005); Moving parts: KUKA orange 2567
Controller	KR C4

Ambient conditions

Humidity class	3k3, DIN EN 60721-3-3
Ambient temperature	
During operation	10 °C to 55 °C (283 K to 328 K)
During storage/transportation	-40 °C to 60 °C (233 K to 333 K)

Foundry robots

Overpressure in the arm	0.01 MPa (0.1 bar)
Compressed air	Free of oil and water
Compressed air supply line	Air line in the cable set
Air consumption	0.1 m^3/h
Air line connection	Quick Star push-in fitting for hose PUN-6x1, blue
Pressure regulator connection	R 1/8", internal thread
Input pressure	0.1 - 1.2 MPa (1 - 12 bar)
Pressure regulator	0.005 - 0.07 MPa (0.05 - 0.7 bar)
Manometer range	0.0 - 0.1 MPa (0.0 - 1.0 bar)
Filter gauge	25 - 30 µm
Thermal loading	10 s/min at 353 K (180 °C)
Resistance	Increased resistance to dust, lubricants, coolants and water vapor.
Special paint finish on wrist	Heat-resistant and heat-reflecting silver paint finish on the in-line wrist.
Special paint finish on the robot	Special paint finish on the entire robot, and an additional protective clear coat.
Other ambient conditions	KUKA Roboter GmbH must be consulted if the robot is to be used under other ambient conditions.

Connecting cables

Cable designation	Connector designation	Interface with robot
Motor cable	X20.1 - X30.1	Harting connectors at both ends
Motor cable	X20.4 - X30.4	Harting connectors at both ends
Control cable	X21 - X31	HAN 3A EMC at both ends
Ground conductor / equipotential bonding 16 mm^2 (optional)		M8 ring cable lug at both ends

Cable lengths	
Standard	7 m, 15 m, 25 m, 35 m, 50 m

For detailed specifications of the connecting cables, see (>>> 8.6 "Description of the connecting cables" Page 115).

4.6.2 Axis data, KR 420 R3080 F

Axis data

Range of motion	
A1	±185 °
A2	20 ° / -130 °
A3	144 ° / -100 °
A4	±350 °
A5	±120 °
A6	±350 °
Speed with rated payload	
A1	90 °/s
A2	80 °/s
A3	75 °/s
A4	90 °/s
A5	83 °/s
A6	130 °/s

The direction of motion and the arrangement of the individual axes may be noted from the diagram (>>> Fig. 4-21).

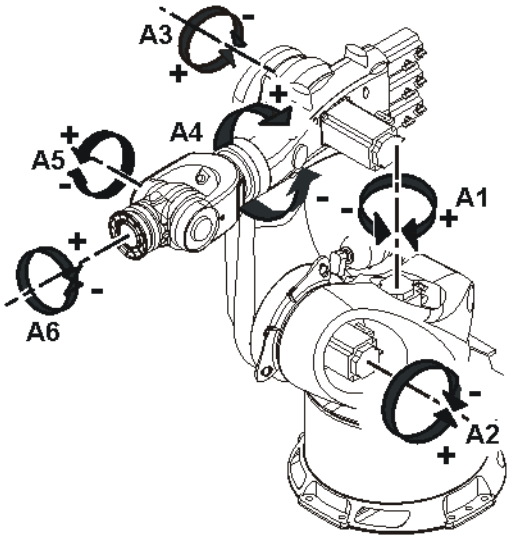

Fig. 4-21: Direction of rotation of robot axes

Working envelope

The diagram (>>> Fig. 4-22) shows the load center of gravity, shape and size of the working envelope.

The reference point for the working envelope is the intersection of axis 4 with axis 5.

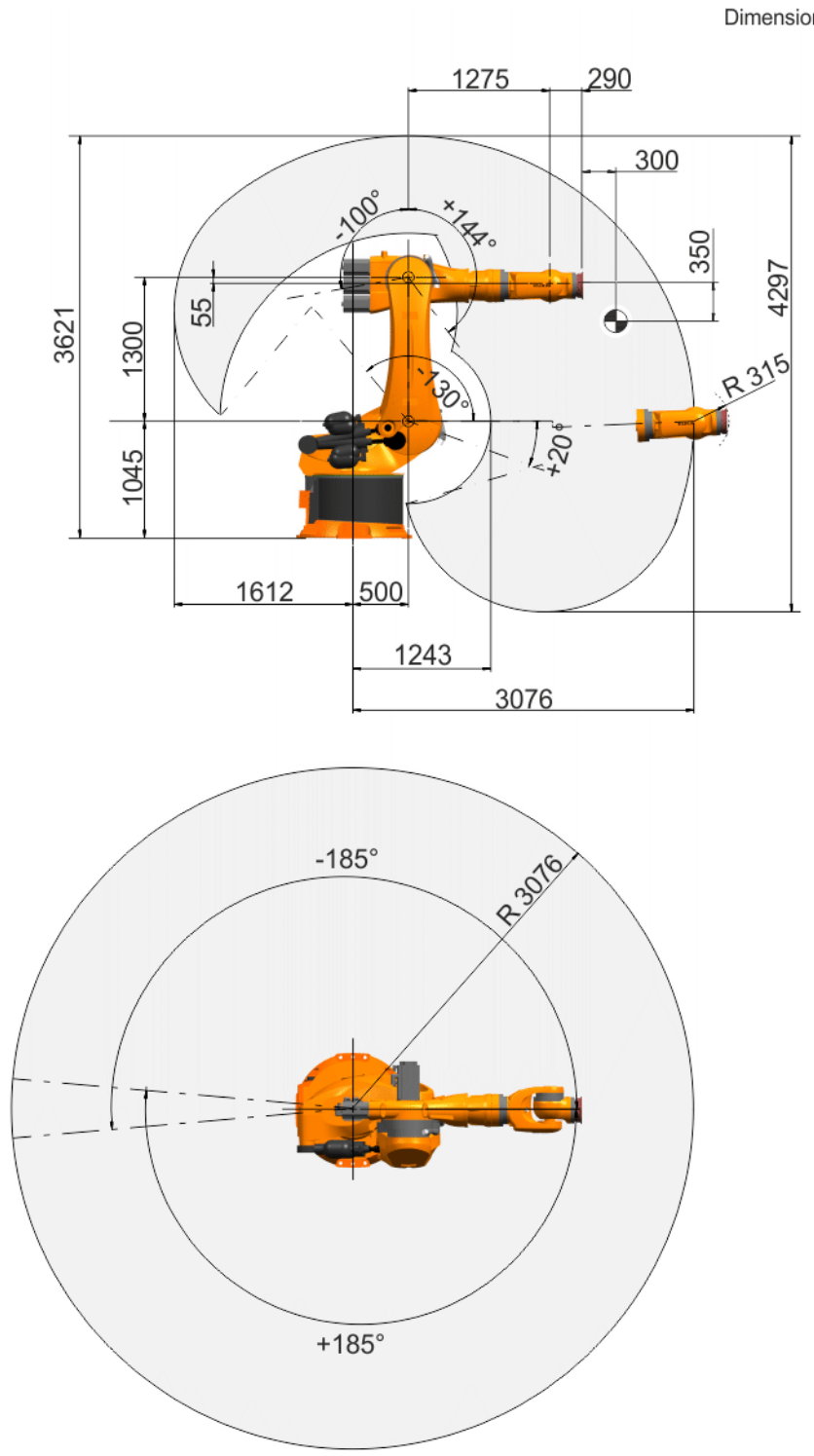

Fig. 4-22: Working envelope KR 420 R3080 (with F variant)

4.6.3 Payloads, KR 420 R3080 F

Payloads

Rated payload	420 kg
Rated mass moment of inertia	210 kgm²
Rated total load	470 kg
Rated supplementary load, base frame	0 kg

Maximum supplementary load, base frame	0 kg
Rated supplementary load, rotating column	0 kg
Maximum supplementary load, rotating column	400 kg
Rated supplementary load, link arm	0 kg
Maximum supplementary load, link arm	100 kg
Rated supplementary load, arm	50 kg
Maximum supplementary load, arm	100 kg
Nominal distance to load center of gravity	
Lxy	350 mm
Lz	300 mm

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

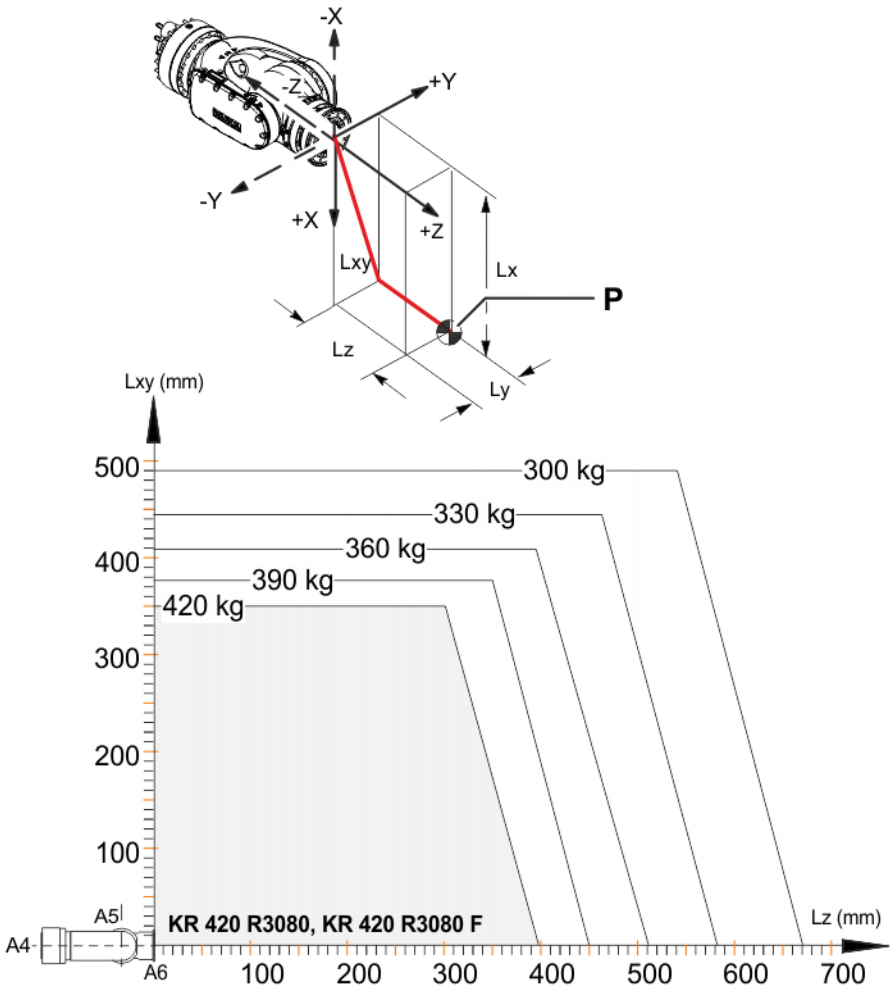

Fig. 4-23: Payload diagram KR 420 R3080 (with F variant)

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 the 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!

In-line wrist

In-line wrist type	ZH500-4F
Mounting flange	-

Mounting flange

Screw grade	12.9
Screw size	M12
Grip length	1.5 x nominal diameter
Depth of engagement	min. 15 mm, max. 18.5 mm
Locating element	12 ^{H7}

The mounting flange is depicted (>>> Fig. 4-24) with axis 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

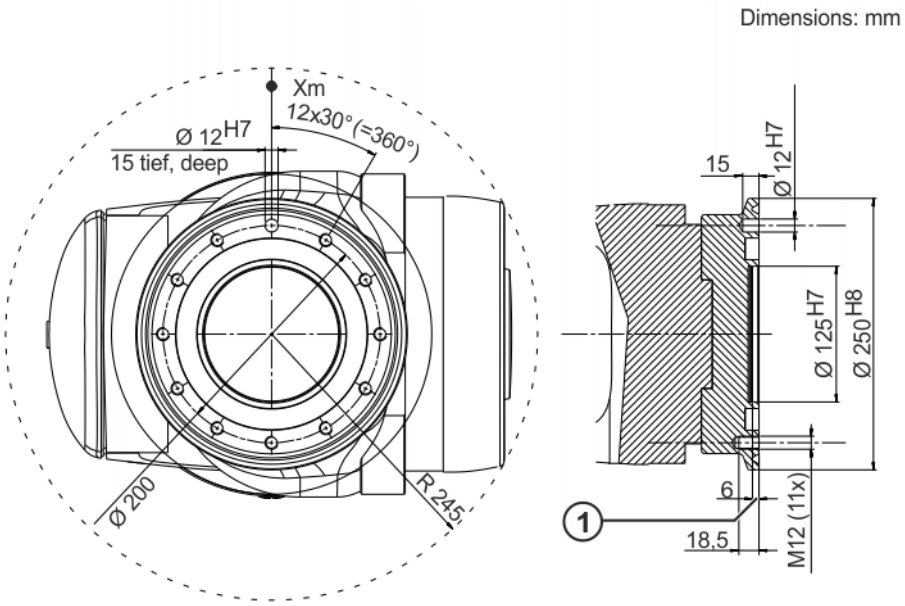

Fig. 4-24: Mounting flange

1 Fitting length

4.6.4 Loads acting on the foundation, KR 420 R3080 F

Loads acting on the foundation

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

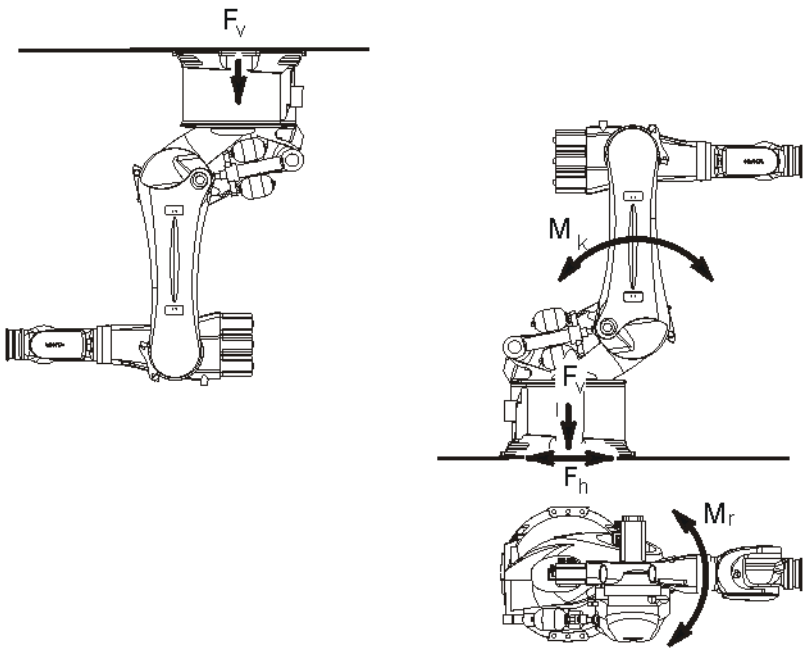

Fig. 4-25: Loads acting on the mounting base

Vertical force	40500 N
Horizontal force	23500 N
Tilting moment	84500 Nm
Torque about axis 1	45500 Nm

NOTICE The mounting base loads specified in the table are the maximum loads that may occur. They must be referred to when dimensioning the mounting bases and must be adhered to for safety reasons.
The supplementary loads are not taken into consideration in the calculation of the foundation load. These supplementary loads must be taken into consideration for F_V.

4.7 Technical data, KR 340 R3330

4.7.1 Basic data, KR 340 R3330

Basic data

	KR 340 R3330
Number of axes	6
Number of controlled axes	6
Work envelope volume	114.5 m³
Pose repeatability (ISO 9283)	± 0.08 mm
Weight	approx. 2421 kg
Rated payload	340 kg
Maximum reach	3326 mm
Protection rating	IP 65
Protection rating, in-line wrist	IP 65
Sound level	< 75 dB (A)
Mounting position	Floor
Robot footprint	-
Permissible angle of inclination	≤ 5 °

	KR 340 R3330
Default color	Base frame: black (RAL 9005); Moving parts: KUKA orange 2567
Controller	KR C4

Ambient conditions

Humidity class	3k3, DIN EN 60721-3-3
Ambient temperature	
During operation	10 °C to 55 °C (283 K to 328 K)
During storage/transportation	-40 °C to 60 °C (233 K to 333 K)

Connecting cables

Cable designation	Connector designation	Interface with robot
Motor cable	X20.1 - X30.1	Harting connectors at both ends
Motor cable	X20.4 - X30.4	Harting connectors at both ends
Control cable	X21 - X31	HAN 3A EMC at both ends
Ground conductor / equipotential bonding 16 mm^2 (optional)		M8 ring cable lug at both ends

Cable lengths	
Standard	7 m, 15 m, 25 m, 35 m, 50 m

For detailed specifications of the connecting cables, see (>>> 8.6 "Description of the connecting cables" Page 115).

4.7.2 Axis data, KR 340 R3330

Axis data

Range of motion	
A1	±185 °
A2	20 ° / -130 °
A3	144 ° / -100 °
A4	±350 °
A5	±120 °
A6	±350 °
Speed with rated payload	
A1	90 °/s
A2	80 °/s
A3	75 °/s
A4	90 °/s
A5	83 °/s
A6	130 °/s

The direction of motion and the arrangement of the individual axes may be noted from the diagram (>>> Fig. 4-26).

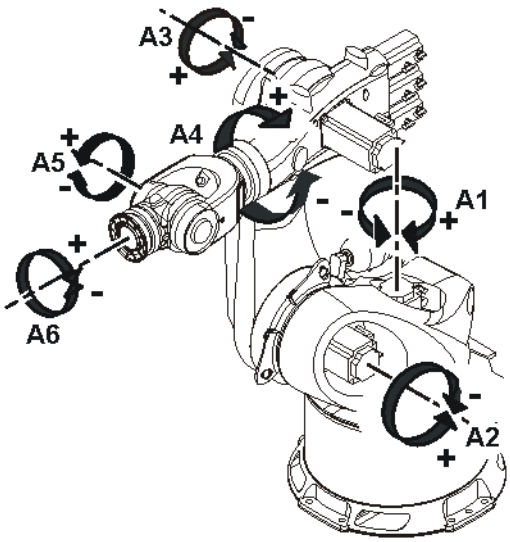

Fig. 4-26: Direction of rotation of robot axes

Working envelope

The diagram (>>> Fig. 4-27) shows the load center of gravity, shape and size of the working envelope.

The reference point for the working envelope is the intersection of axis 4 with axis 5.

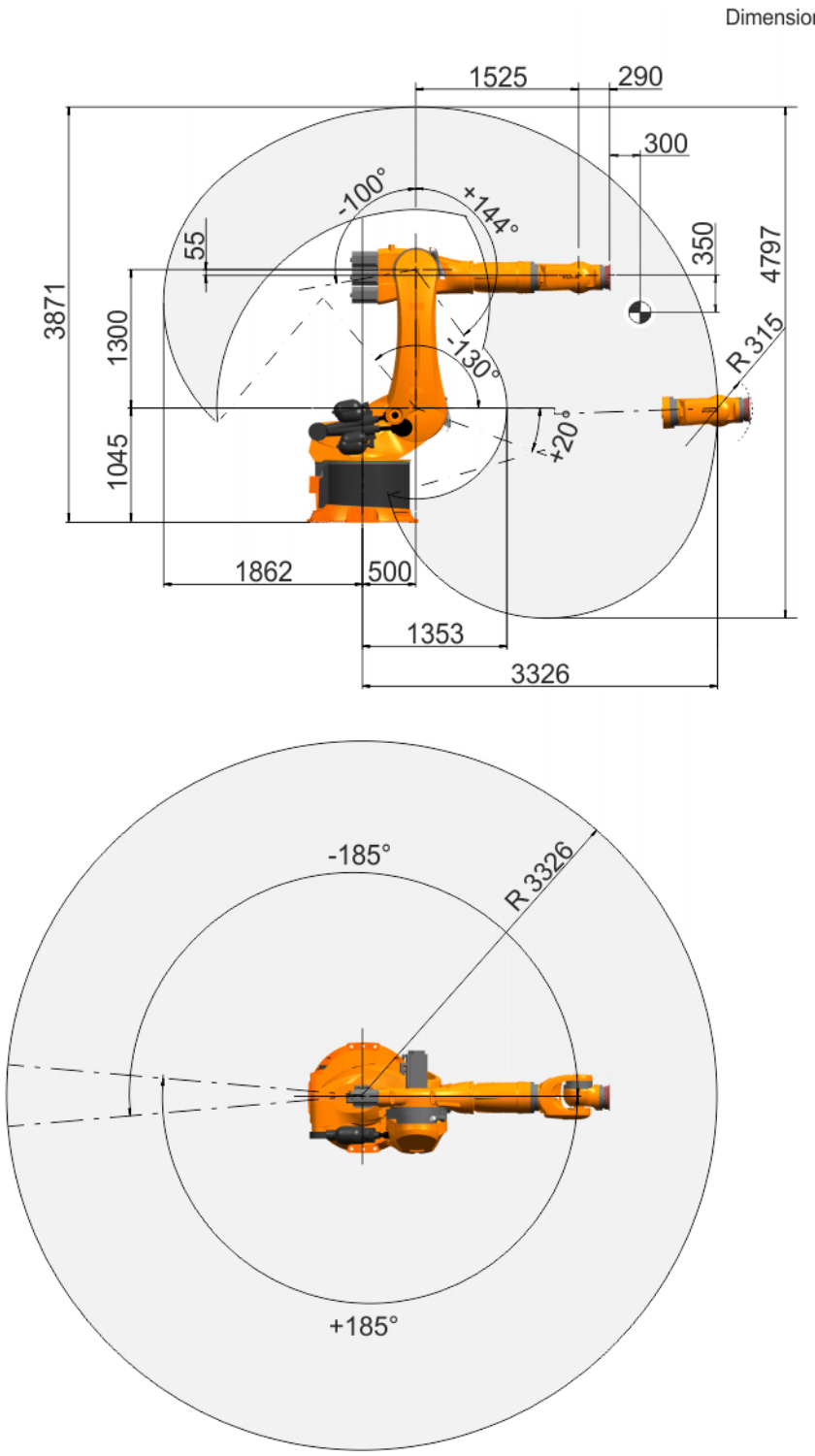

Fig. 4-27: Working envelope KR 340 R3330 (with F variant)

4.7.3 Payloads, KR 340 R3330

Payloads

Rated payload	340 kg
Rated mass moment of inertia	170 kgm²
Rated total load	390 kg
Rated supplementary load, base frame	0 kg

Maximum supplementary load, base frame	0 kg
Rated supplementary load, rotating column	0 kg
Maximum supplementary load, rotating column	400 kg
Rated supplementary load, link arm	0 kg
Maximum supplementary load, link arm	100 kg
Rated supplementary load, arm	50 kg
Maximum supplementary load, arm	100 kg
Nominal distance to load center of gravity	
Lxy	350 mm
Lz	300 mm

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

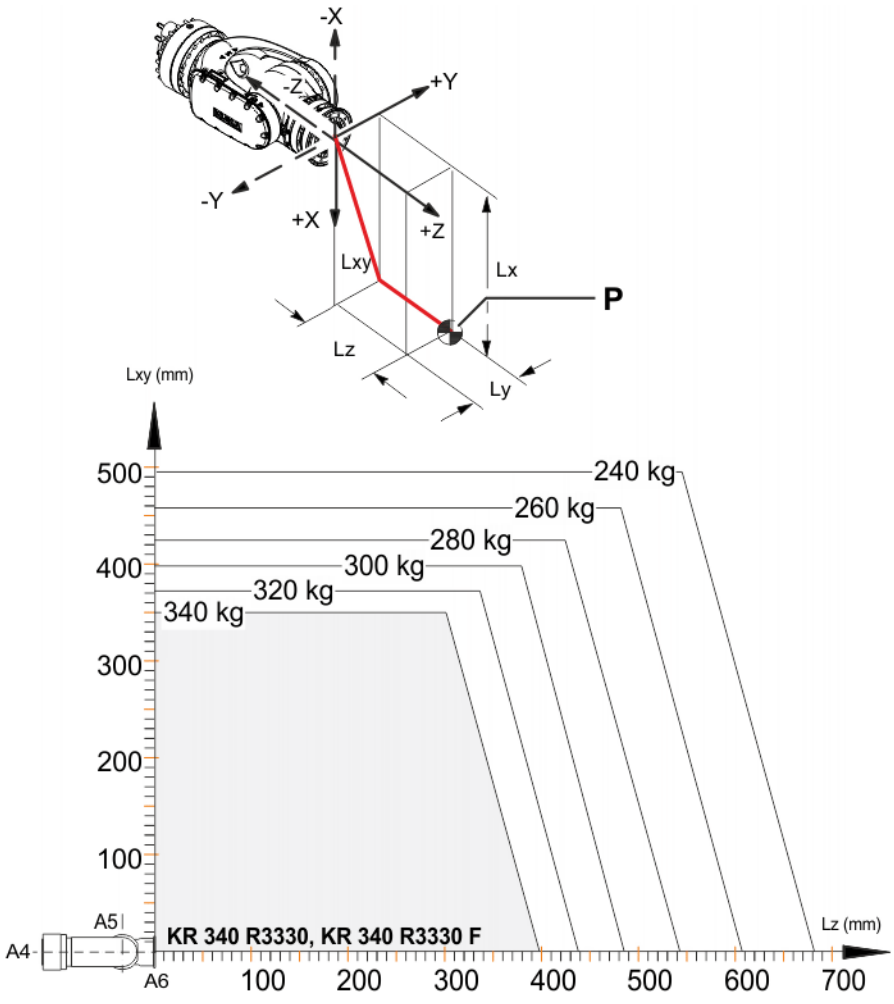

Fig. 4-28: Payload diagram KR 340 R3330 (with F variant)

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 the 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!

In-line wrist

In-line wrist type	ZH500-4
Mounting flange	-

Mounting flange

Screw grade	12.9
Screw size	M12
Grip length	1.5 x nominal diameter
Depth of engagement	min. 15 mm, max. 18.5 mm
Locating element	12 ^{H7}

The mounting flange is depicted (>>> Fig. 4-29) with axis 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

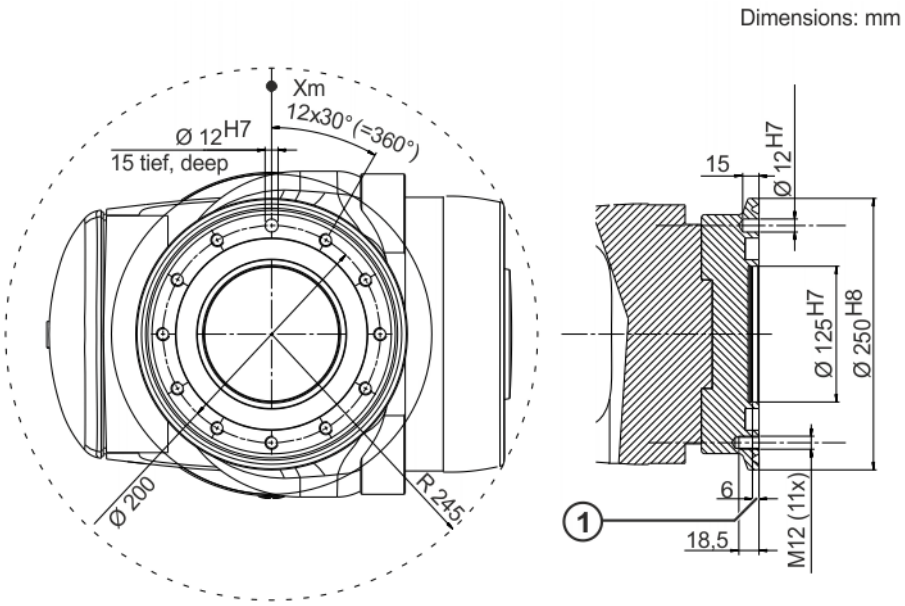

Fig. 4-29: Mounting flange

1 Fitting length

4.7.4 Loads acting on the foundation, KR 340 R3330

Loads acting on the foundation

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

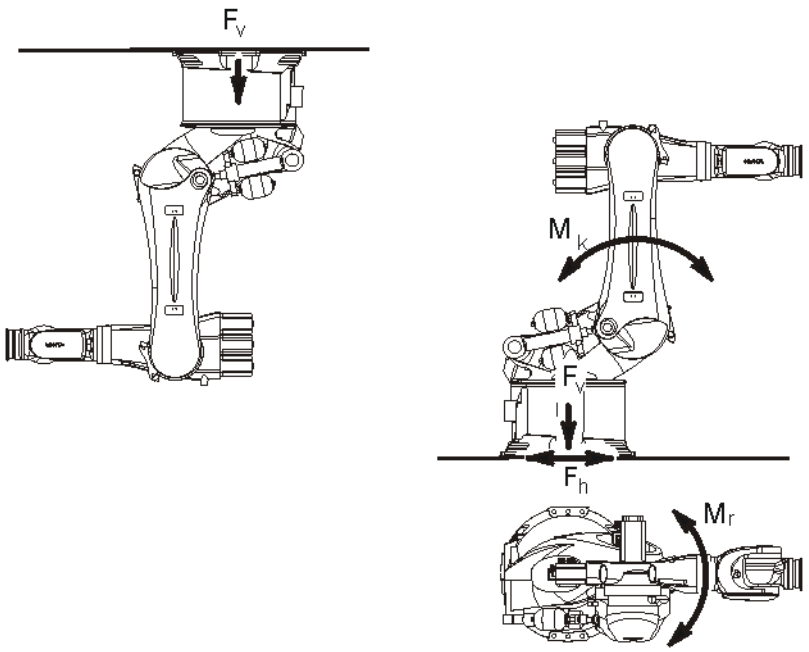

Fig. 4-30: Loads acting on the mounting base

Vertical force	40500 N
Horizontal force	23500 N
Tilting moment	84500 Nm
Torque about axis 1	45500 Nm

NOTICE The mounting base loads specified in the table are the maximum loads that may occur. They must be referred to when dimensioning the mounting bases and must be adhered to for safety reasons.
The supplementary loads are not taken into consideration in the calculation of the foundation load. These supplementary loads must be taken into consideration for F_V.

4.8 Technical data, KR 340 R3330 F

4.8.1 Basic data, KR 340 R3330 F

Basic data

	KR 340 R3330 F
Number of axes	6
Number of controlled axes	6
Work envelope volume	114.5 m³
Pose repeatability (ISO 9283)	± 0.08 mm
Weight	approx. 2421 kg
Rated payload	340 kg
Maximum reach	3326 mm
Protection rating	IP 65
Protection rating, in-line wrist	IP 67
Sound level	< 75 dB (A)
Mounting position	Floor
Robot footprint	-
Permissible angle of inclination	≤ 5 °

	KR 340 R3330 F
Default color	Base frame: black (RAL 9005); Moving parts: KUKA orange 2567
Controller	KR C4

Ambient conditions

Humidity class	3k3, DIN EN 60721-3-3
Ambient temperature	
During operation	10 °C to 55 °C (283 K to 328 K)
During storage/transportation	-40 °C to 60 °C (233 K to 333 K)

Foundry robots

Overpressure in the arm	0.01 MPa (0.1 bar)
Compressed air	Free of oil and water
Compressed air supply line	Air line in the cable set
Air consumption	0.1 m^3/h
Air line connection	Quick Star push-in fitting for hose PUN-6x1, blue
Pressure regulator connection	R 1/8", internal thread
Input pressure	0.1 - 1.2 MPa (1 - 12 bar)
Pressure regulator	0.005 - 0.07 MPa (0.05 - 0.7 bar)
Manometer range	0.0 - 0.1 MPa (0.0 - 1.0 bar)
Filter gauge	25 - 30 µm
Thermal loading	10 s/min at 353 K (180 °C)
Resistance	Increased resistance to dust, lubricants, coolants and water vapor.
Special paint finish on wrist	Heat-resistant and heat-reflecting silver paint finish on the in-line wrist.
Special paint finish on the robot	Special paint finish on the entire robot, and an additional protective clear coat.
Other ambient conditions	KUKA Roboter GmbH must be consulted if the robot is to be used under other ambient conditions.

Connecting cables

Cable designation	Connector designation	Interface with robot
Motor cable	X20.1 - X30.1	Harting connectors at both ends
Motor cable	X20.4 - X30.4	Harting connectors at both ends
Control cable	X21 - X31	HAN 3A EMC at both ends
Ground conductor / equipotential bonding 16 mm^2 (optional)		M8 ring cable lug at both ends

Cable lengths	
Standard	7 m, 15 m, 25 m, 35 m, 50 m

For detailed specifications of the connecting cables, see (>>> 8.6 "Description of the connecting cables" Page 115).

4.8.2 Axis data, KR 340 R3330 F

Axis data

Range of motion	
A1	±185 °
A2	20 ° / -130 °
A3	144 ° / -100 °
A4	±350 °
A5	±120 °
A6	±350 °
Speed with rated payload	
A1	90 °/s
A2	80 °/s
A3	75 °/s
A4	90 °/s
A5	83 °/s
A6	130 °/s

The direction of motion and the arrangement of the individual axes may be noted from the diagram (>>> Fig. 4-31).

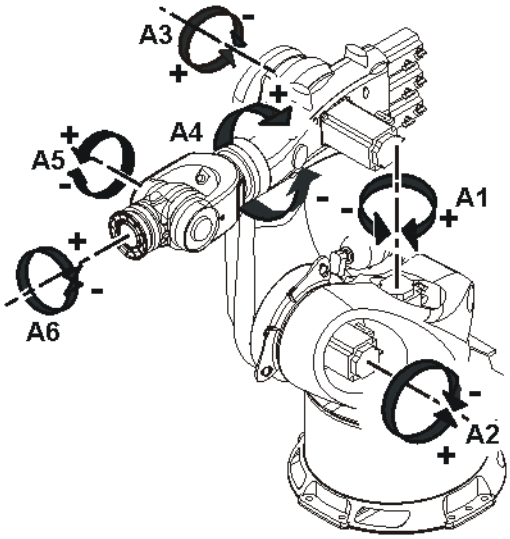

Fig. 4-31: Direction of rotation of robot axes

Working envelope

The diagram (>>> Fig. 4-32) shows the load center of gravity, shape and size of the working envelope.

The reference point for the working envelope is the intersection of axis 4 with axis 5.

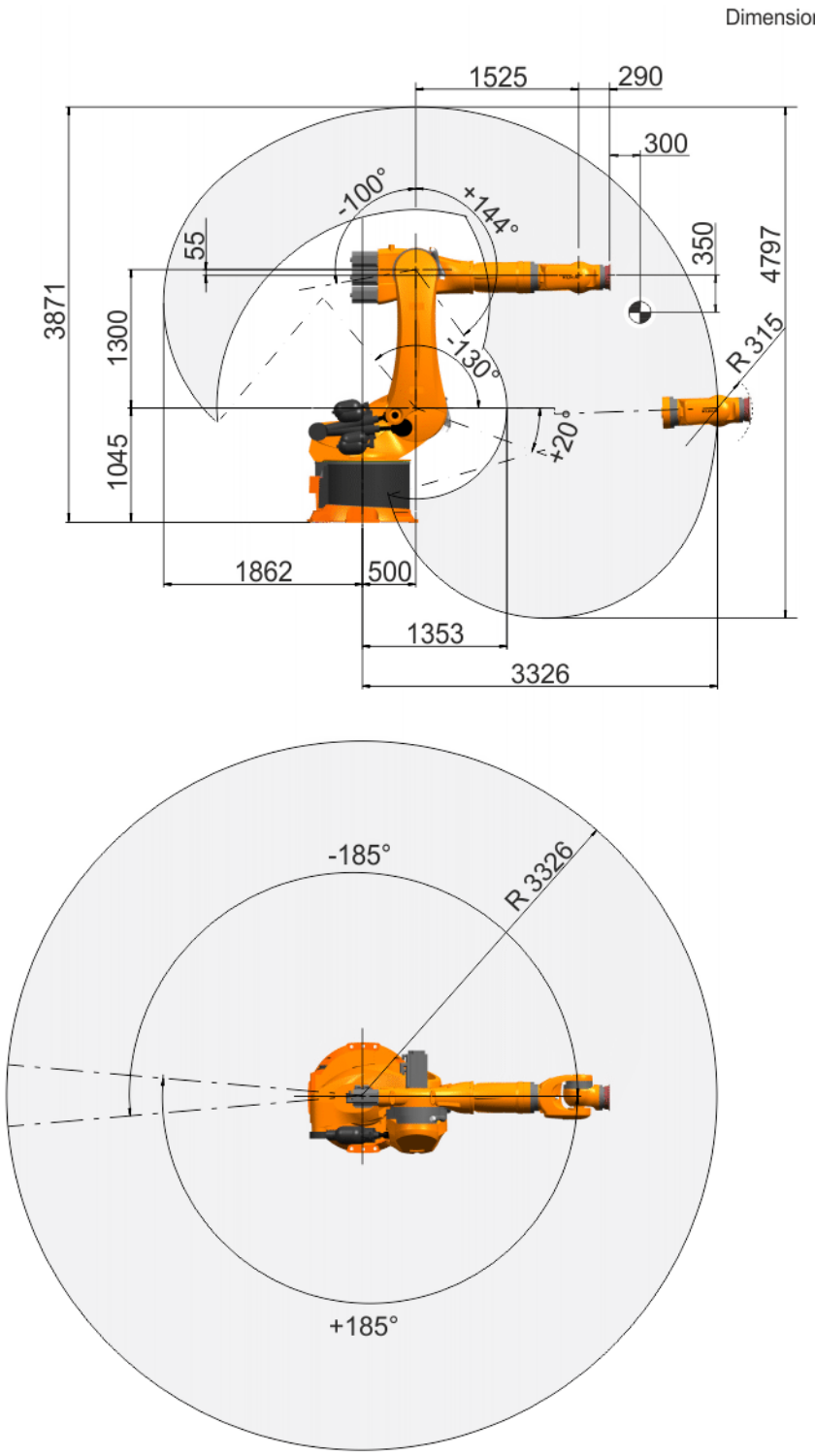

Fig. 4-32: Working envelope KR 340 R3330 (with F variant)

4.8.3 Payloads, KR 340 R3330 F

Payloads

Rated payload	340 kg
Rated mass moment of inertia	170 kgm²
Rated total load	390 kg
Rated supplementary load, base frame	0 kg

Maximum supplementary load, base frame	0 kg
Rated supplementary load, rotating column	0 kg
Maximum supplementary load, rotating column	400 kg
Rated supplementary load, link arm	0 kg
Maximum supplementary load, link arm	100 kg
Rated supplementary load, arm	50 kg
Maximum supplementary load, arm	100 kg
Nominal distance to load center of gravity	
Lxy	350 mm
Lz	300 mm

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

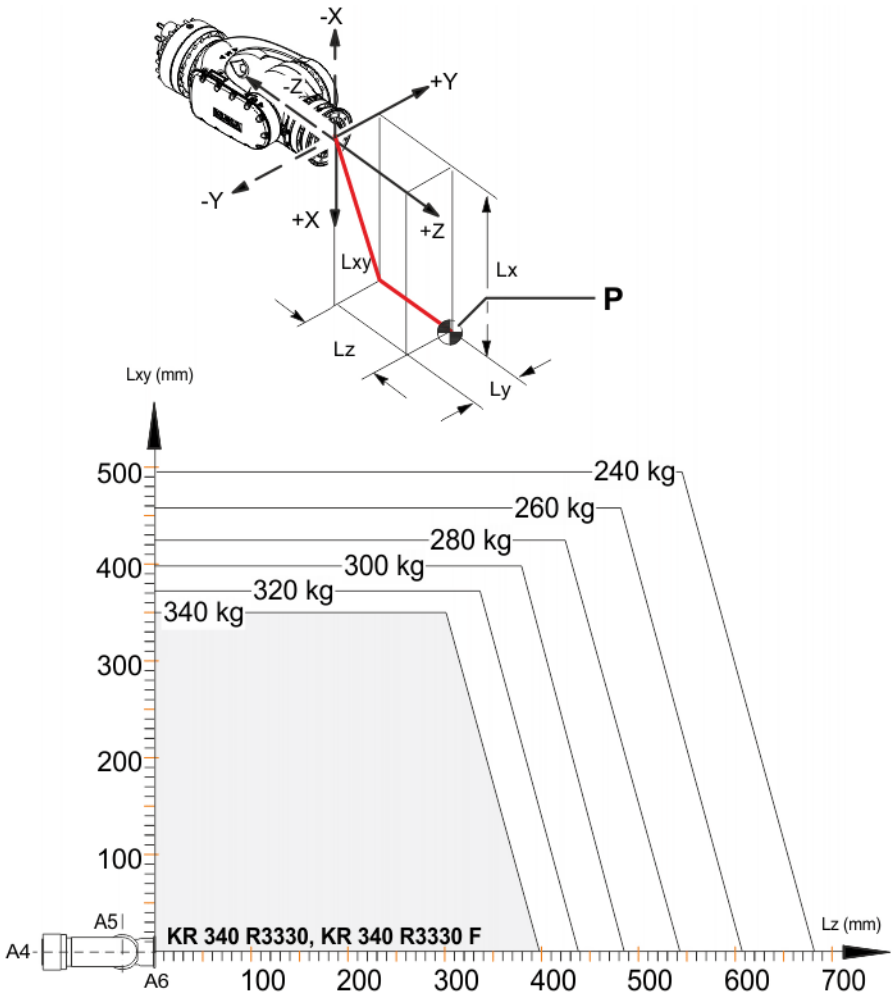

Fig. 4-33: Payload diagram KR 340 R3330 (with F variant)

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 the 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!

In-line wrist

In-line wrist type	ZH500-4F
Mounting flange	-

Mounting flange

Screw grade	12.9
Screw size	M12
Grip length	1.5 x nominal diameter
Depth of engagement	min. 15 mm, max. 18.5 mm
Locating element	12 ^{H7}

The mounting flange is depicted (>>> Fig. 4-34) with axis 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

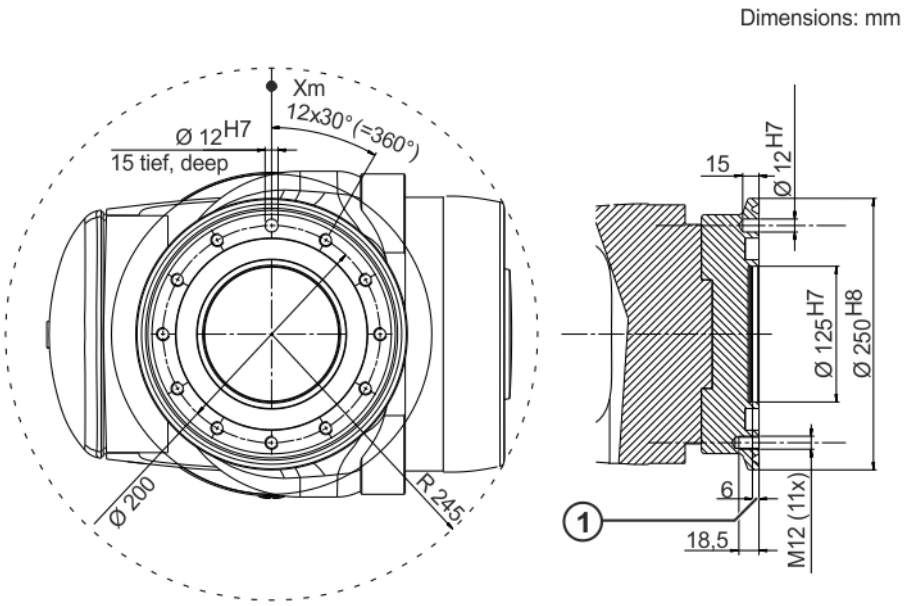

Fig. 4-34: Mounting flange

1 Fitting length

4.8.4 Loads acting on the foundation, KR 340 R3330 F

Loads acting on the foundation

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

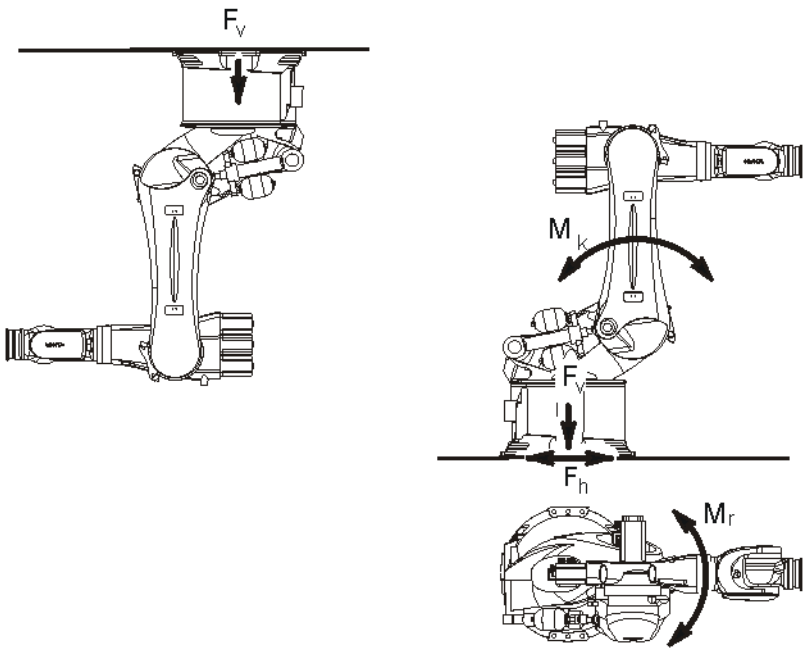

Fig. 4-35: Loads acting on the mounting base

Vertical force	40500 N
Horizontal force	23500 N
Tilting moment	84500 Nm
Torque about axis 1	45500 Nm

NOTICE The mounting base loads specified in the table are the maximum loads that may occur. They must be referred to when dimensioning the mounting bases and must be adhered to for safety reasons.
The supplementary loads are not taken into consideration in the calculation of the foundation load. These supplementary loads must be taken into consideration for F_v.

4.9 Supplementary load

Description

The robot can carry supplementary loads on the arm, on the rotating column and on the link 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.

Dimensions: mm

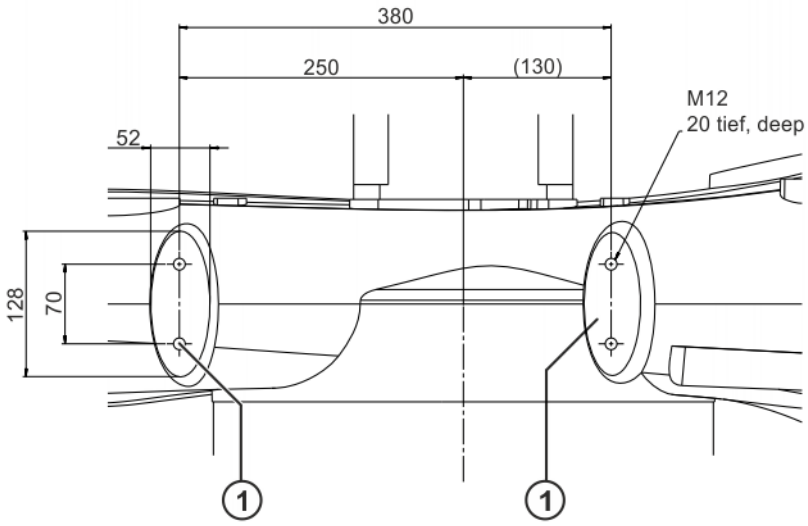

Fig. 4-36: Supplementary load, arm

1 Support bracket for supplementary load

Dimensions: mm

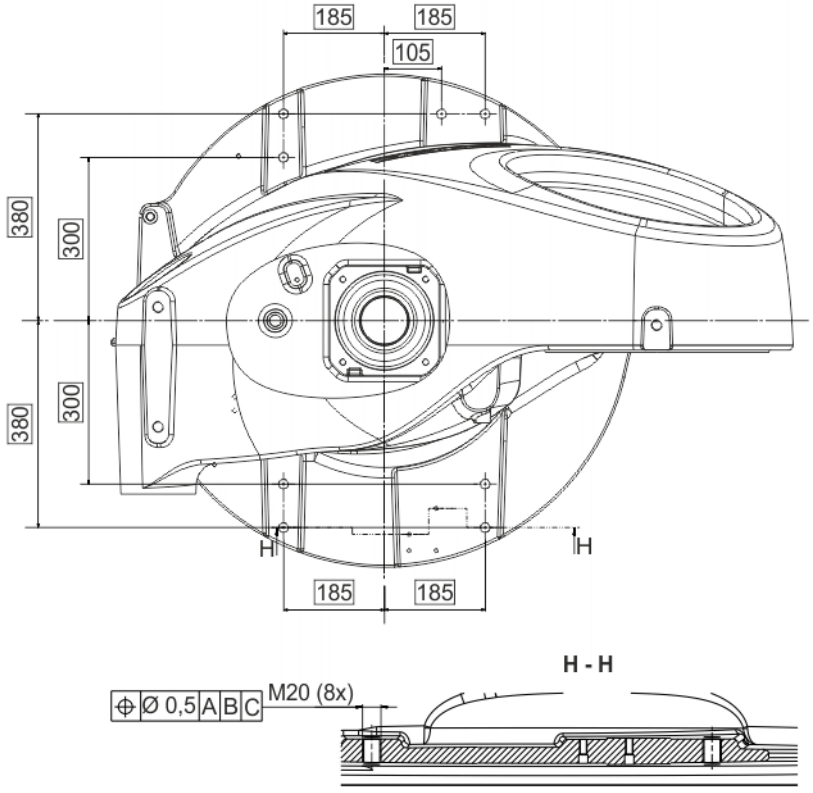

Fig. 4-37: Supplementary load, rotating column

Dimensions: mm

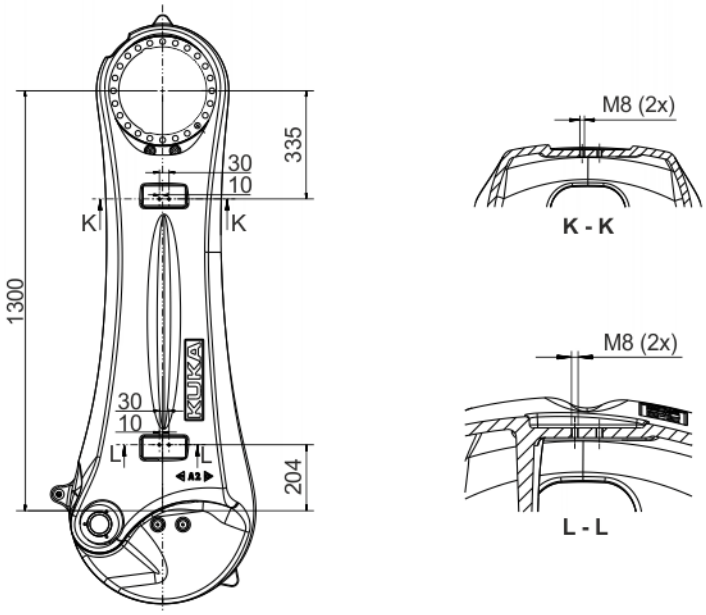

Fig. 4-38: Supplementary load, link arm

4.10 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.

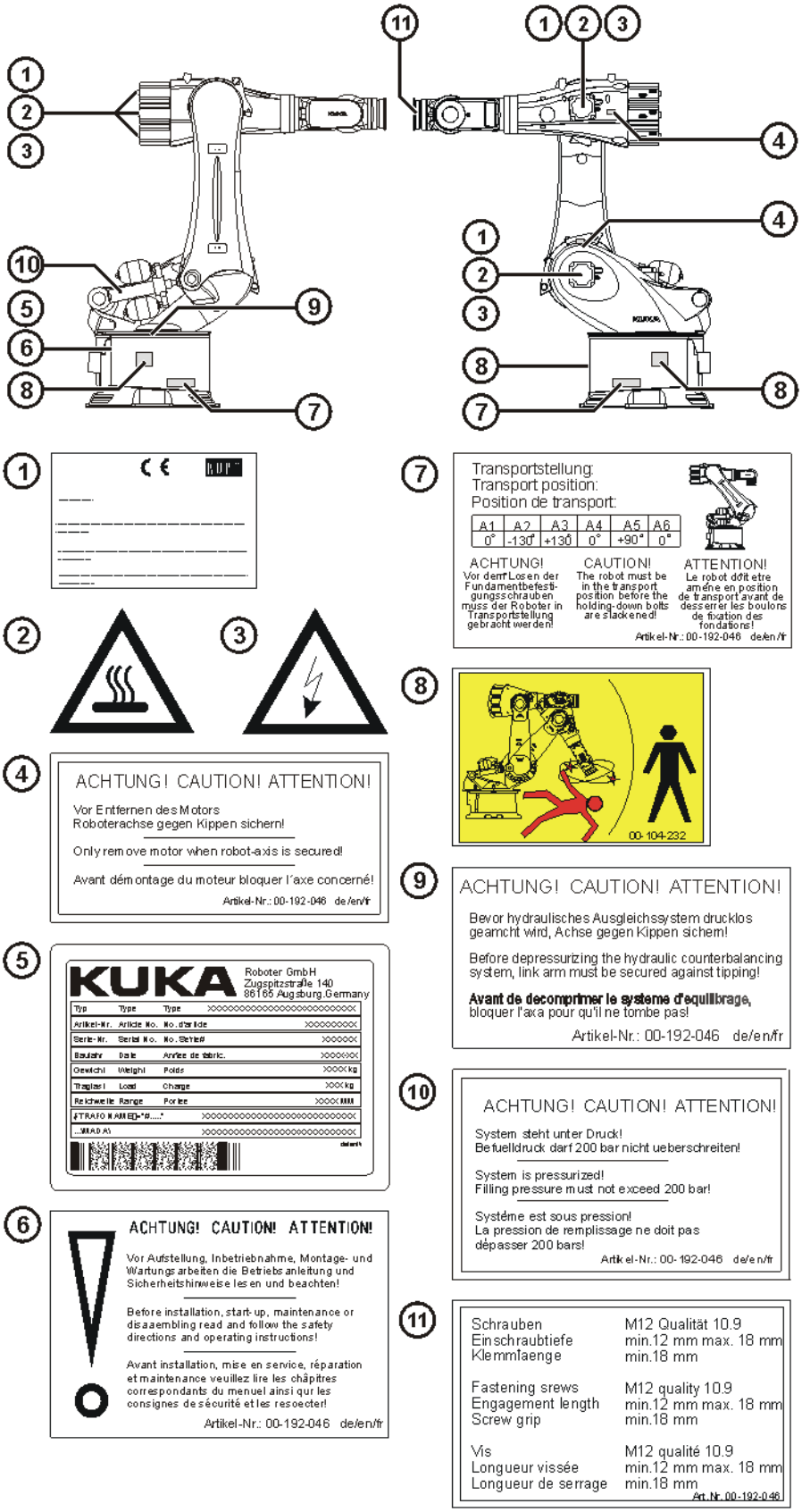

Fig. 4-39: Plates and labels

4.11 Stopping distances and times

4.11.1 General information

Information concerning the data:

- The stopping distance is the angle traveled by the robot from the moment the stop signal is triggered until the robot comes to a complete standstill.
- The stopping time is the time that elapses from the moment the stop signal is triggered until the robot comes to a complete standstill.
- The data are given for the main axes A1, A2 and A3. The main axes are the axes with the greatest deflection.
- Superposed axis motions can result in longer stopping distances.
- Stopping distances and stopping times in accordance with DIN EN ISO 10218-1, Annex B.
- Stop categories:
  - Stop category 0 » STOP 0
  - Stop category 1 » STOP 1

  according to IEC 60204-1
- The values specified for Stop 0 are guide values determined by means of tests and simulation. They are average values which conform to the requirements of DIN EN ISO 10218-1. The actual stopping distances and stopping times may differ due to internal and external influences on the braking torque. It is therefore advisable to determine the exact stopping distances and stopping times where necessary under the real conditions of the actual robot application.
- Measuring technique

  The stopping distances were measured using the robot-internal measuring technique.
- The wear on the brakes varies depending on the operating mode, robot application and the number of STOP 0 triggered. It is therefore advisable to check the stopping distance at least once a year.

4.11.2 Terms used

Term	Description
m	Mass of the rated load and the supplementary load on the arm.
Phi	Angle of rotation (°) about the corresponding axis. This value can be entered in the controller via the KCP and is displayed on the KCP.
POV	Program override (%) = velocity of the robot motion. This value can be entered in the controller via the KCP and is displayed on the KCP.
Extension	Distance (l in %) (>>> Fig. 4-40) between axis 1 and the intersection of axes 4 and 5. With parallelogram robots, the distance between axis 1 and the intersection of axis 6 and the mounting flange.
KCP	The KCP teach pendant has all the operator control and display functions required for operating and programming the robot system.

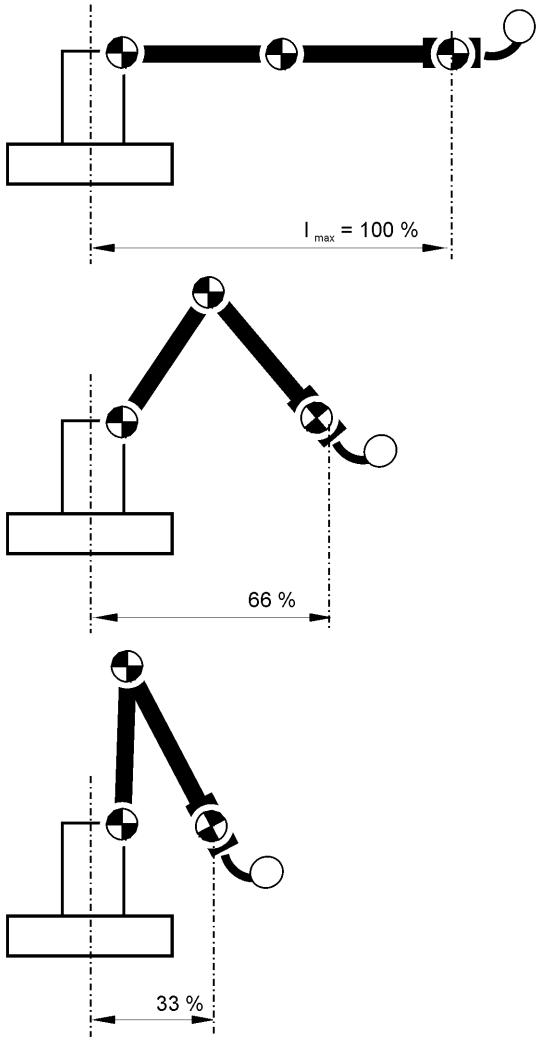

Fig. 4-40: Extension

4.11.3 Stopping distances and times KR 500 R2830, KR 500 R2830 F, KR 500 R2830 C

4.11.3.1 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	23.79	0.692
Axis 2	30.94	0.666
Axis 3	19.40	0.362

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

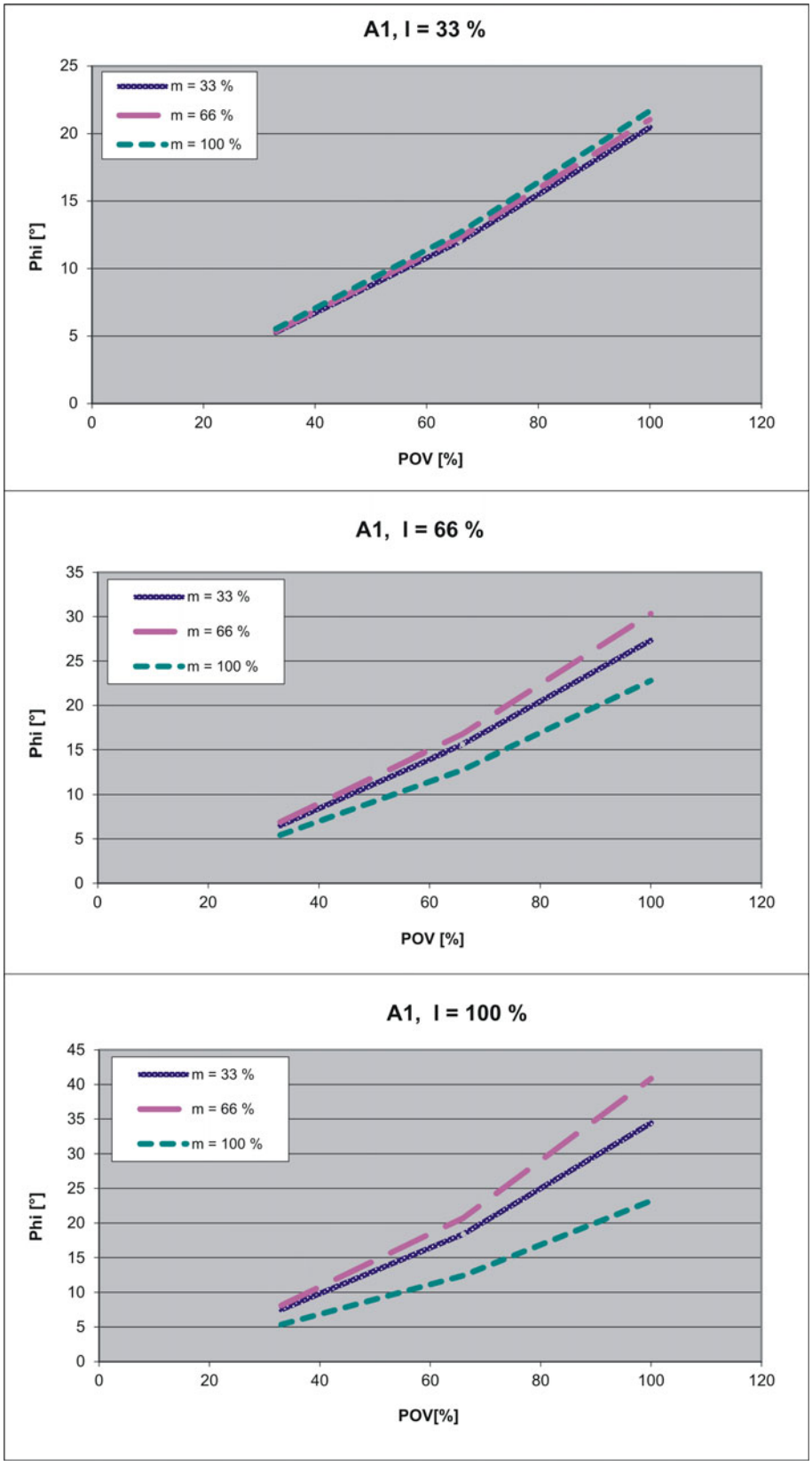

Fig. 4-41: Stopping distances for STOP 1, axis 1

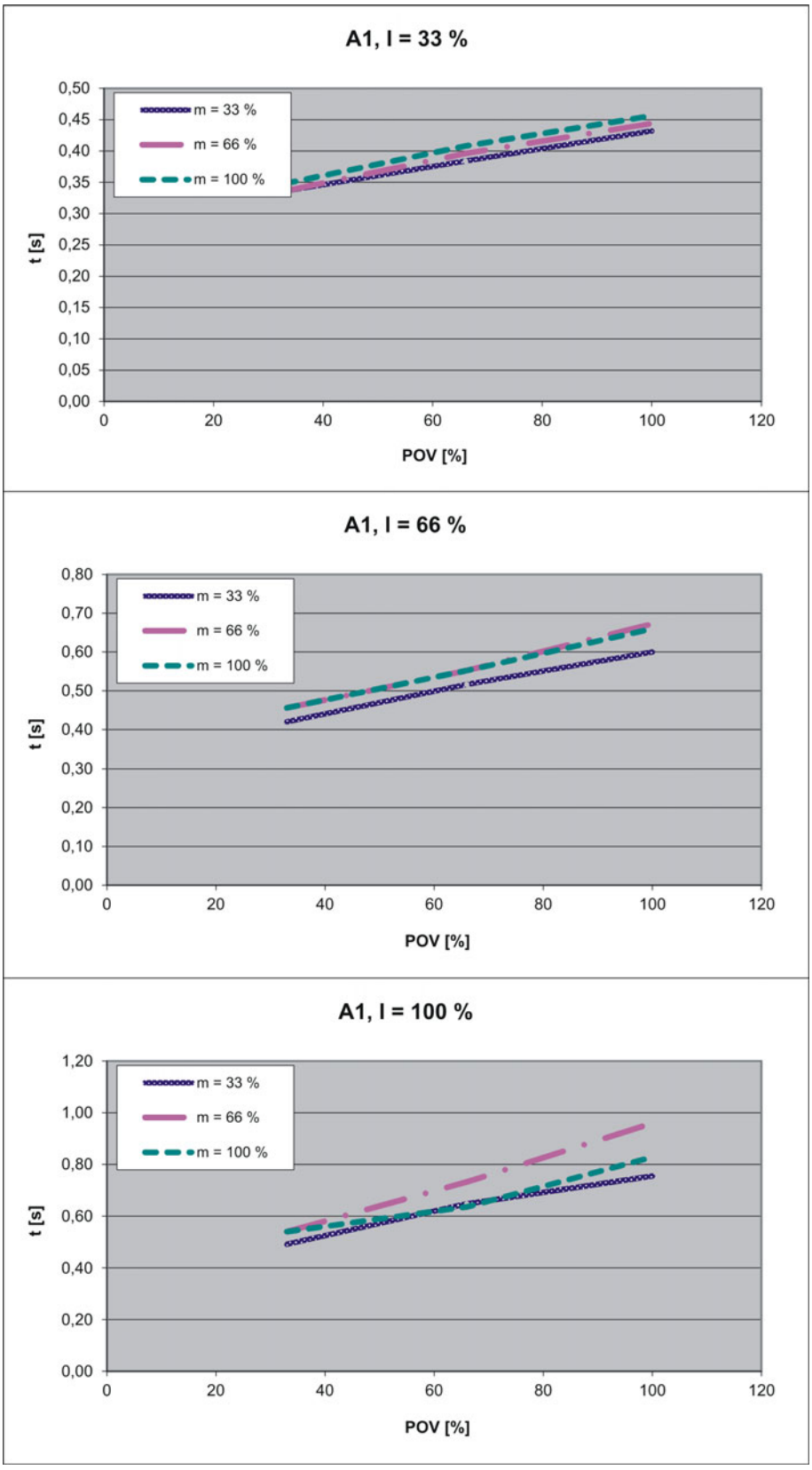

Fig. 4-42: Stopping times for STOP 1, axis 1

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

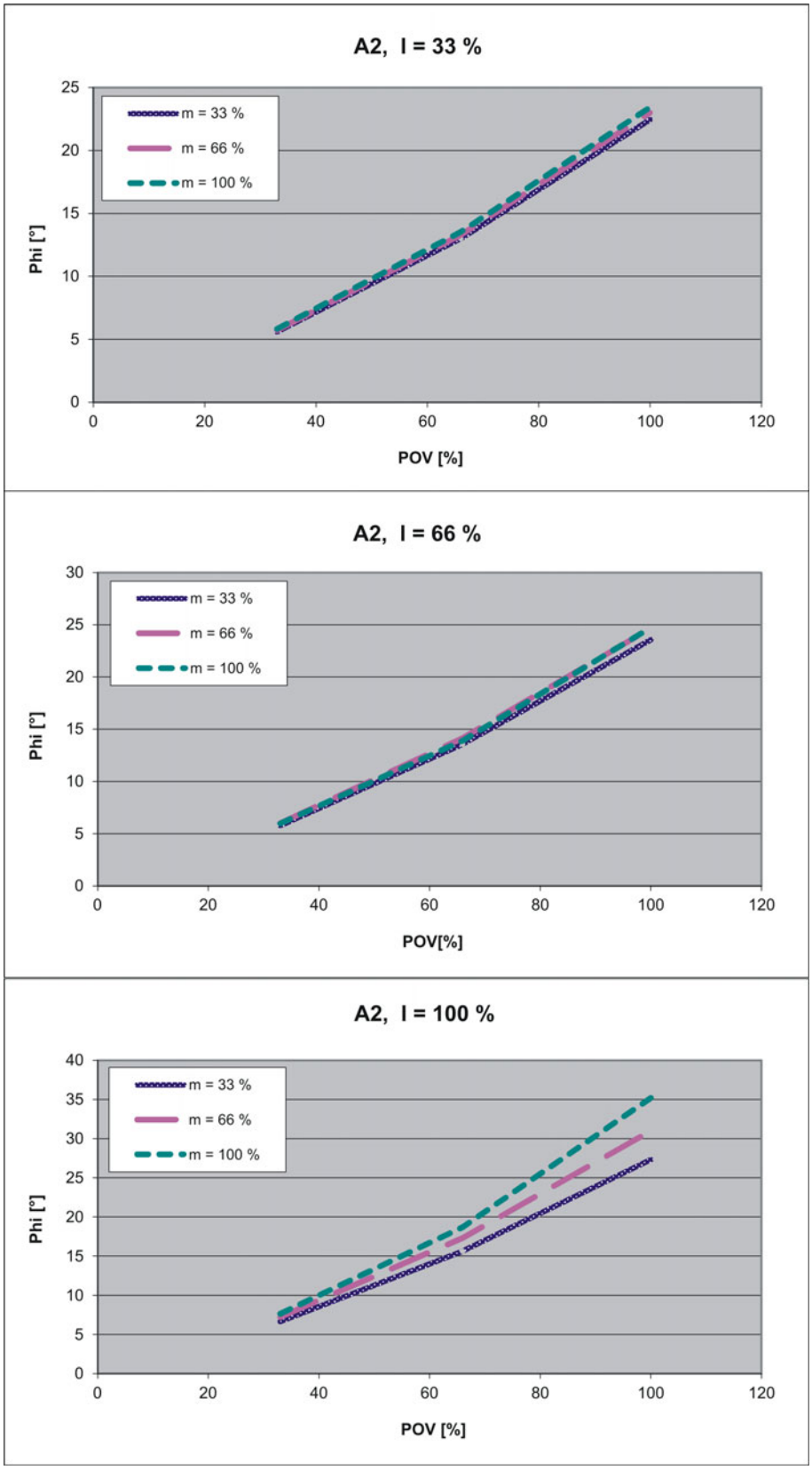

Fig. 4-43: Stopping distances for STOP 1, axis 2

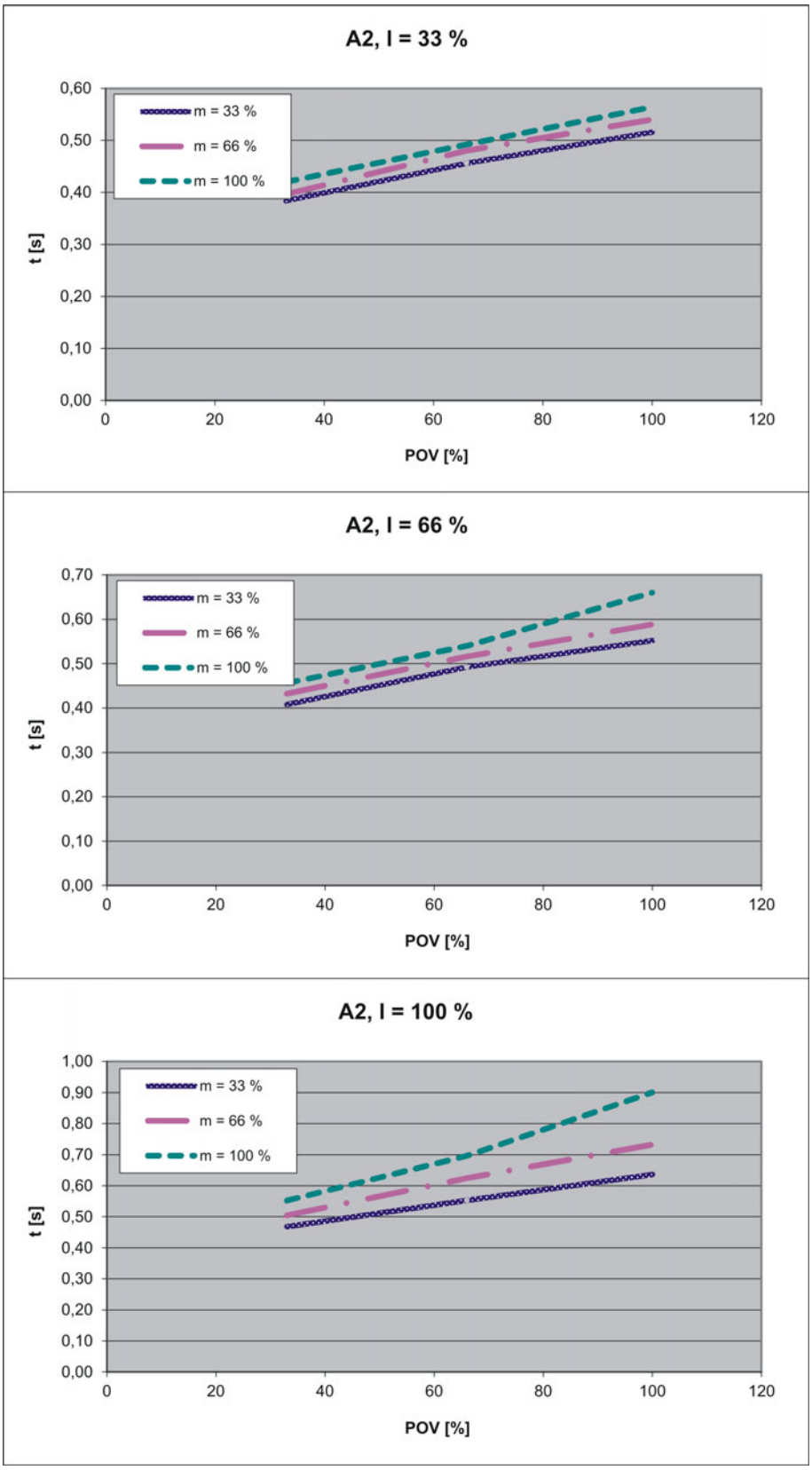

Fig. 4-44: Stopping times for STOP 1, axis 2

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

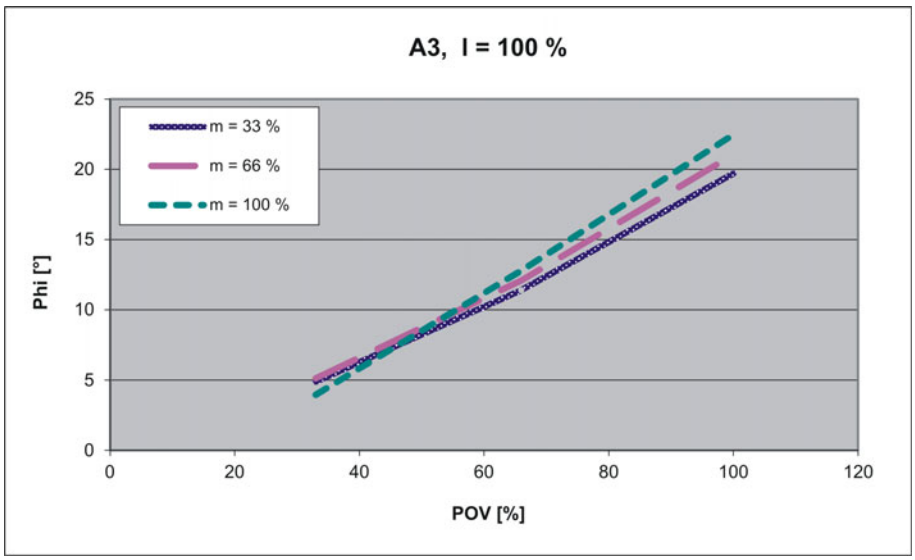

Fig. 4-45: Stopping distances for STOP 1, axis 3

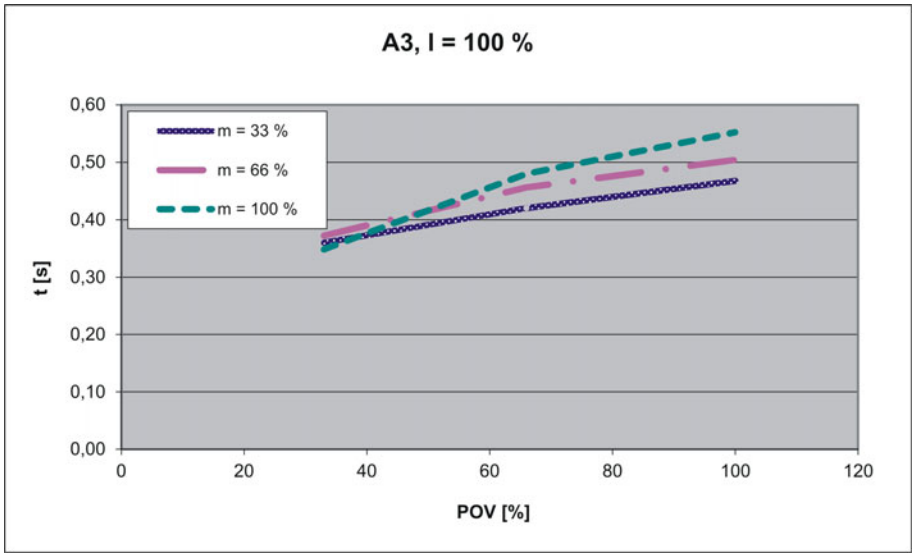

Fig. 4-46: Stopping times for STOP 1, axis 3

4.11.4 Stopping distances and times KR 420 R3080, KR 420 R3080 F

4.11.4.1 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	48.17	0.982
Axis 2	35.96	0.778
Axis 3	20.41	0.387

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

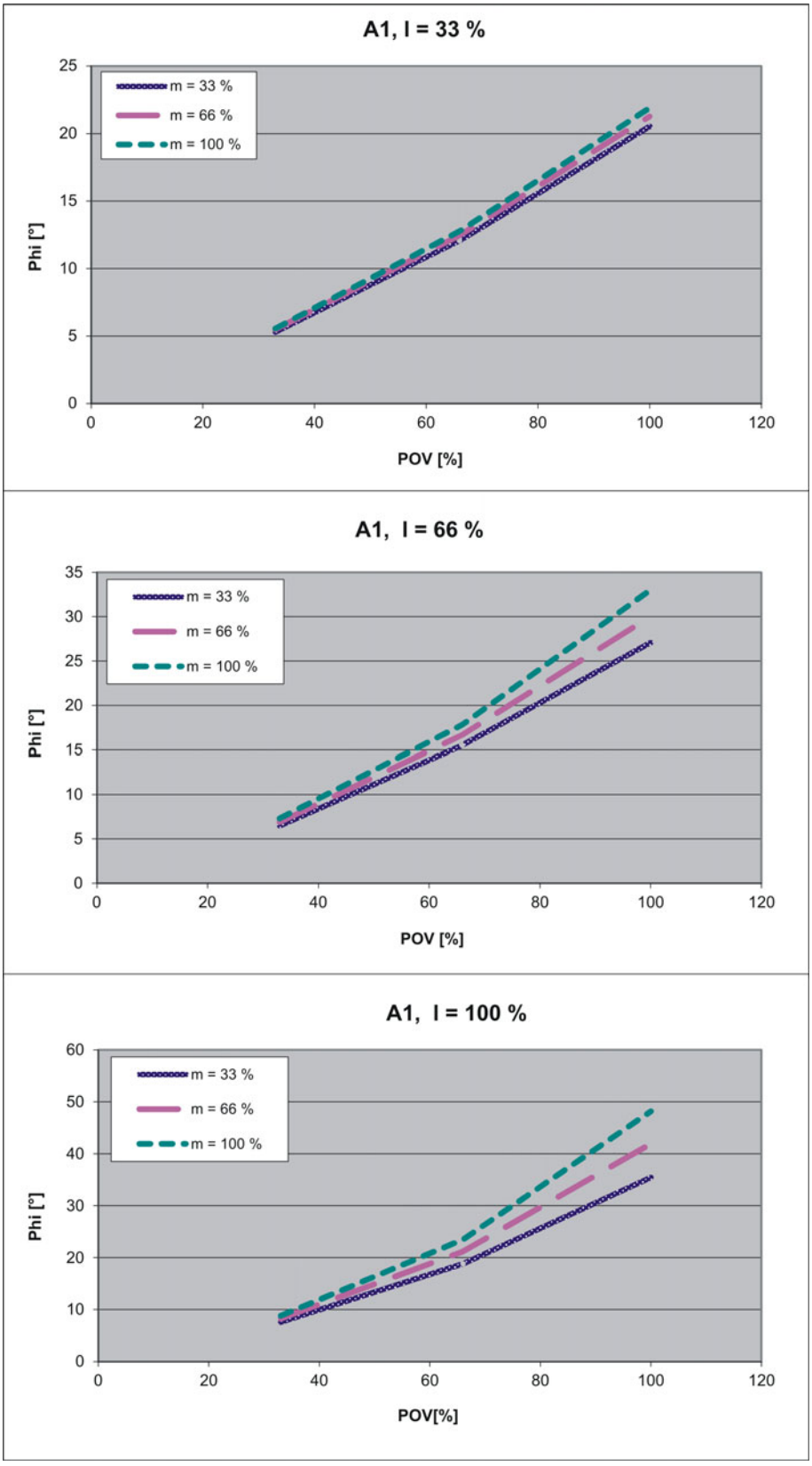

Fig. 4-47: Stopping distances for STOP 1, axis 1

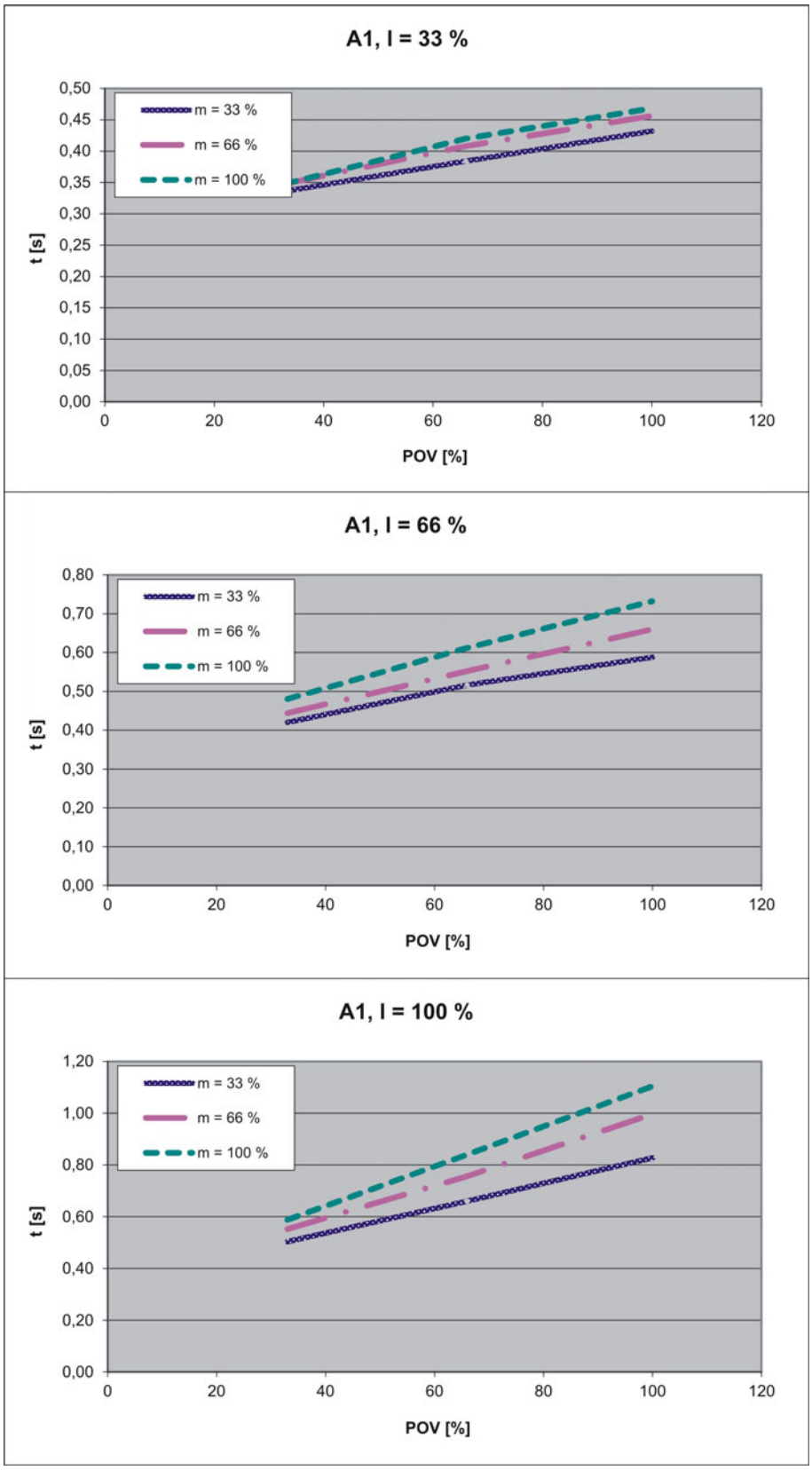

Fig. 4-48: Stopping times for STOP 1, axis 1

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

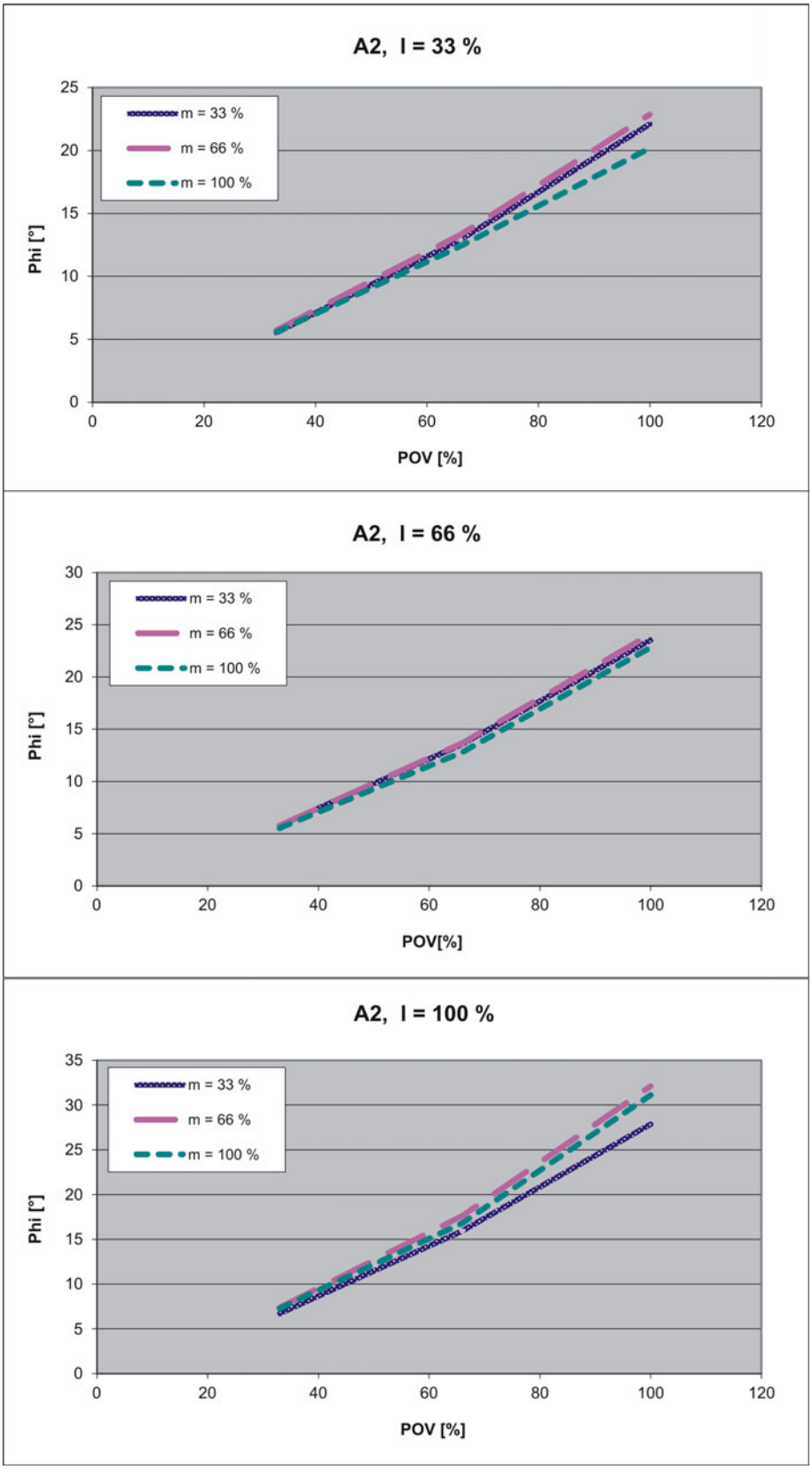

Fig. 4-49: Stopping distances for STOP 1, axis 2

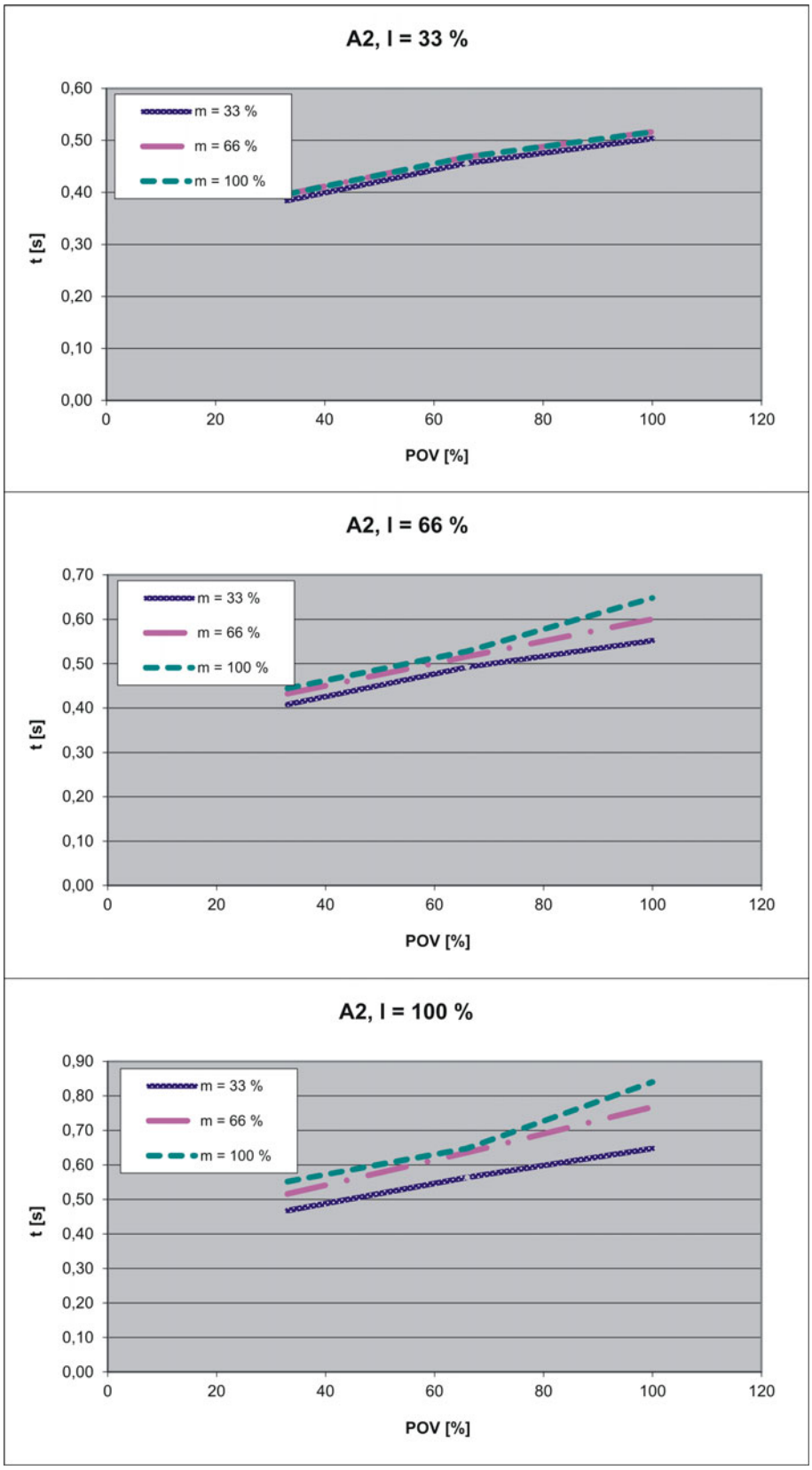

Fig. 4-50: Stopping times for STOP 1, axis 2

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

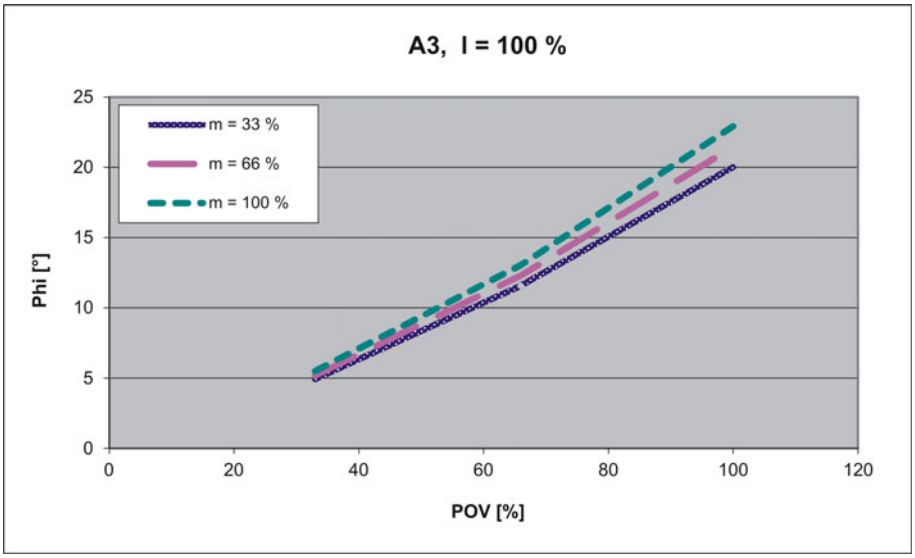

Fig. 4-51: Stopping distances for STOP 1, axis 3

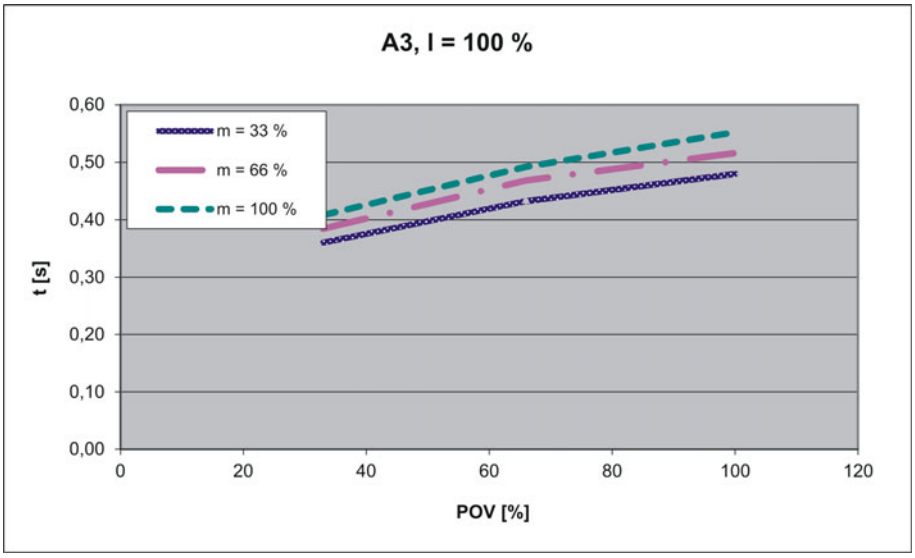

Fig. 4-52: Stopping times for STOP 1, axis 3

4.11.5 Stopping distances and times KR 340 R3330, KR 340 R3330 F

4.11.5.1 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	47.67	0.97
Axis 2	36.34	0.785
Axis 3	20.98	0.401

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

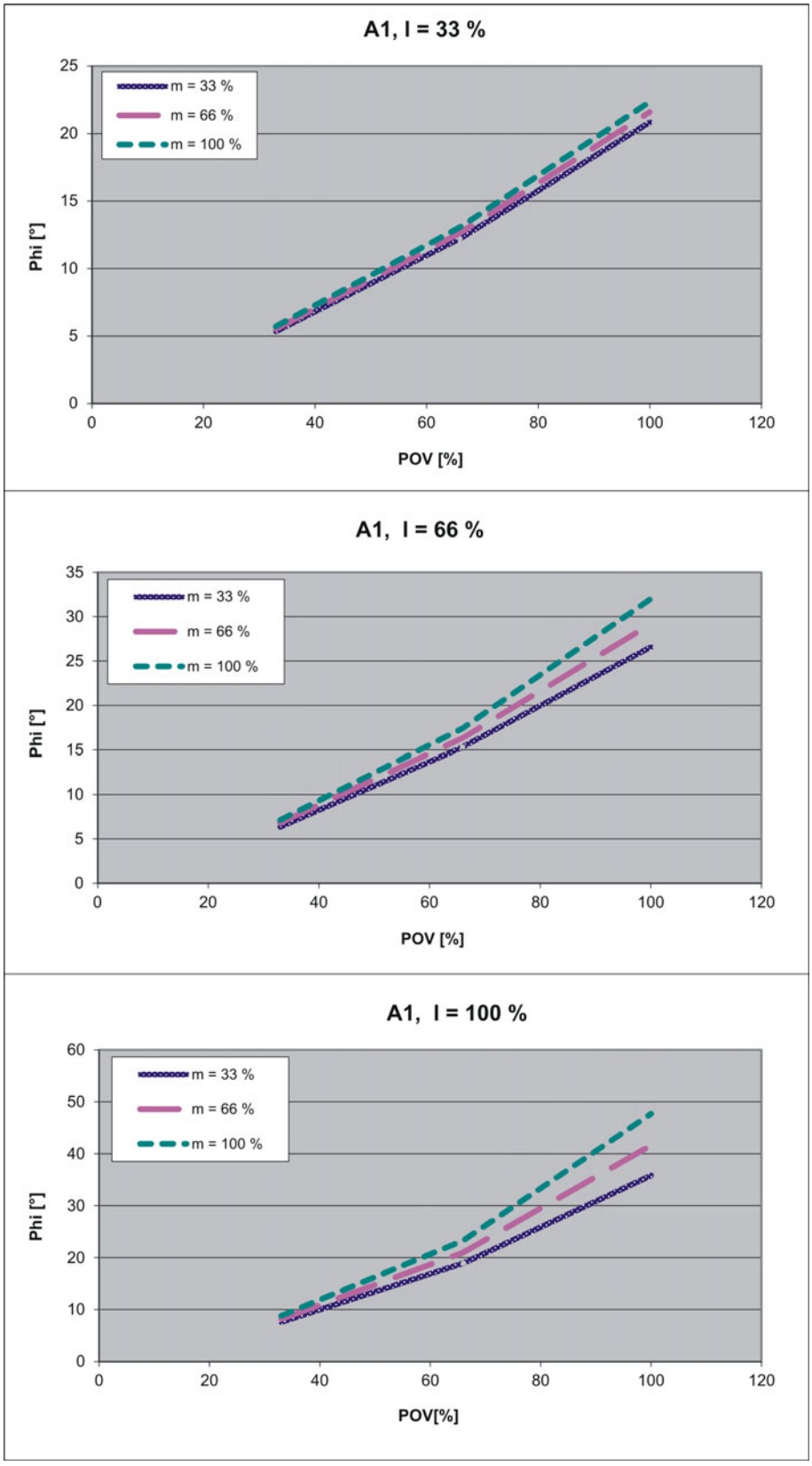

Fig. 4-53: Stopping distances for STOP 1, axis 1

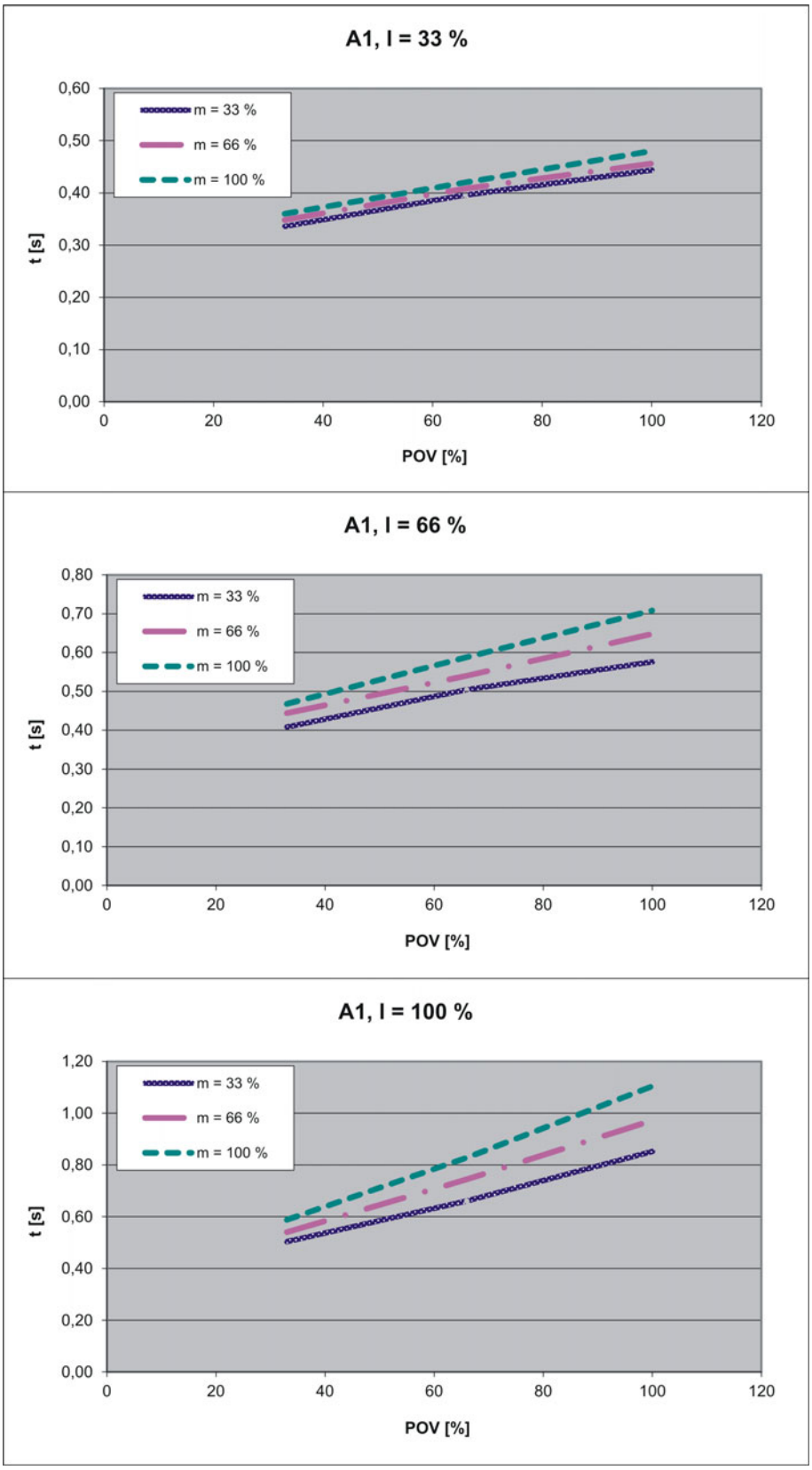

Fig. 4-54: Stopping times for STOP 1, axis 1

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

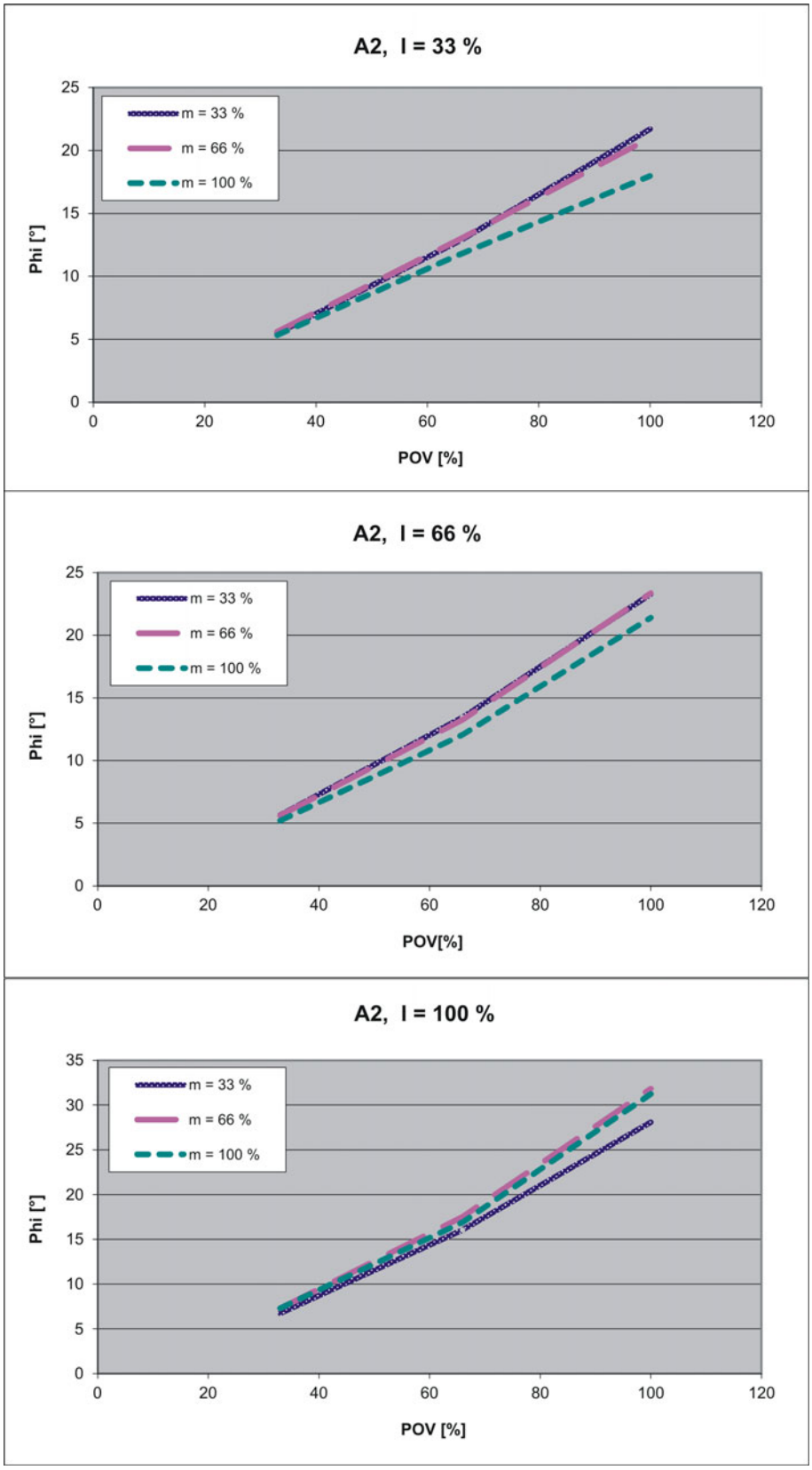

Fig. 4-55: Stopping distances for STOP 1, axis 2

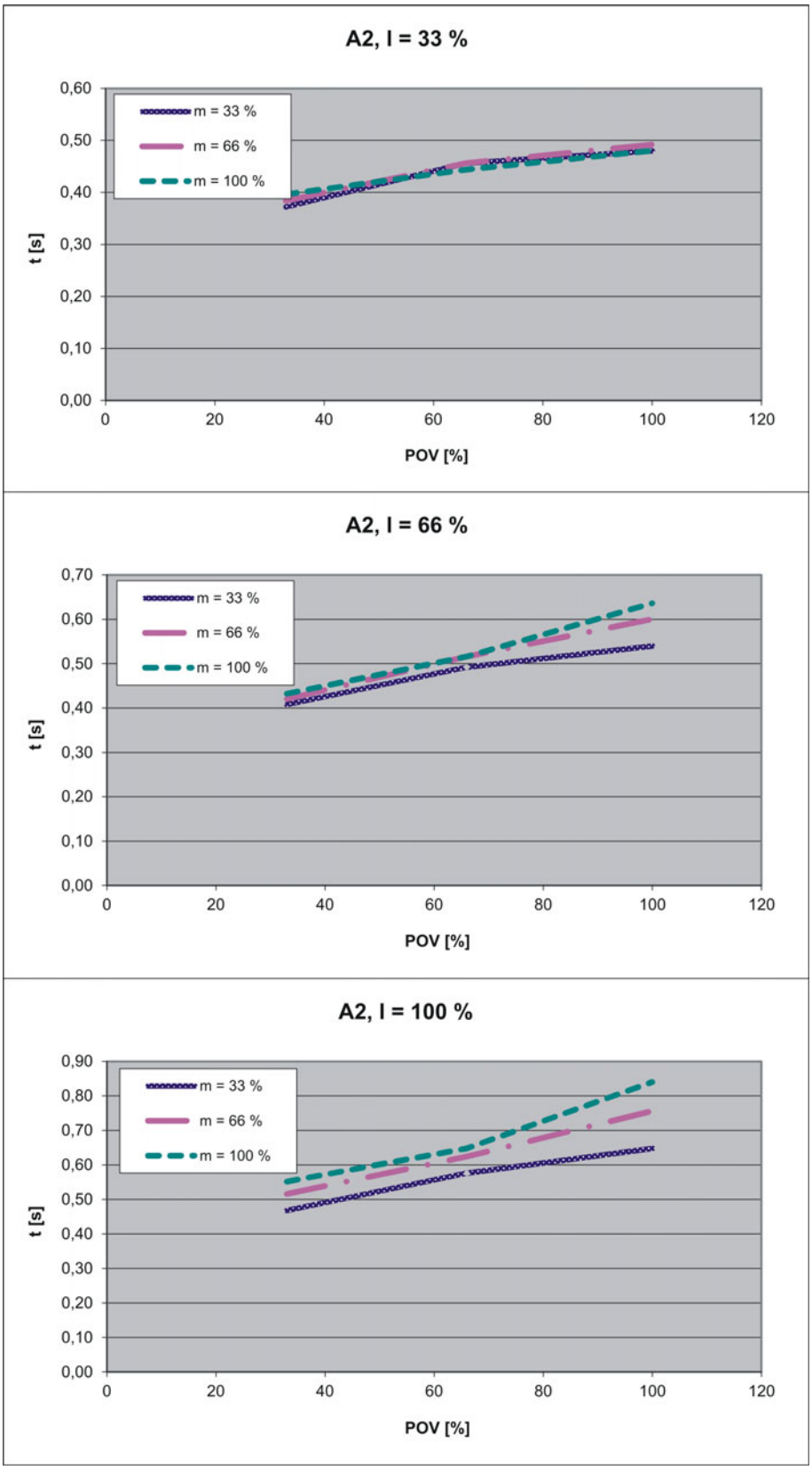

Fig. 4-56: Stopping times for STOP 1, axis 2

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

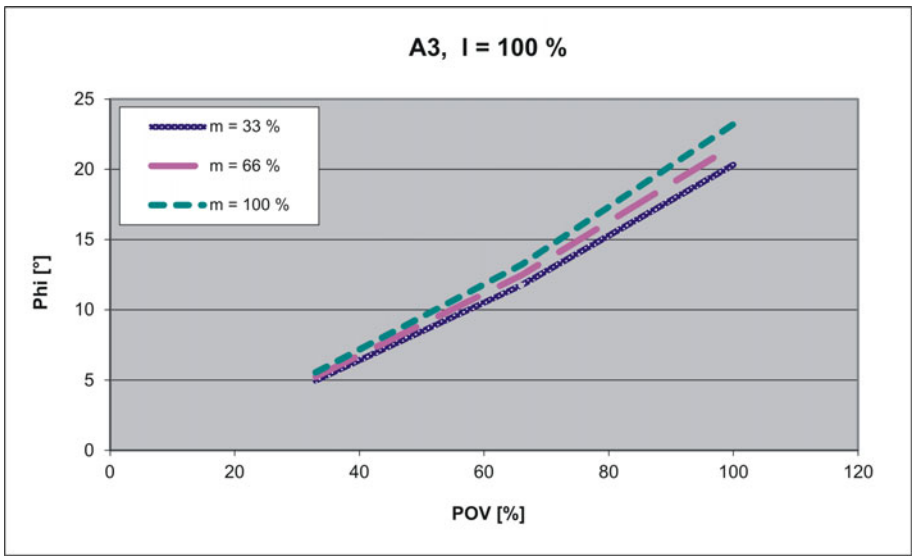

Fig. 4-57: Stopping distances for STOP 1, axis 3

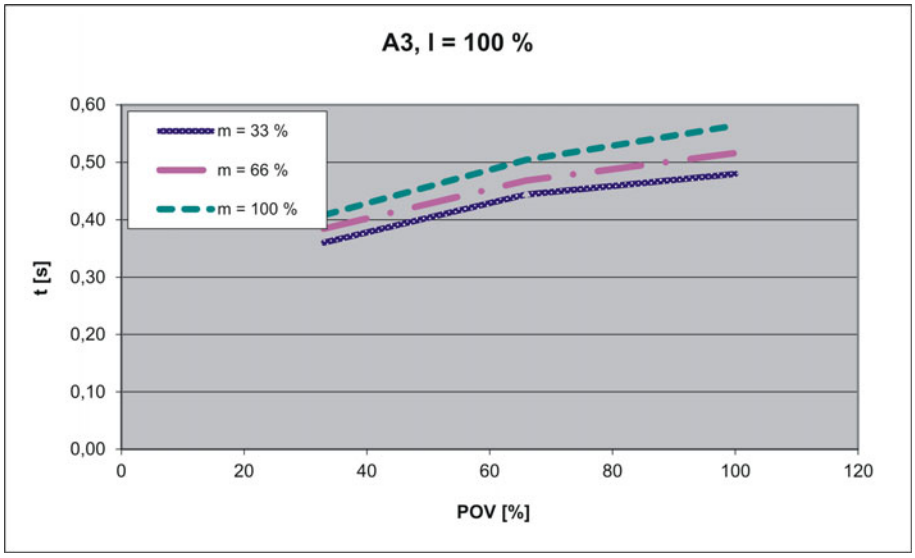

Fig. 4-58: Stopping times for STOP 1, axis 3

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.

Any use or application deviating from the intended use is deemed to be misuse and is not allowed. The manufacturer is not liable for any damage resulting from such misuse. The risk lies entirely with the user.

Operation of the industrial robot in accordance with its intended use also requires compliance with 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 misuse and is not allowed. This includes e.g.:

- Transportation of persons and animals
- Use as a climbing aid
- Operation outside the specified 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

The 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 always 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 is not allowed 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.

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 aging during storage.
KCP	KUKA Control Panel Teach pendant for the KR C2/KR C2 edition2005 The KCP has all the operator control and display functions required for operating and programming the industrial robot.
KUKA smartPAD	see “smartPAD”
Manipulator	The robot arm and the associated electrical installations
Safety zone	The safety zone is situated outside the danger zone.
smartPAD	Teach pendant for the KR C4 The smartPAD has all the operator control and display functions required for operating and programming the industrial robot.
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.

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.

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, the manipulator can no longer be operated safely. The manipulator must be taken out of operation and KUKA Roboter GmbH must be consulted before it is put back into operation (>>> 13 "KUKA Service" Page 225).

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 the KR C4. 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 drive energy

The system user is responsible for ensuring that the training of personnel with regard to the response to emergencies or exceptional situations also includes how the manipulator can be moved without drive energy.

Description

The following options are available for moving the manipulator without drive energy 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

  There is no release device available for the wrist axes of variants in the low payload category. This is not necessary because the wrist axes can be moved directly by hand.

Information about the options available for the various robot models and about how to use them can be found in the assembly and operating instructions for the robot or requested from KUKA Roboter GmbH.

NOTICE Moving the manipulator without drive energy can damage the motor brakes of the axes concerned. The motor must be replaced if the brake has been damaged. The manipulator may therefore be moved without drive energy only in emergencies, e.g. for rescuing persons.

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 signs
- 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 out. 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 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/smartPAD

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

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

⚠ WARNING The operator must ensure that decoupled KCPs/smartPADs 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/smartPAD must not be used as long as an external keyboard and/or external mouse are connected to the control cabinet.

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

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 functions 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.

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.

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.

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

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
- Teaching
- 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 and the provisions 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	2012
EN ISO 12100	**Safety of machinery:** General principles of design, risk assessment and risk reduction	2010
EN ISO 10218-1	**Industrial robots:** Safety **Note:** Content equivalent to **ANSI/RIA R.15.06-2012, Part 1**	2011
EN 614-1	**Safety of machinery:** Ergonomic design principles - Part 1: Terms and general principles	2009
EN 61000-6-2	**Electromagnetic compatibility (EMC):** Part 6-2: Generic standards; Immunity for industrial environments	2005
EN 61000-6-4 + A1	**Electromagnetic compatibility (EMC):** Part 6-4: Generic standards; Emission standard for industrial environments	2011
EN 60204-1 + A1	**Safety of machinery:** Electrical equipment of machines - Part 1: General requirements	2009

6 Planning

6.1 Information for planning

In the planning and design phase, care must be taken regarding the functions or applications to be executed by the kinematic system. The following conditions can lead to premature wear. They necessitate shorter maintenance intervals and/or earlier exchange of components. In addition, the permissible operating parameters specified in the technical data must be taken into account during planning.

- Continuous operation near temperature limits or in abrasive environments
- Continuous operation close to the performance limits, e.g. high rpm of an axis
- High duty cycle of individual axes
- Monotonous motion profiles, e.g. short, frequently recurring axis motions
- Static axis positions, e.g. continuous vertical position of a wrist axis

If one or more of these conditions are to apply during operation of the kinematic system, KUKA Roboter GmbH must be consulted.

6.2 Mounting base 175 mm

Description

The mounting base with centering (>>> Fig. 6-1) is used when the robot is fastened to the floor, i.e. directly on a concrete foundation with a thickness of at least 175 mm.

The mounting base consists of:

- Bedplate
- Chemical anchors (resin-bonded anchors) with Dynamic Set
- Fasteners

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. The minimum dimensions must be observed.

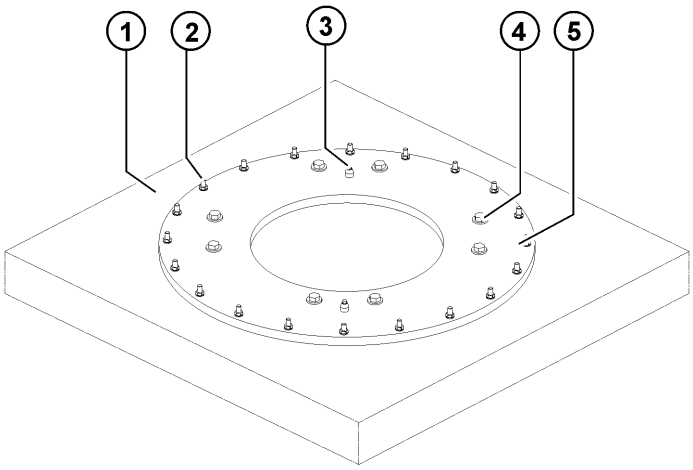

Fig. 6-1: Mounting base 175 mm

1	Concrete foundation	4	Hexagon bolt

2 Chemical anchor (resin-bonded anchor)
3 Pin
5 Bedplate

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 provides all the necessary information on the mounting base, together with the required foundation data.

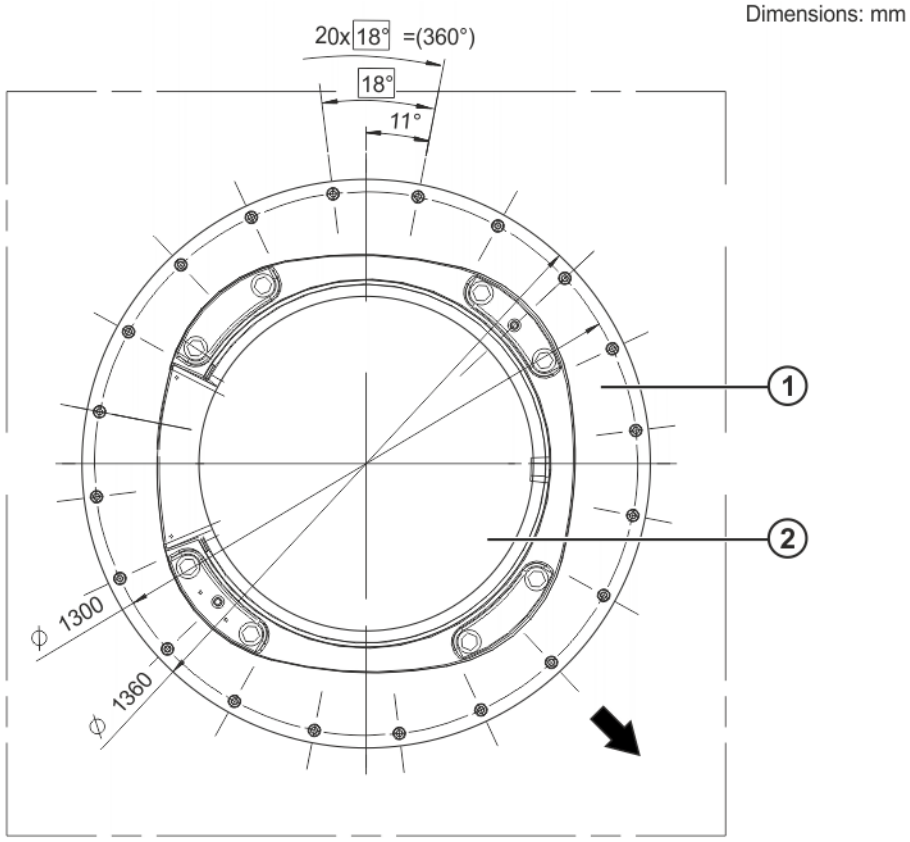

Fig. 6-2: Mounting base 175 mm, dimensioned drawing

1 Robot
2 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).

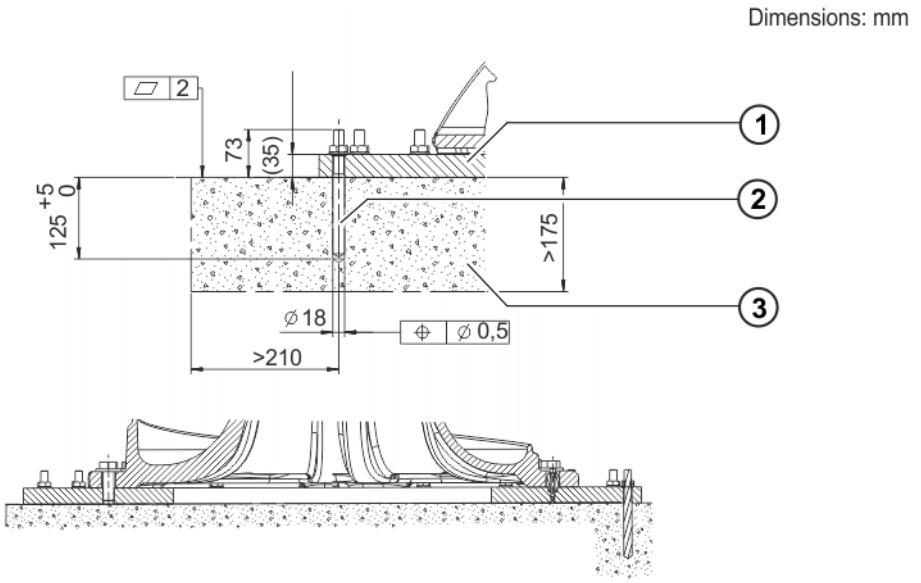

Fig. 6-3: Cross-section of foundation 175 mm

1 Bedplate
2 Chemical anchors (resin-bonded anchors) with Dynamic Set
3 Concrete foundation

6.3 Mounting base 200 mm

Description

The mounting base with centering (>>> Fig. 6-4) is used when the robot is fastened to the floor, i.e. directly on a concrete foundation with a thickness of at least 200 mm.

The mounting base with centering consists of:

- Bedplates
- Chemical anchors
- Fastening elements

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.

The minimum dimensions must be observed.

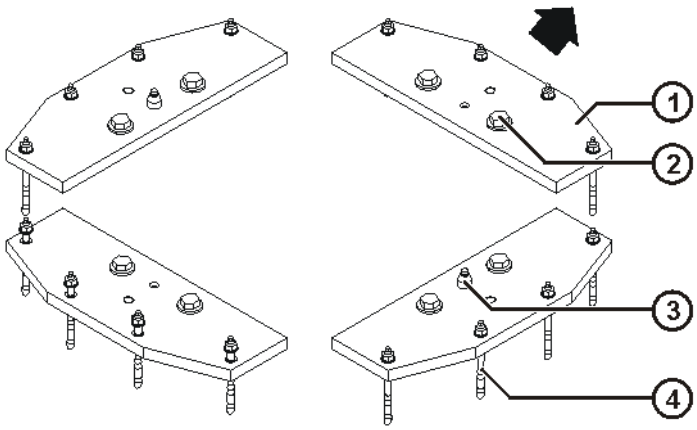

Fig. 6-4: Mounting base 200 mm

1 Bedplate
2 Hexagon bolt
3 Pin with Allen screw
4 Resin-bonded anchors with Dynamic Set

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 illustrations provide all the necessary information on the mounting base, together with the required foundation data.

Dimensions: mm

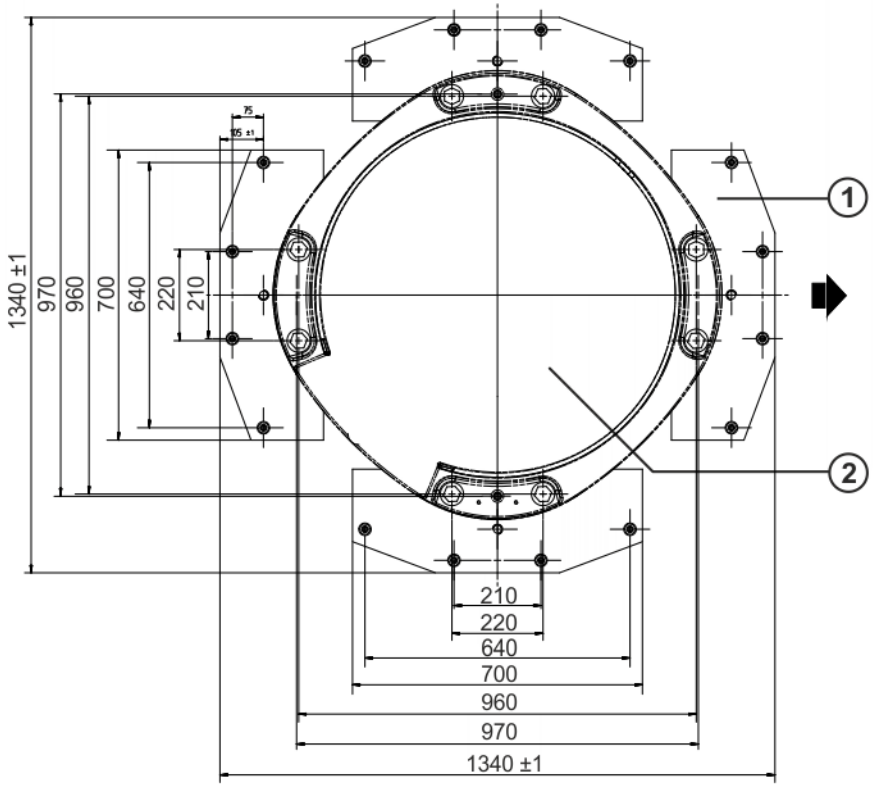

Fig. 6-5: Mounting base 200 mm, dimensioned drawing

1 Bedplates
2 Robot

To ensure that the anchor forces are safely transmitted to the foundation, observe the dimensions for concrete foundations specified in the following illustration.

Dimensions: mm

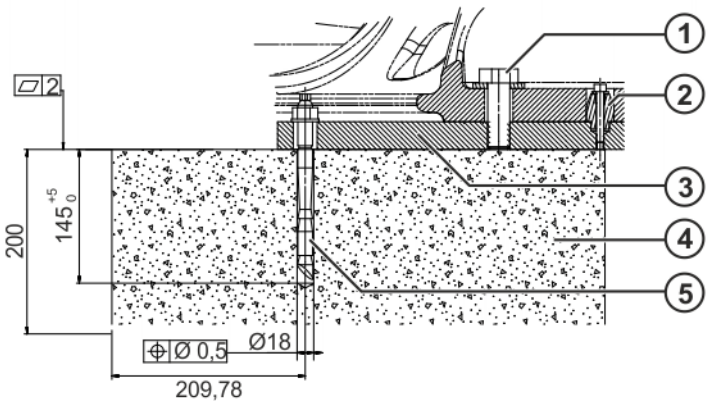

Fig. 6-6: Cross-section of foundation 200 mm

1	Hexagon bolt	4	Concrete foundation
2	Pin	5	Resin-bonded anchor
3	Bedplate		

6.4 Machine frame mounting

Description

The machine frame mounting assembly is used when the robot is fastened on a steel structure, a booster frame (pedestal) or a KUKA linear unit. This assembly is also used if the manipulator is installed in an inverted position, i.e. on the ceiling. It must be ensured that the substructure is able to withstand safely the forces occurring during operation (foundation loads). The following diagram contains all the necessary information that must be observed when preparing the mounting surface (>>> Fig. 6-7).

The machine frame mounting assembly consists of:

- Pin with fasteners
- Hexagon bolts with conical spring washers

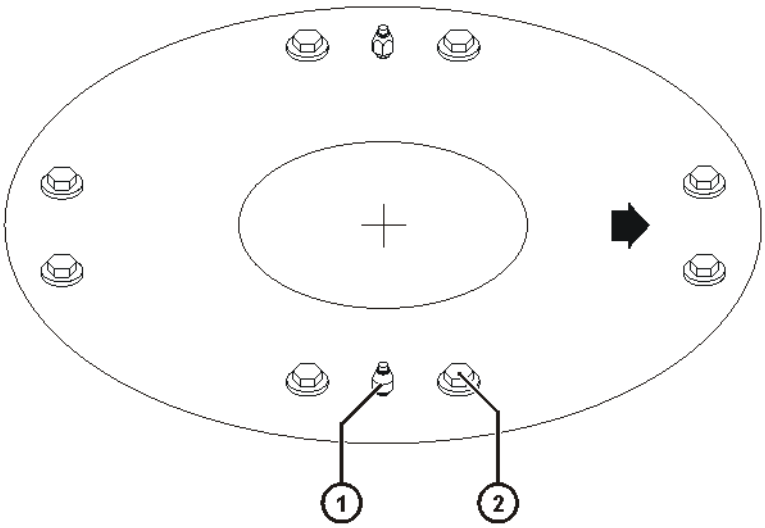

Fig. 6-7: Machine frame mounting

1	Pin		
2	Hexagon bolt		

Dimensioned drawing

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

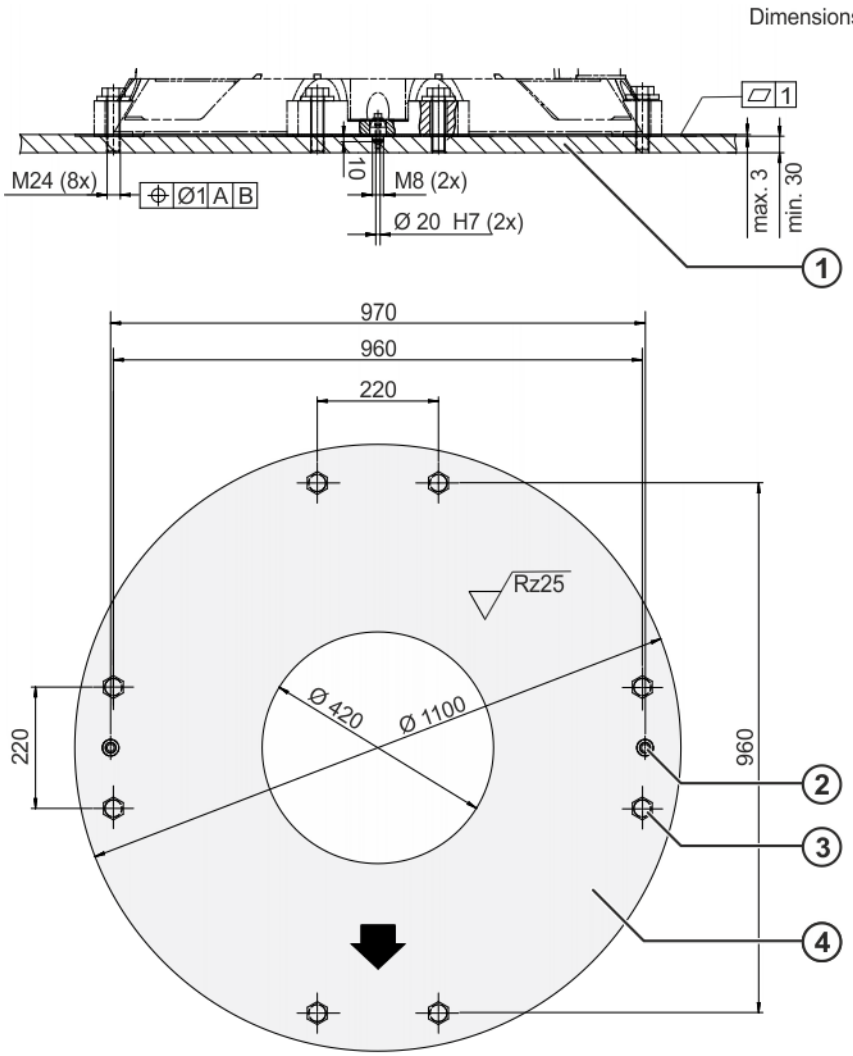

Fig. 6-8: Machine frame mounting, dimensioned drawing

1	Steel structure	3	Hexagon bolt (8x)
2	Pins (2x)	4	Mounting surface

6.5 Connecting cables and interfaces

Connecting cables

The connecting cables comprise all the cables for transferring energy and signals between the robot and the robot controller. They are connected to the robot junction boxes with connectors. The set of connecting cables comprises:

- Motor cable X20.1 - X30.1
- Motor cable X20.4 - X30.4
- Control cable X21 - X31
- Ground conductor (optional)

Depending on the specification of the robot, various connecting cables are used. Cable lengths of 7 m, 15 m, 25 m, 35 m and 50 m are available. The maximum length of the connecting cables must not exceed 50 m. Thus if the robot is operated on a linear unit which has its own energy supply chain these cables must also be taken into account.

For the connecting cables, a ground conductor is always required to provide a low-resistance connection between the robot and the control cabinet in accordance with DIN EN 60204. The ground conductor is not part of the scope of supply and can be ordered as an option. The connection must be made by the customer. The tapped holes for connecting the ground conductor are located on the base frame of the robot.

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.

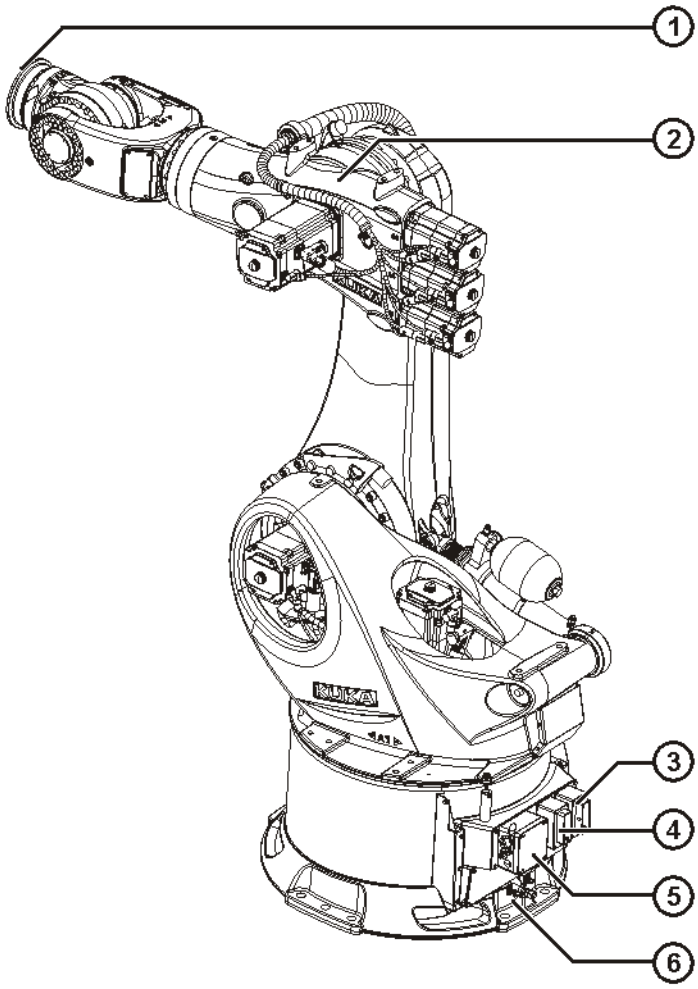

Fig. 6-9: Connecting cables and interfaces

1 Interface A6, tool
2 Interface A3, arm
3 Connection, motor cable X30.4
4 Connection, motor cable X30.1
5 Connection, control cable X31
6 Interface A1, base frame

7 Transportation

7.1 Transporting the robot

Description

Move the robot into its transport position 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. Remove any disruptive add-on parts (e.g. energy supply system) before transportation.

Transport position

The robot must be in the transport position (>>> Fig. 7-1) before it can be transported. The robot is in the transport position when the axes are in the following positions:

Axis	A1	A2	A3	A4	A5	A6
Angle	0°	-130°	+130°	0°	+90°	0°

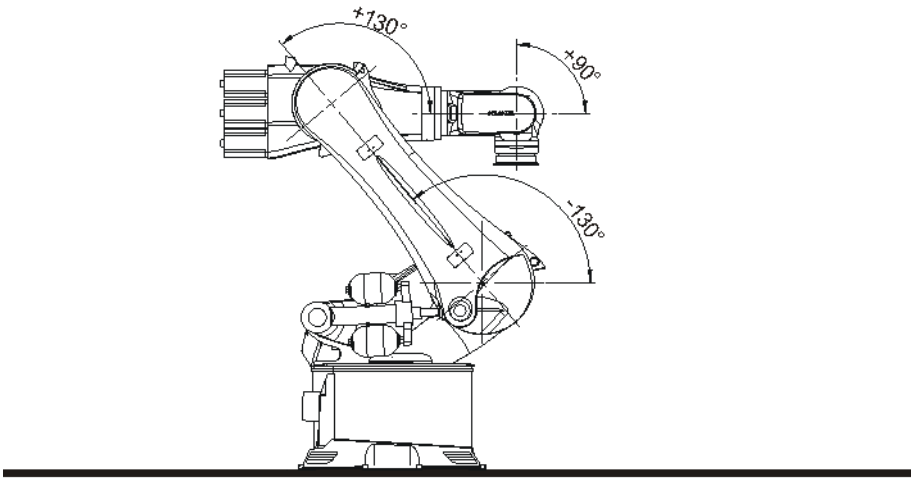

Fig. 7-1: Transport position

Transport dimensions

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

Dimensions: mm

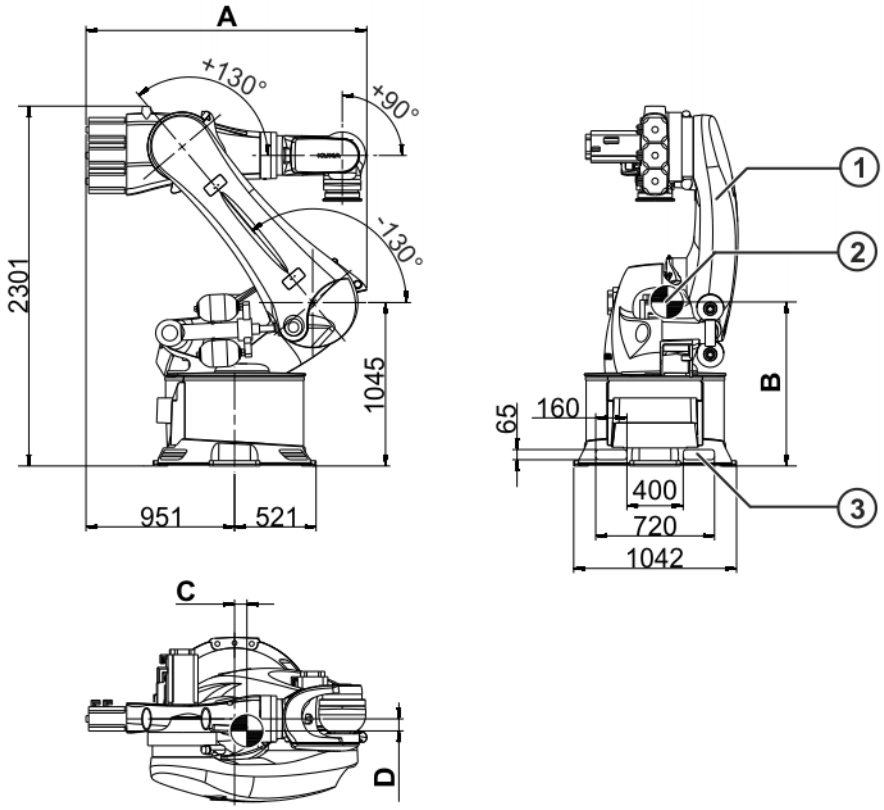

Fig. 7-2: Transport dimensions

1 Robot
2 Center of gravity
3 Fork slots

Robot	A	B	C	D
KR 500 R2830 KR 500 R2830 F KR 500 R2830 C	1,803 mm	1,053 mm	78 mm	77 mm
KR 420 R3080 KR 420 R3080 F	2,040 mm	1,059 mm	100 mm	77 mm
KR 340 R3330 KR 340 R3330 F	2,290 mm	1,069 mm	122 mm	77 mm

Transportation

The robot can be transported by fork lift truck or using lifting tackle.

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

For transport by fork lift truck (>>> Fig. 7-3), two fork slots are provided in the base frame. The robot can be picked up by the fork lift truck from the front and rear. The base frame must not be damaged when inserting the forks into the fork slots. The fork lift truck must have a minimum payload capacity of 3,500 kg and an adequate fork length.

Ceiling-mounted robots can only be transported by fork lift truck.

NOTICE Avoid excessive loading of the fork slots through undue inward or outward movement of hydraulically adjustable forks of the fork lift truck. Failure to do so may result in material damage.

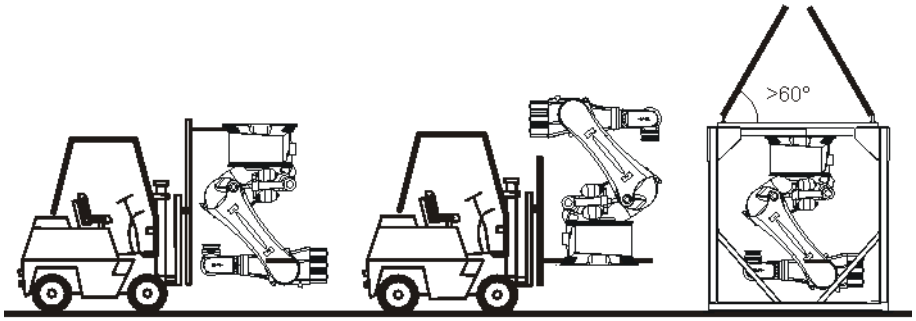

Fig. 7-3: Transportation by fork lift truck

Transportation with lifting tackle

The robot can also be transported using lifting tackle. The robot must be in the transport position.

The lifting tackle must be attached using 3 M20 DIN 580 eyebolts and positioned along the robot as illustrated (>>> Fig. 7-4). The lifting tackle must consist of 3 legs of the following length:

- Length of leg G1: 2,020 mm
- Length of leg G2: 2,140 mm
- Length of leg G3: 1,480 mm

All the legs must be long enough and must be routed in such a way that the robot is not damaged. Installed tools and items of equipment that could be damaged during transportation must be removed.

Installed tools and items of equipment can cause undesirable shifts in the center of gravity, which are liable to cause a collision during transportation. The user shall be liable for any damage to the robot or to other material property resulting from this.

Tools and items of equipment must be removed from a robot before it is exchanged.

⚠ 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!

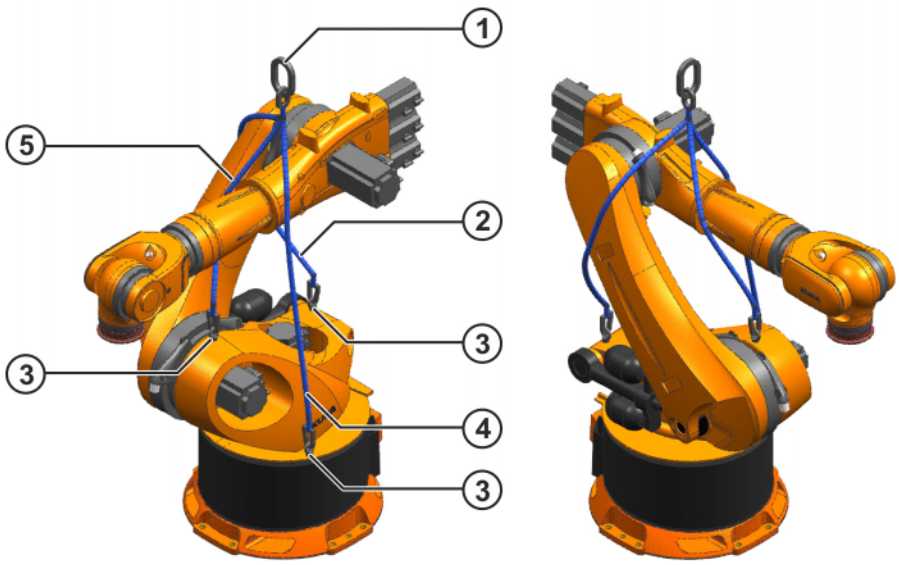

Fig. 7-4: Transportation using lifting tackle

1 Lifting tackle assembly
2 Leg G1 (length: 2,020 mm)
3 M20 DIN 580 eyebolt
4 Leg G2 (length: 2,140 mm)
5 Leg G3 (length: 1,480 mm)

8 Start-up and recommissioning

8.1 Installing the mounting base 175 mm

Description

These instructions apply to the “mounting base” variant for a concrete thickness of at least 175 mm. The robot is fastened to an appropriate concrete foundation using the plate and chemical anchors (resin-bonded anchors).

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

When using chemical anchors (resin-bonded anchors), use only resin capsules and anchors (threaded rods) 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.

Precondition

- 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.
- Lifting tackle with a carrying capacity of 300 kg and 4x M24 DIN 580 eyebolts must be available.

Special tools

The following special tools are required:

- Drill with a ø 18 mm bit
- Setting tool approved by the anchor manufacturer

Procedure

1. Lift the bedplate with fork lift truck or lifting tackle (>>> Fig. 8-1). If using lifting tackle, screw in 4x M24 DIN 580 eyebolts. The bedplate weighs approx. 300 kg.
2. Determine the position of the plate on the foundation in relation to the working envelope.
3. Set the bedplate down on the foundation in its installation position.

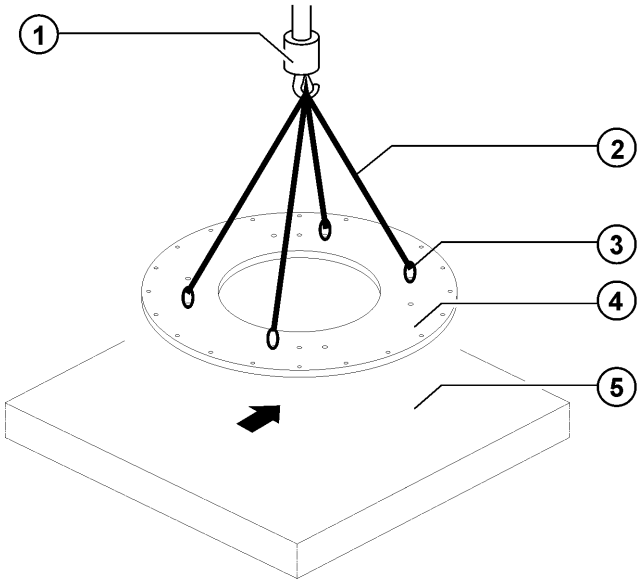

Fig. 8-1: Transporting the plate

1 Crane
2 Lifting tackle
3 Eyebolts
4 Plate
5 Concrete foundation

⚠ WARNING If the bedplate is not fully seated on the foundation, fill the gap with leveling compound. To do this, lift the bedplate again and apply sufficient leveling compound to the underside of the bedplate. Then set the bedplates down again and align them, removing any excess leveling compound. No leveling compound must be allowed to penetrate into the tapped holes for fastening the robot.

4. Check that the bedplate is horizontal. The maximum permissible deviation is 3°.
5. Allow the leveling compound to cure for about 3 hours. The curing time is longer at temperatures below 293 K (20 °C).
6. Remove the 4 eyebolts.
7. Drill 20 anchor holes (>>> Fig. 8-2) through the holes of the bedplates into the foundation.
8. Clean the anchor holes.
9. Insert 20 resin capsules one after the other.
10. Clamp the setting tool with the chemical anchor rod in the drill and insert it into the anchor hole at max. 750 rpm. The chemical 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.

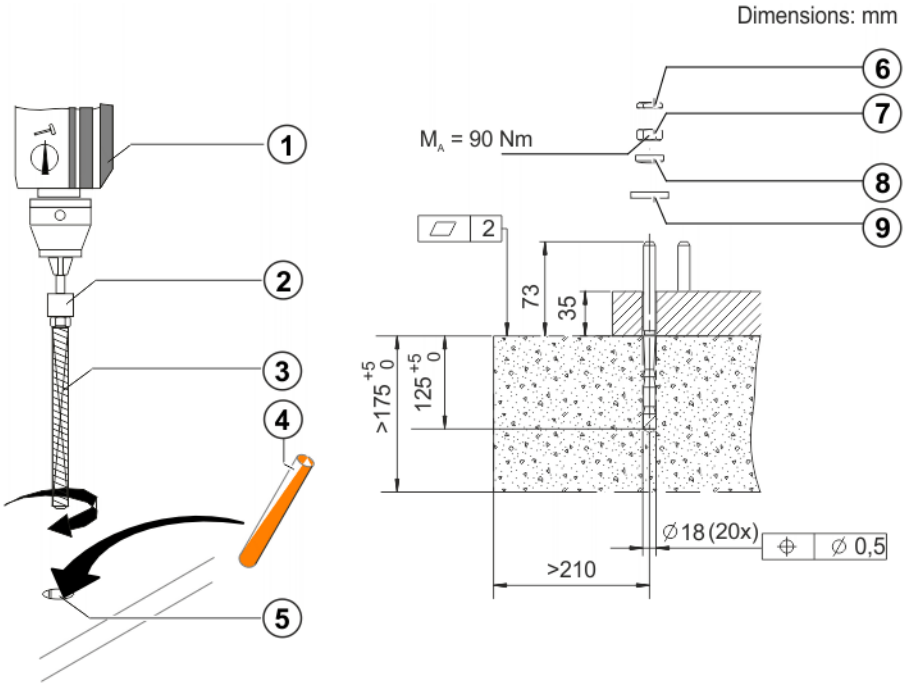

Fig. 8-2: Installing the chemical anchors, 175 mm

1 Drill
2 Setting tool
3 Chemical anchor rod
4 Resin capsule
5 Anchor hole
6 Lock nut
7 Hexagon nut
8 Spherical washer
9 Filling disc

11. Repeat step 10 for all chemical anchors.
12. Allow the resin to cure. See table, or as specified by manufacturer. These values are guide values.

Temperature	Time
≥293 K (+20 °C)	20 minutes
≥283 K (+10 °C)	30 minutes
≥273 K (0 °C)	1 hour

13. Mount filling disc and spherical washer.
14. Fit hexagon nuts and tighten with a torque wrench in diagonally opposite sequence, increasing the tightening torque to 90 Nm in several stages.
15. Fit and tighten the lock nut.
16. Inject injection resin into the hole on the filling disc until the cavity is completely filled. Observe the curing time.

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

8.2 Installing the mounting base 200 mm

Description

These instructions apply to the “mounting base” variant for a concrete thickness of at least 200 mm. The robot is fastened to an appropriate concrete foundation using 4 bedplates and resin-bonded anchors.

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 (Dynamic Set), 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.

Precondition

- 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 18 mm bit
- Setting tool approved by the anchor manufacturer

Procedure

1. Lift the robot with fork lift truck or lifting tackle.
2. Fasten the 4 bedplates to the robot using 2 M24x70 hexagon bolts and conical spring washers for each one; M_A = 640 Nm.

   2 bedplates are fitted with 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. Allow the leveling compound to cure for about 3 hours. The curing time is longer at temperatures below 293 K (+20 °C).
7. Drill 16 anchor holes through the holes of the bedplates into the foundation (>>> 8.2 "Installing the mounting base 200 mm" Page 109).
8. Clean the anchor holes.
9. Insert 16 resin capsules one after the other.
10. Clamp the setting tool with the chemical anchor rod in the drill and insert it into the anchor hole at max. 750 rpm. The chemical 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.

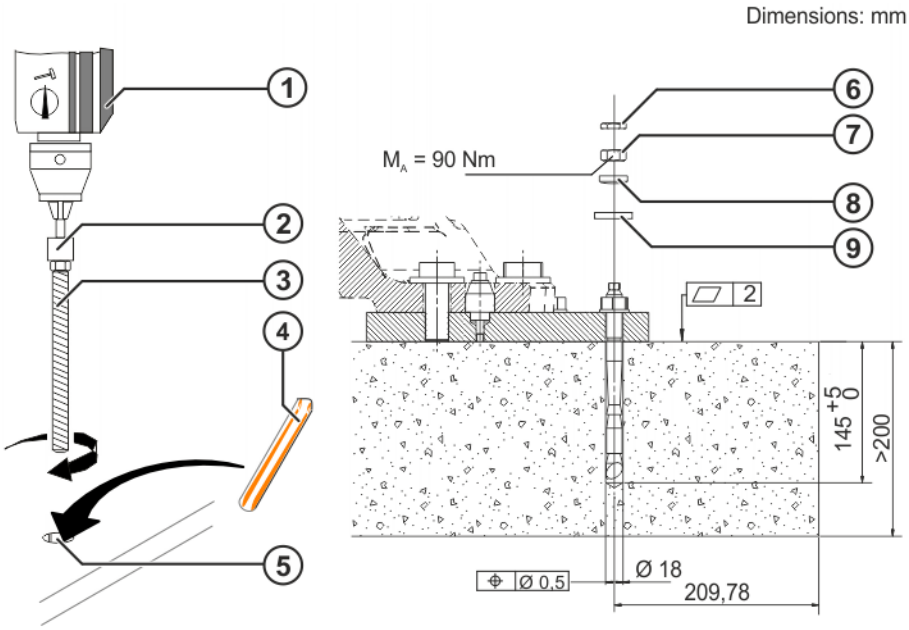

Fig. 8-3: Installing the chemical anchors, 200 mm

1	Drill	6	Lock nut
2	Setting tool	7	Hexagon nut
3	Chemical anchor rod	8	Spherical washer
4	Resin capsule	9	Filling disc
5	Anchor hole		

11. Repeat step 12 for all chemical anchors.
12. Allow the resin to cure. See table, or as specified by manufacturer. These values are guide values.

Temperature	Time
≥293 K (+20 °C)	20 minutes
≥283 K (+10 °C)	30 minutes
≥273 K (0 °C)	1 hour

13. Mount filling disc and spherical washer.
14. Fit hexagon nuts and tighten with a torque wrench in diagonally opposite sequence, increasing the tightening torque to 90 Nm in several stages.
15. Fit and tighten the lock nut.
16. Inject injection resin into the hole on the filling disc until the cavity is completely filled. Observe the curing time.

8.3 Installing 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.

Precondition

- The mounting surface has been prepared as shown in the diagram (>>> Fig. 6-8).
- The substructure has been checked for sufficient safety.
- The machine frame mounting assembly is complete.

Procedure

1. Clean the mounting surface (>>> Fig. 8-4) of the robot.
2. Check the hole pattern.
3. Insert 2 pins and 2 M8x55 Allen screws with conical spring washers and tighten with a torque wrench; M_A = 23 Nm.
4. Prepare 8 M24x70 hexagon bolts and conical spring washers.

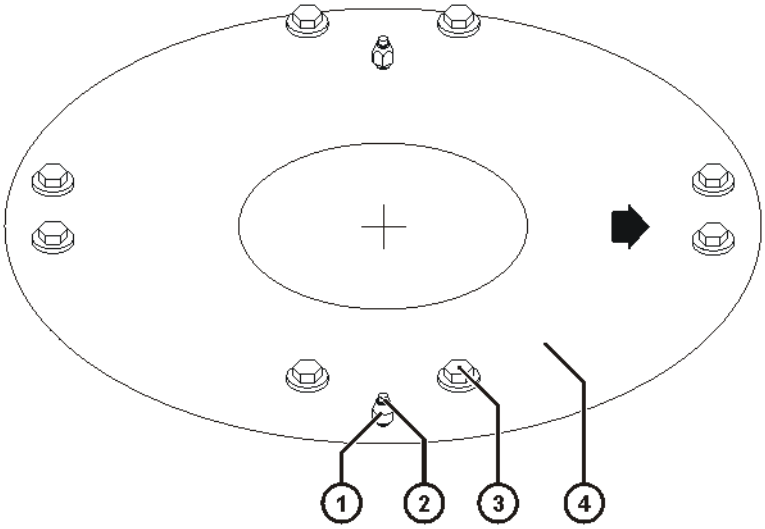

Fig. 8-4: Installing the machine frame mounting assembly

1 Pin
2 Allen screw with conical spring washer (2x)
3 Hexagon bolt with conical spring washer (8x)
4 Mounting surface

The foundation is now ready for the robot to be installed.

8.4 Installing a floor-mounted robot

Description

This description is valid for the installation of floor-mounted robots with the following assembly:

- Mounting base 175 mm
  (>>> 6.2 "Mounting base 175 mm" Page 95)
- Mounting base 200 mm
  (>>> 6.3 "Mounting base 200 mm" Page 97)

8 hexagon bolts with conical spring washers are used for fastening the robot to the bedplate or to a machine frame. A pin and a sword pin are provided to ensure correct positioning.

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

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.
- Compressed air supply to the robot available; F variant only.

Procedure

1. Check that the pins are undamaged and fitted securely.
   (>>> Fig. 8-5)
   (>>> Fig. 8-6)
2. Bring the robot to the installation site by crane or fork lift truck.
   The lifting tackle must not damage the robot.
3. Lower the robot vertically onto the mounting base. Ensure that an entirely vertical position is maintained in order to prevent damage to the pins.
4. Insert 8 M24x70 hexagon bolts with conical spring washers.
5. Tighten 8 hexagon bolts with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to 640 Nm.
6. Remove the fork lift truck or lifting tackle.
7. Connect the motor cables X30.1 and X30.4 and the control cable X31.
8. Connect the ground conductor between the robot controller and the robot to the ground conductor connection.
9. Connect the ground conductor between the system component and the robot to the ground conductor connection.
10. Check the equipotential bonding in accordance with VDE 0100 and EN 60204-1.

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

11. Connect compressed air supply to the pressure regulator and set the pressure regulator to zero; F variant only.
12. Open compressed air supply and set pressure regulator to 0.01 MPa (0.1 bar); F variant only.
13. Mount tooling, if required.
14. Retighten the hexagon bolts with a torque wrench after 100 hours of operation.

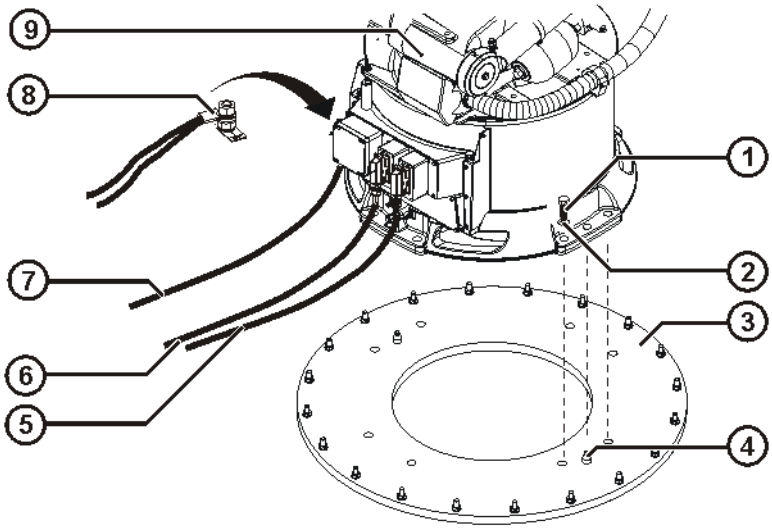

Fig. 8-5: Installing the robot with mounting base 175 mm

1	Hexagon bolt	6	Motor cable X30.1
2	Conical spring washer	7	Control cable
3	Bedplate	8	Ground conductor connection
4	Pin	9	Rotating column
5	Motor cable X30.4		

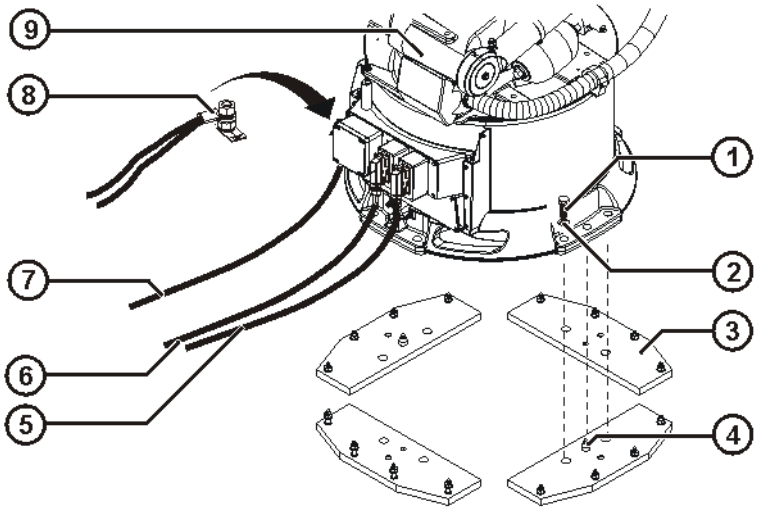

Fig. 8-6: Installing the robot with mounting base 200 mm

1	Hexagon bolt	6	Motor cable X30.1
2	Conical spring washer	7	Control cable
3	Bedplate	8	Ground conductor connection
4	Pin	9	Rotating column
5	Motor cable X30.4		

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.

8.5 Installing a ceiling-mounted robot

Description This description is valid for the installation of ceiling-mounted robots with the mounting variant “Machine frame mounting”. For installation on the ceiling, the

robot can be transported in a transport frame – already in the correct orientation. It is removed from this frame by fork lift truck and brought to the site of installation.

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

Precondition

- The machine frame has been prepared.
- The installation site is accessible with a fork lift truck.
- Any tools or other system components which would hinder the work have been removed.
- The robot is in the transport position and in the ceiling-mounting position.
- The connecting cables and ground conductors are routed to the robot and installed.

Procedure

1. Check that the pins are undamaged and fitted securely.
2. Bring the robot to the installation site with the fork lift truck.
3. Clean the mounting surface on the robot and the gantry.
4. Raise the robot vertically with the fork lift truck and place it against the ceiling structure. Ensure that an entirely vertical position is maintained in order to prevent damage to the pins.
5. Insert 8 M24x100-10.9 hexagon bolts with conical spring washers. Continue pressing the robot against the ceiling structure until all of the hexagon bolts have been inserted and tightened with a torque wrench.
6. Tighten the hexagon bolts with torque wrench. Gradually increase the tightening torque to 860 Nm.
7. Remove the fork lift truck.
8. Connect the motor cables X30.1 and X30.4 and the control cable X31.
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 60204-1.

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.

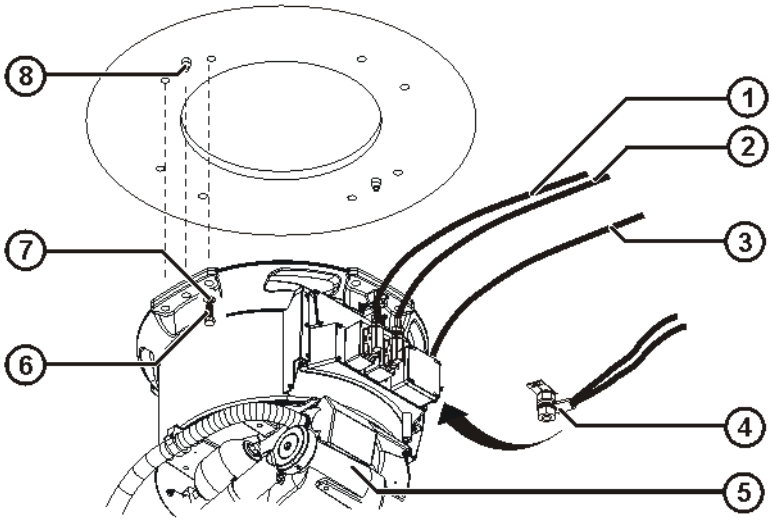

Fig. 8-7: Installing ceiling-mounted robots

1	Motor cable X30.4	5	Rotating column
2	Motor cable X30.1	6	Hexagon bolt
3	Control cable	7	Conical spring washer
4	Ground conductor connection	8	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

Configuration

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

The connecting cables comprise:

- Motor cable (2x)
- Control cable
- Ground conductor, optional

Interface

For connection of the connecting cables between the robot controller and the robot, the following connectors are available at the interfaces:

Cable designation	Connector designation robot controller - robot	Connection
Motor cable	X20.1 - X30.1	HAN size 24
Motor cable	X20.4 - X30.4	HAN size 24
Data cable	X21 - X31	Rectangular connector
Ground conductor / equipotential bonding 16 mm^2 (optional)		M8 ring cable lug

For the connecting cables, a ground conductor is always required to provide a low-resistance connection between the robot and the control cabinet in accordance with DIN EN 60204. The ground conductor is not part of the scope of supply and can be ordered as an option. The connection must be made by the customer. The tapped holes for connecting the ground conductor are located on the base frame of the robot.

Standard connecting cable

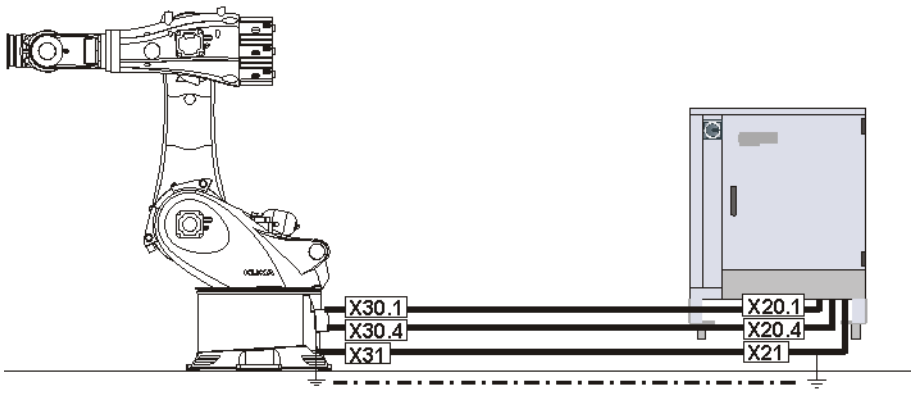

Fig. 8-8: Connecting cables, overview

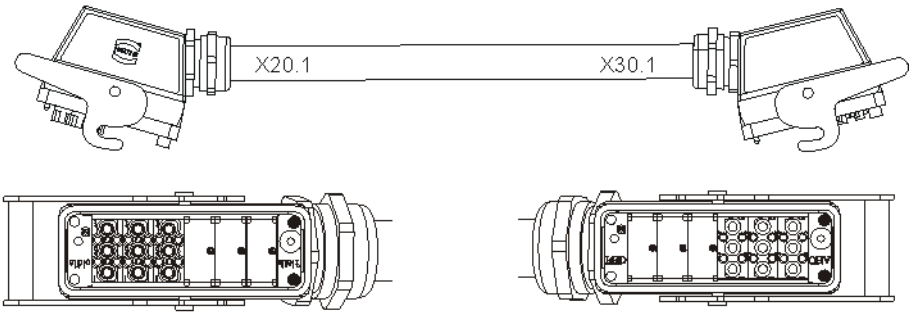

Fig. 8-9: Connecting cable, motor cable, X20.1 - X30.1

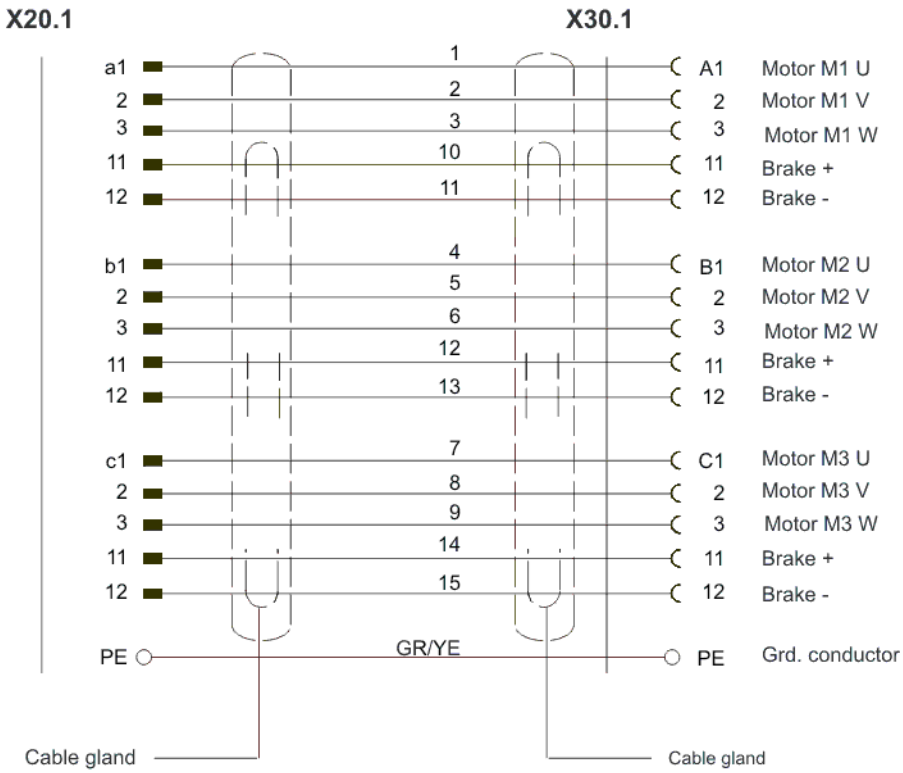

Fig. 8-10: Wiring diagram, motor cable X20.1 - X30.1

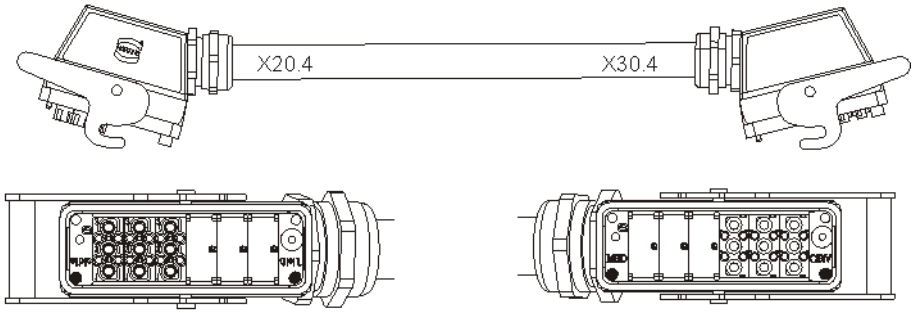

Fig. 8-11: Connecting cable, motor cable, X20.4 - X30.4

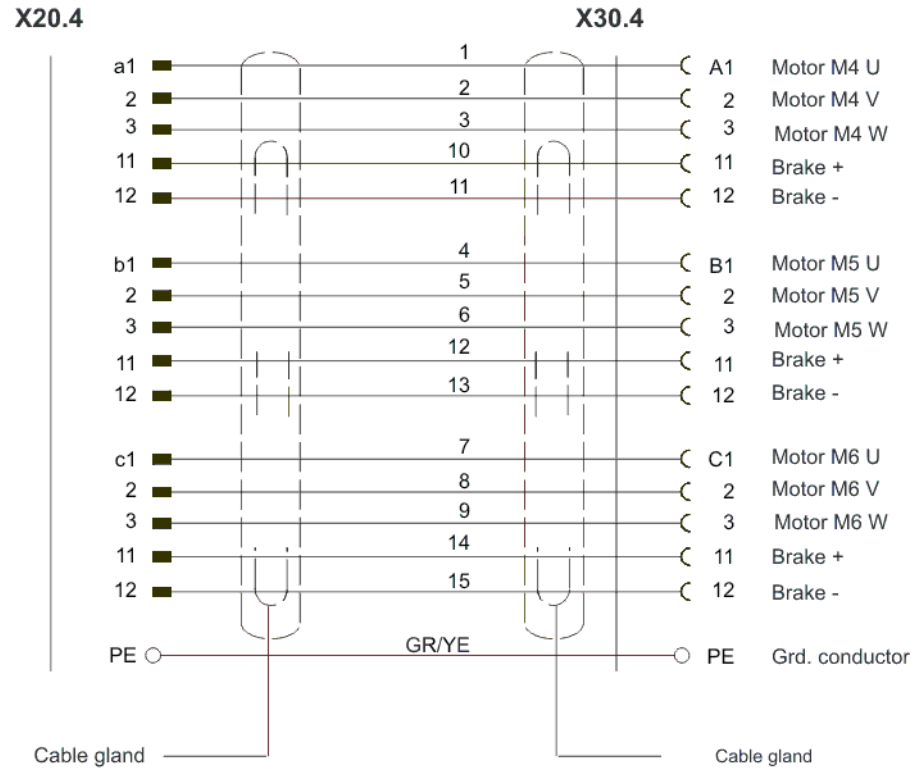

Fig. 8-12: Wiring diagram, motor cable X20.4-X30.4

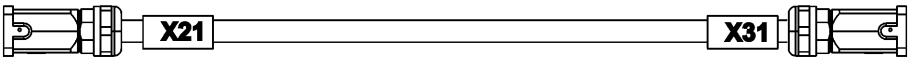

Fig. 8-13: Connecting cable, data cable X21 - X31

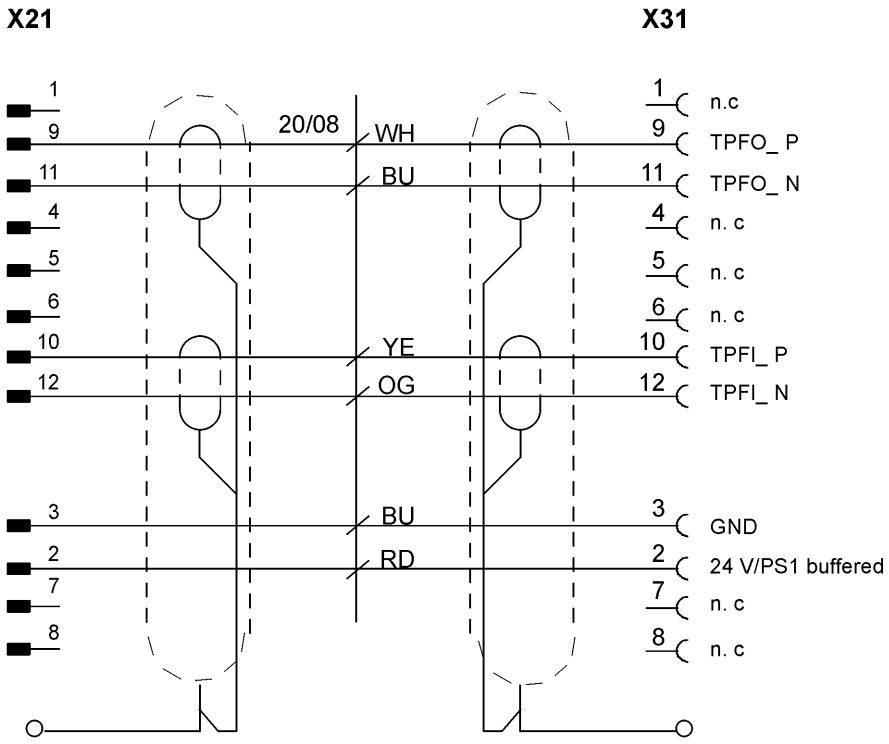

Fig. 8-14: Connecting cable, wiring diagram, data cable X21 - X31

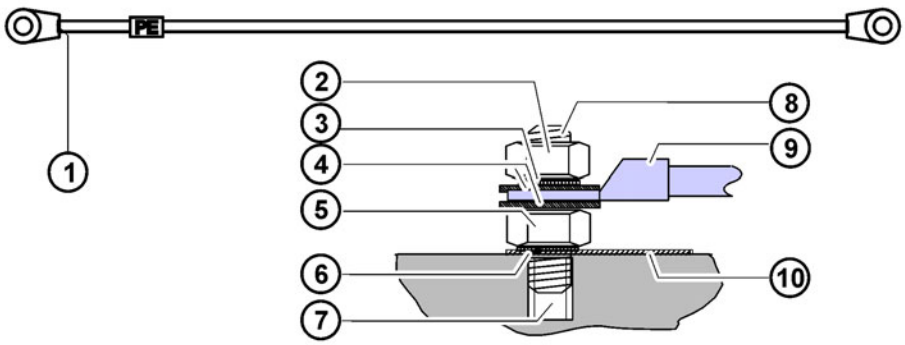

Fig. 8-15: Connecting cable, ground conductor

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

8.7 Moving the manipulator without drive energy

Description

The release device (optional) can be used for moving the manipulator after an accident or malfunction without drive energy.

This option is only for use in exceptional circumstances and emergencies, e.g. for freeing people.

Precondition

- Robot controller is switched off.

Procedure

SAFETY INSTRUCTIONS	The following procedure must be followed exactly!

1. Remove the protective cap from the motor (>>> Fig. 8-16).
2. 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.

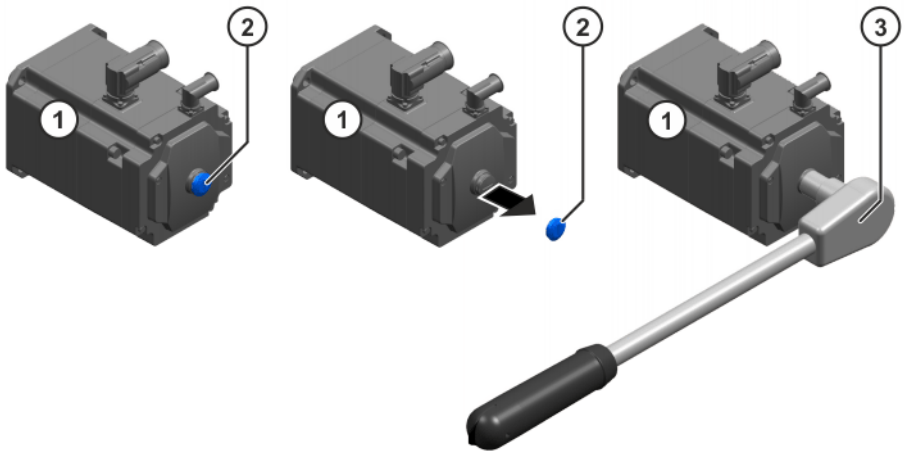

Fig. 8-16: Fitting the release device onto the motor

1	Motor	3	Release device
2	Protective cap		

⚠ 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/rechargeable screwdriver with torque bracket, all robot axes must be remastered. Injuries or damage to property may otherwise result.

9 Maintenance

9.1 Maintenance symbols

Maintenance symbols

	Oil change
	Lubricate with grease gun
	Lubricate with brush
	Tighten screw/nut
	Check component, visual inspection
	Clean component
	Exchange battery

9.2 Maintenance table

Description

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

The maintenance intervals given in the table are valid for the operating conditions specified in the technical data. KUKA Roboter GmbH must be consulted in the case of discrepancies.

Further information can be found in the section “Information for planning” (>>> 6.1 "Information for planning" Page 95).

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. Non-approved lubricants may cause premature wear and failure of assemblies.

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.

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.

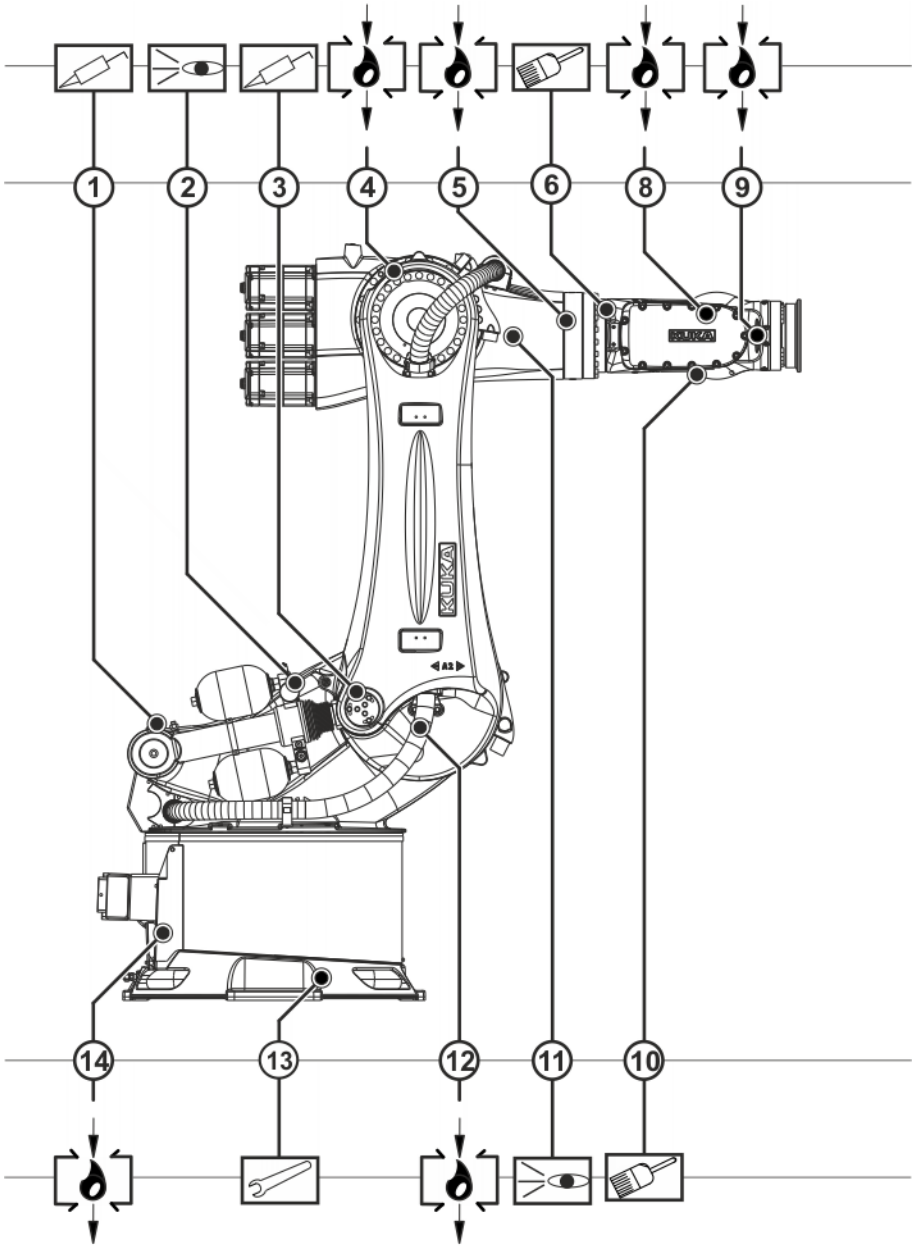

Fig. 9-1: Maintenance work

Interval	Item	Activity	Lubricant
100 h*	13	Check tightening torque for anchor nuts and holding-down bolts. * Once only, after initial start-up or recommissioning.	-
10,000 h 5,000 h for in-line wrist F	6	O-ring A4 Lift O-ring out of groove and remove old grease. Grease O-ring with brush and fit it back into groove (>>> 9.3 "Regreasing the seal (O-ring) on A4" Page 125)	Optigear Olit CLS Art. no. 83-087-241 10 g
10,000 h 5,000 h for in-line wrist F	10	O-ring A5 Lift O-ring out of groove and remove old grease. Grease O-ring with brush and fit it back into groove (>>> 9.4 "Regreasing the seal (O-ring) on A5" Page 126)	Optigear Olit CLS Art. no. 83-087-241 10 g
5,000 h* or 1 year at the latest	1	Lubricate bearings of counterbalancing system on rotating column. Grease nipples in the middle position and at the plus and minus end positions. *In the case of frequently recurring, short-distance movements (less than 40°) about axis 2, the maintenance interval is 3000 hours.	SKF LGEV2 Art. no. 00-111-651 10 cm^3
5,000 h* or 1 year at the latest	3	Lubricate bearings of counterbalancing system on link arm. Grease nipples in the middle position and at the plus and minus end positions. *In the case of frequently recurring, short-distance movements (less than 40°) about axis 2, the maintenance interval is 3000 hours.	SKF LGEV2 Art. no. 00-111-651 10 cm^3
5,000 h	2	Carry out a visual inspection of the counterbalancing system, check the condition, check that the pressure is correct and check for leaks.	Hyspin ZZ 46 Art. no. 83-236-202

Interval	Item	Activity	Lubricant
15,000 h or 6 years at the latest*	11	Check drive shafts for axial play. (>>> 9.6 "Checking drive shafts A4 to A6" Page 139) In the case of axial play in the universal joint, exchange the drive shaft. (>>> 10.4 "Exchanging motors and drive shafts A4 to A6" Page 162) After initial inspection, the universal shafts must be checked for play once a year. * Once only, after initial start-up or recommissioning.	-
20,000 h	4	Carry out oil change on A3. (>>> 9.9 "Changing the gear oil on A3" Page 145)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 3.5 l
20,000 h 10,000 h for in-line wrist F	5	Carry out oil change on A4. (>>> 9.10 "Changing the gear oil on A4" Page 147)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 2.2 l
20,000 h 10,000 h for in-line wrist F	8	Carry out oil change on A5. (>>> 9.11 "Changing the gear oil on A5" Page 149)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 2.5 l
20,000 h 10,000 h for in-line wrist F	9	Carry out oil change on A6. (>>> 9.12 "Changing the gear oil on A6" Page 150)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 5.2 l
20,000 h	12	Carry out oil change on A2. (>>> 9.8 "Changing the gear oil on A2" Page 143)	Optigear Synthetic RO 150 Art. no. 00-144-898 Quantity of oil 10.0 l
20,000 h	14	Carry out oil change on A1. (>>> 9.7 "Changing the gear oil in A1" Page 141)	Optigear Synthetic RO 150 Art. no. 00-144-898 Floor-mounted robot: 11.0 l Ceiling-mounted robot: 13.0 l

Interval	Item	Activity	Lubricant
20,000 h or 5 years at the latest		Grease cables of cable set and energy supply system. (>>> 9.13 "Greasing the cable set" Page 152)	Cable grease RB1 Art. no. 00.101-456 200 cm^3
1 year*	11	Check drive shafts for axial play. (>>> 9.6 "Checking drive shafts A4 to A6" Page 139) In the case of axial play in the universal joint, exchange the drive shafts. (>>> 10.4 "Exchanging motors and drive shafts A4 to A6" Page 162) * After initial inspection	-

9.3 Regreasing the seal (O-ring) on A4

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. Pull O-ring A4 out of the groove.
2. Remove old grease from O-ring A4.
3. Perform a visual inspection of O-ring A4.
   In the case of damage and cracks, inform KUKA Service.
4. Grease O-ring A4 with Optimol Olit CLS using a brush.
5. Insert O-ring A4 back into the groove.

NOTICE The O-ring in the groove must not be twisted.

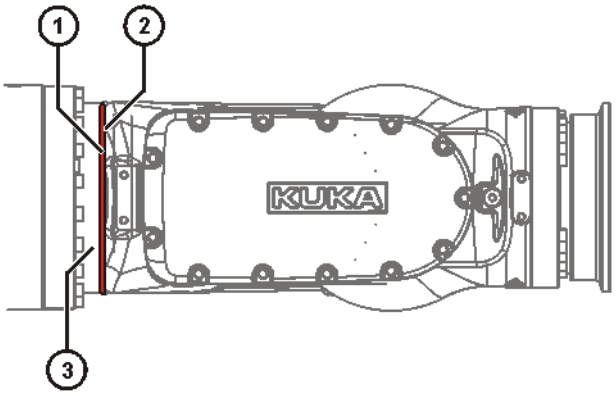

Fig. 9-2: Regreasing seal (O-ring) on A4

1 O-ring (marked in red)
2 Groove
3 Gear unit A4

9.4 Regreasing the seal (O-ring) on A5

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. Pull O-ring A5 out of the groove.
2. Remove old grease from O-ring A5.
3. Perform a visual inspection of O-ring A5.
   In the case of damage and cracks, inform KUKA Service.
4. Grease O-ring A5 with Optimol Olit CLS using a brush.
5. Push O-ring A5 back into the groove.

NOTICE The O-ring in the groove must not be twisted.

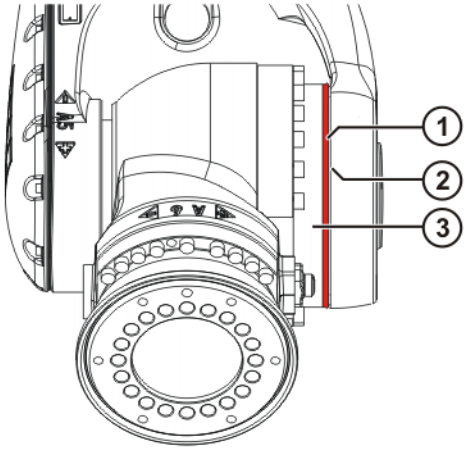

Fig. 9-3: Checking and regreasing the seal on A5

1	O-ring (marked in red)	3	Gear unit A5
2	Groove		

9.5 Checking the counterbalancing system

Description

The following describes those tasks which must be carried out at the intervals specified in the maintenance table.

Precondition

- The robot is operational and can be moved at jog velocity.
- There is no hazard posed by system components or other robots.
- The robot is secured if work is being performed directly on the robot.

⚠ 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.

Procedure

Activity	Corrective action
Check hydraulic oil pressure. 1. Move axis 2 manually to -90°. The link arm is now vertical, while the arm may be in any position. Then wait 1 minute. 2. Check the following pressure on the pressure gauge: ■ Floor-mounted robot: 130 bar ■ Ceiling-mounted robot: 230 bar	Re-adjust the counterbalancing system. (>>> 9.5.1.3 "Filling and adjusting the counterbalancing system on a floor-mounted robot" Page 130) (>>> 9.5.1.5 "Filling and adjusting the counterbalancing system on a ceiling-mounted robot (fastened to ceiling)" Page 136)
Check the attachments for damage and ensure that they are clean and do not leak.	Clean the counterbalancing system, identify and eliminate any leaks. If necessary, exchange the counterbalancing system. (>>> 10.5 "Exchanging the counterbalancing system on floor-mounted robots" Page 166)
Check the collar for dirt and damage.	Clean or exchange the collar. (>>> 10.5 "Exchanging the counterbalancing system on floor-mounted robots" Page 166)

9.5.1 Counterbalancing system

Description Depending on various causes, the following work may be required on the counterbalancing system:

Cause	Activity	Description
Incorrect pressure.	1. Depressurize 2. Fill and adjust	Depressurize: ■ (>>> 9.5.1.1 "Depressurizing the counterbalancing system on a floor-mounted robot" Page 128) ■ (>>> 9.5.1.2 "Depressurizing the counterbalancing system on a ceiling-mounted robot" Page 129) Fill and adjust: ■ (>>> 9.5.1.3 "Filling and adjusting the counterbalancing system on a floor-mounted robot" Page 130) ■ (>>> 9.5.1.4 "Filling and adjusting the counterbalancing system on a ceiling-mounted robot (fastened to floor)" Page 133) ■ (>>> 9.5.1.5 "Filling and adjusting the counterbalancing system on a ceiling-mounted robot (fastened to ceiling)" Page 136)
The counterbalancing system has been drained and must be refilled.	Top up the gas and oil pressure.	(>>> 9.5.1.3 "Filling and adjusting the counterbalancing system on a floor-mounted robot" Page 130)

⚠ 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.

Robot	Floor-mounted robots		Ceiling-mounted robots			
			Filling on the floor A2 at -130°		Filling on the ceiling A2 at -90°	
	Gas pressure P_0	Oil pressure P_1	Gas pressure P_0	Oil pressure P_1	Gas pressure P_0	Oil pressure P_1
KR 360-3 KR 500-3	100 bar	130 bar	150 bar	218 bar	150 bar	230 bar
KR 360 L280-3 KR 500 L420-3	100 bar	130 bar	150 bar	218 bar	150 bar	230 bar
KR 360 L240-3 KR 500 L340-3	100 bar	130 bar	-	-	-	-

9.5.1.1 Depressurizing the counterbalancing system on a floor-mounted robot

Description These instructions are valid for floor-mounted robots.

Precondition
- A measuring tube and collection receptacle must be available.
- The robot must be firmly bolted to the floor.

Procedure
1. Move the link arm into a vertical position and secure it using a crane (>>> Fig. 9-4).
   The link arm must not be able to move after reducing the oil pressure.

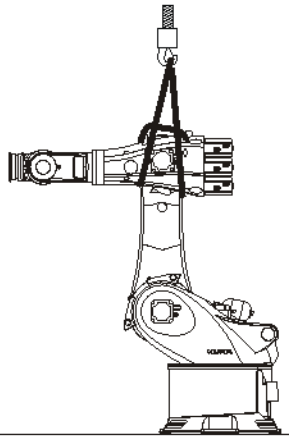

Fig. 9-4: Securing the link arm

2. Remove the screw cap and connect the tube to the vent connection (>>> Fig. 9-5).
3. Drain the hydraulic oil into a suitable receptacle.
   The draining process is complete when the pressure gage indicating the oil pressure reads zero and no more oil flows into the receptacle.
4. Dispose of used hydraulic oil with minimum environmental impact.

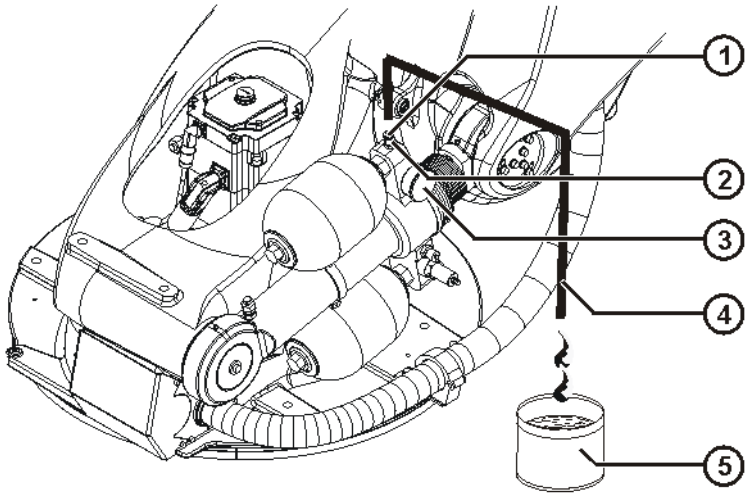

Fig. 9-5: Draining the hydraulic oil

1	Screw cap	4	Tube
2	Vent connection	5	Collection receptacle
3	Pressure gauge		

9.5.1.2 Depressurizing the counterbalancing system on a ceiling-mounted robot

Description These instructions are valid for ceiling-mounted robots.

Precondition
- A measuring tube and collection receptacle must be available.

Procedure
1. Move the link arm to the -130° position and secure it.
   The link arm must not be able to move after reducing the oil pressure.
2. Remove the screw cap and connect the tube to the vent connection (>>> Fig. 9-6).
3. Drain the hydraulic oil into a suitable receptacle.
   The draining process is complete when the pressure gage indicating the oil pressure reads zero and no more oil flows into the receptacle.
4. Dispose of used hydraulic oil with minimum environmental impact.

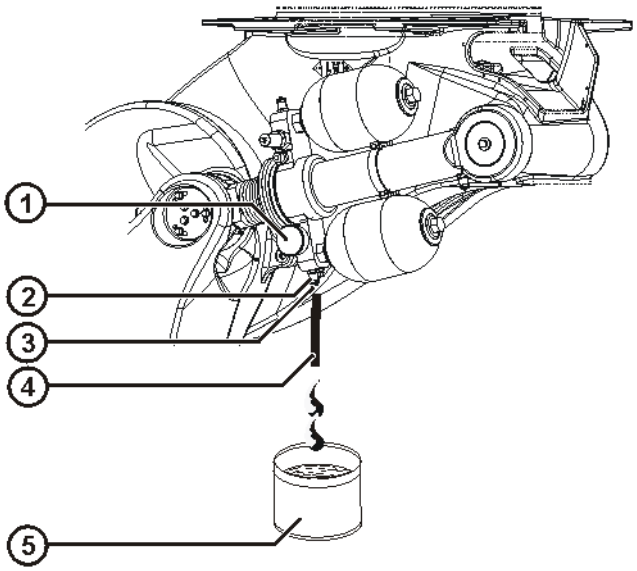

Fig. 9-6: Draining the hydraulic oil

1	Pressure gauge	4	Tube
2	Vent connection	5	Collection receptacle
3	Screw cap		

9.5.1.3 Filling and adjusting the counterbalancing system on a floor-mounted robot

Description

These instructions are valid for floor-mounted robots.

The gas pressure must always be set on both diaphragm accumulators!

Precondition

- A measuring tube and collection receptacle must be available.
- A nitrogen cylinder with pressure reducer must be available. Minimum pressure 120 bar.
- An accumulator filling device must be available.
- A hydraulic pump must be available.
- The robot must be firmly bolted to the floor.

Procedure

1. Move the link arm into a vertical position and secure it using a crane (>>> Fig. 9-7).
   The link arm must not be able to move after reducing the hydraulic oil pressure.

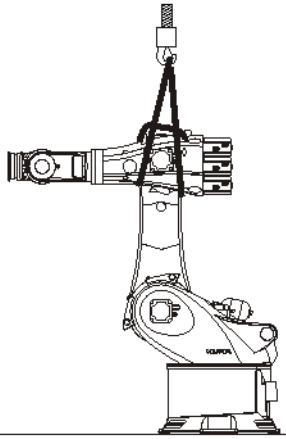

Fig. 9-7: Securing the link arm

2. Remove the screw cap and connect the tube to the vent valve (>>> Fig. 9-8).
3. Place a suitable receptacle under the tube and collect the hydraulic oil.

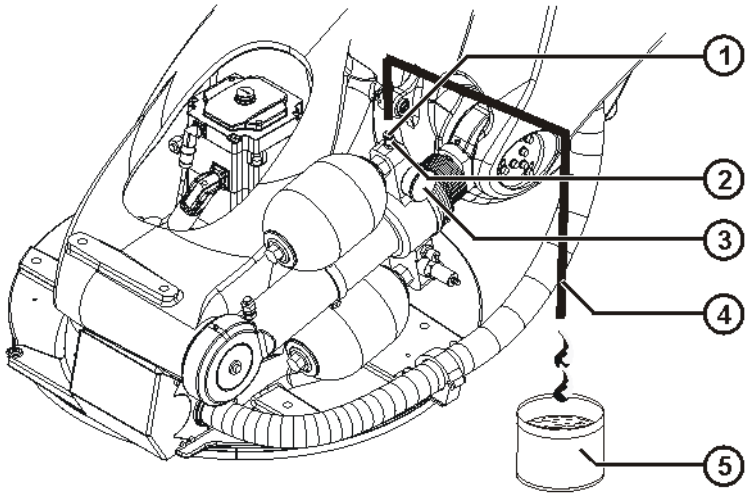

Fig. 9-8: Draining the hydraulic oil

1	Screw cap	4	Tube
2	Vent valve	5	Collection receptacle
3	Pressure gauge		

4. Drain the oil until the pressure gauge reads zero.

   The oil side of the diaphragm accumulator is now depressurized and can be vented during subsequent filling of the gas side.
5. Connect the filling and testing device (accessory) for the diaphragm accumulator to a standard commercial nitrogen cylinder via the tube and a pressure reducer.
6. Set the pressure reducer to 120 bar.

⚠ WARNING For safety reasons, the Allen screw on the accumulator may under no circumstances be unscrewed by more than a quarter of a turn without the filling and testing device being connected. The pressure in the accumulator may never be adjusted without the filling and testing device connected.

7. Remove the protective caps from the diaphragm accumulator and unscrew the Allen screw slightly (without a torque wrench, by a quarter of a turn at the most) (>>> Fig. 9-9).

   No gas must be allowed to escape. If, in spite of care being taken, gas does escape (hissing sound!), the sealing ring of Allen screw must be replaced. This must only be done when the diaphragm accumulator is completely depressurized.
8. Connect the filling and testing device to the gas connection of the diaphragm accumulator. Turn the gas valve rod counterclockwise, thereby opening the gas connection via the Allen screw; a full turn is necessary after the start of pointer deflection on the pressure gauge of the filling and testing device.

   The pressure gauge on the counterbalancing system indicates the nitrogen pressure in the diaphragm accumulator. If the nitrogen pressure is greater than 100 bar, carry out step 9. If the nitrogen pressure is too low, carry out steps 10 to 11. Then in either case, continue with step 12.
9. Open the pressure relief valve and discharge nitrogen until the specified pressure of 100 bar is reached.

   The reading on the pressure gauge must be rechecked after 2 to 3 minutes and the nitrogen pressure corrected if necessary.
10. Open the shut-off valve on the nitrogen cylinder and raise the nitrogen pressure to 110 bar.

11. Close the shut-off valve.
12. Open the pressure relief valve and discharge nitrogen until the specified pressure of 100 bar is reached.

    The reading on the pressure gauge must be rechecked after 2 to 3 minutes and the nitrogen pressure corrected if necessary.
13. Turn the Allen screw clockwise by means of the gas valve rod and tighten it. Then open the pressure relief valve and discharge the remaining pressure in the tube.
14. Disconnect filling and testing device from diaphragm accumulator.

    The filling and testing device may only be disconnected if the Allen screw has been tightened by means of the gas valve rod.
15. Firmly retighten the Allen screw; M_A = 20 Nm.
16. Carry out steps 7 to 15 for the 2nd diaphragm accumulator.
17. Screw on the protective caps.

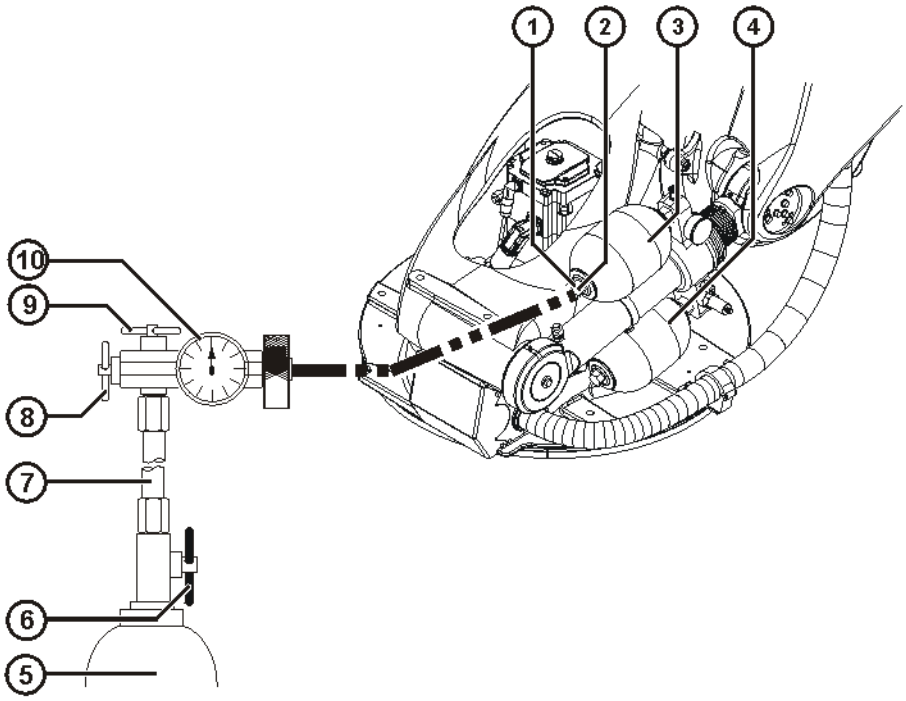

Fig. 9-9: Setting the gas pressure

1	Protective cap	6	Shut-off valve
2	Allen screw	7	Tube
3	Diaphragm accumulator 1	8	Gas valve rod
4	Diaphragm accumulator 2	9	Pressure relief valve
5	Nitrogen cylinder	10	Pressure gauge

18. Release and remove the tube on the nitrogen cylinder.
19. Unscrew the screw cap on the filler neck and connect the hydraulic tube (>>> Fig. 9-10).

    The hydraulic tube must already be free from air.
20. Unscrew the screw cap on the vent connection and connect the measuring tube (unless the tube is still connected from the preceding tasks).
21. Dip the measuring tube into the liquid in the collection receptacle.
22. Put the hydraulic pump into operation and allow hydraulic oil to flow out into the collection receptacle until no more bubbles escape.

    The reservoir of the hydraulic pump must only be filled with filtered Hyspin ZZ 46 (filter gauge 3 µm).

23. Close the vent valve at the vent connection.
24. Continue to operate the hydraulic pump until the hydraulic oil pressure is approx. 10 bar above the specified value of 130 bar. Then lower the pump pressure to “0”.
25. After approx. 10 minutes, check the hydraulic oil pressure and reduce it to 130 bar by opening the vent valve.
26. Unscrew the hydraulic tube and screw the screw cap back onto the filler neck.
27. Unscrew the measuring tube and screw the screw cap back onto the vent connection.
28. Unscrew the screw plugs from the underside of the counterbalancing system and remove any leaked oil. Then screw the screw plugs back in and tighten them with M_A = 20 Nm.
29. Check the counterbalancing system for leaks.
30. Remove crane and elements securing the link arm.

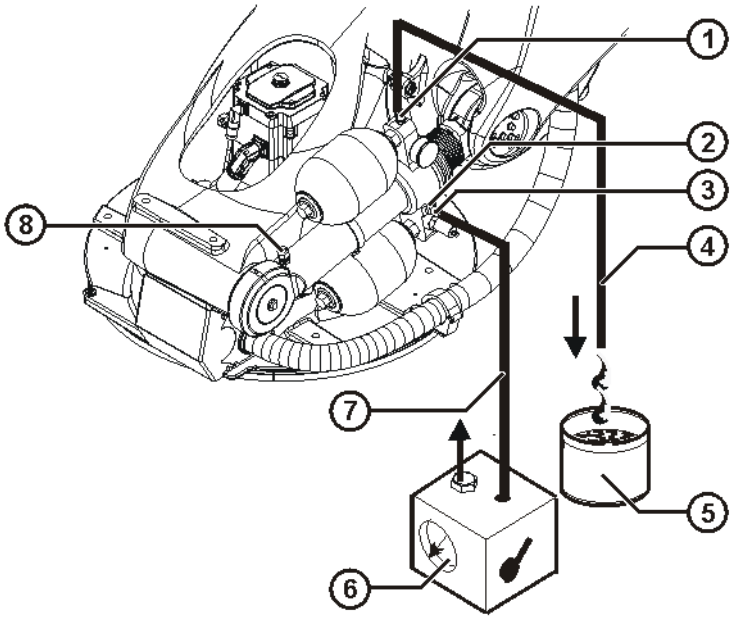

Fig. 9-10: Topping up the hydraulic oil

1	1st vent connection	5	Collection receptacle
2	Filler neck	6	Hydraulic pump
3	Screw plug	7	Hydraulic hose
4	Measuring tube	8	2nd vent connection

9.5.1.4 Filling and adjusting the counterbalancing system on a ceiling-mounted robot (fastened to floor)

Description

The following instructions apply to ceiling-mounted robots (C variant). To fill and adjust the counterbalancing system, the ceiling-mounted robot must be removed from the ceiling and securely fastened to the floor (to the foundation).

The gas pressure must always be set on both diaphragm accumulators, and additional venting must be carried out on the cylinder base (on the piston side).

Precondition

- A measuring tube and collection receptacle must be available.
- A nitrogen cylinder with pressure reducer must be available. Minimum pressure 170 bar.
- An accumulator filling device must be available.

- A hydraulic pump must be available.

Procedure

1. Move the link arm to the -130° position and secure it.
   The link arm must not be able to move after reducing the hydraulic oil pressure.
2. Remove the screw cap and connect the tube to the vent valve (>>> Fig. 9-11).
3. Place a suitable receptacle under the tube and collect the hydraulic oil.

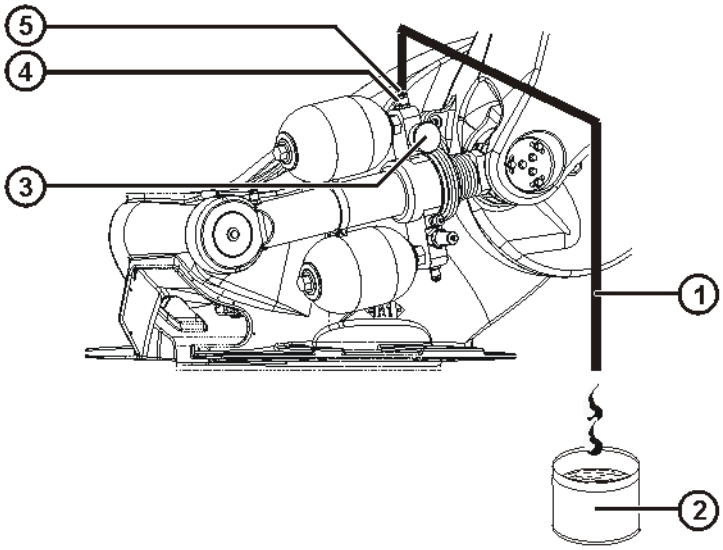

Fig. 9-11: Draining the hydraulic oil

1	Tube	4	Vent valve
2	Collection receptacle	5	Screw cap
3	Pressure gauge		

4. Drain the oil until the pressure gauge reads zero.
   The oil side of the diaphragm accumulator is now depressurized and can be vented during subsequent filling of the gas side.
5. Connect the filling and testing device (accessory) for the diaphragm accumulator to a standard commercial nitrogen cylinder via the tube and a pressure reducer.
6. Set the pressure reducer to 150 bar.

⚠ WARNING For safety reasons, the Allen screw on the accumulator may under no circumstances be unscrewed by more than a quarter of a turn without the filling and testing device being connected. The pressure in the accumulator may never be adjusted without the filling and testing device connected.

7. Remove the protective caps from the diaphragm accumulator and unscrew the Allen screw slightly (without a torque wrench, by a quarter of a turn at the most) (>>> Fig. 9-12).
   No gas must be allowed to escape. If, in spite of care being taken, gas does escape (hissing sound!), the sealing ring of Allen screw must be replaced. This must only be done when the diaphragm accumulator is completely depressurized.
8. Connect the filling and testing device to the gas connection of the diaphragm accumulator. Turn the gas valve rod counterclockwise, thereby opening the gas connection via the Allen screw; a full turn is necessary after the start of pointer deflection on the pressure gauge of the filling and testing device.

The pressure gauge on the counterbalancing system indicates the nitrogen pressure in the diaphragm accumulator. If the nitrogen pressure is greater than 150 bar, carry out step 9. If the nitrogen pressure is too low, carry out steps 10 to 11. Then in either case, continue with step 12.

9. Open the pressure relief valve and discharge nitrogen until the specified pressure of 150 bar is reached.

   The reading on the pressure gauge must be rechecked after 2 to 3 minutes and the nitrogen pressure corrected if necessary.

10. Open the shut-off valve on the nitrogen cylinder and raise the nitrogen pressure to 160 bar.
11. Close the shut-off valve.
12. Open the pressure relief valve and discharge nitrogen until the specified pressure of 150 bar is reached.

    The reading on the pressure gauge must be rechecked after 2 to 3 minutes and the nitrogen pressure corrected if necessary.

13. Turn the Allen screw clockwise by means of the gas valve rod and tighten it. Then open the pressure relief valve and discharge the remaining pressure in the tube.
14. Disconnect filling and testing device from diaphragm accumulator.

    The filling and testing device may only be disconnected if the Allen screw has been tightened by means of the gas valve rod.

15. Firmly retighten the Allen screw; M_A = 20 Nm.

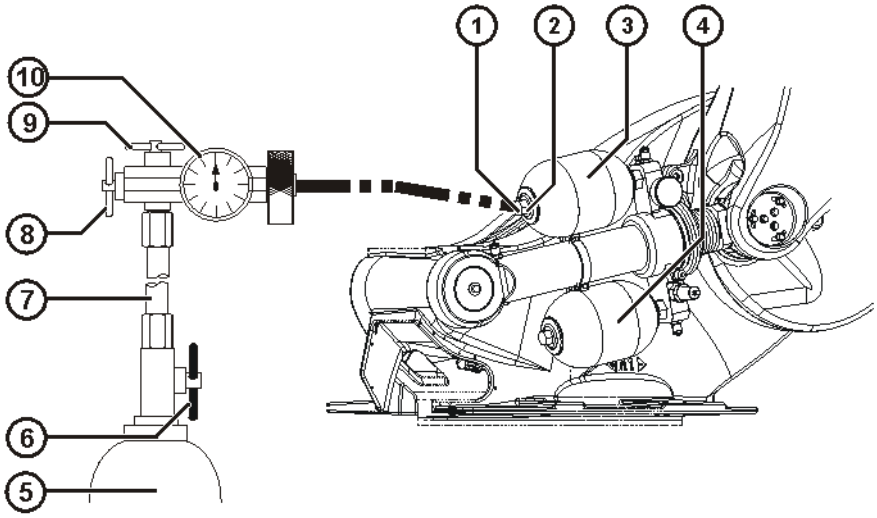

Fig. 9-12: Setting the gas pressure

1	Protective cap	6	Shut-off valve
2	Allen screw	7	Tube
3	Diaphragm accumulator 1	8	Gas valve rod
4	Diaphragm accumulator 2	9	Pressure relief valve
5	Nitrogen cylinder	10	Pressure gauge

16. Screw on the protective caps.
17. Carry out steps 7 to 15 for the 2nd diaphragm accumulator.
18. Release and remove the tube on the nitrogen cylinder.
19. Unscrew the screw cap on the filler neck and connect the hydraulic tube (>>> Fig. 9-13).

    The hydraulic tube must already be free from air.

20. Unscrew the screw cap on the vent connection and connect the measuring tube (unless the tube is still connected from the preceding tasks).

21. Dip the measuring tube into the liquid in the collection receptacle.
22. Put the hydraulic pump into operation and allow hydraulic oil to flow out into the collection receptacle until no more bubbles escape.

    The reservoir of the hydraulic pump must only be filled with filtered Hyspin ZZ 46 (filter gauge 3 µm).
23. Close the vent valve at the vent connection.
24. Carry out steps 18 to 23 for the second vent connection.
25. Continue to operate the hydraulic pump until the hydraulic oil pressure is approx. 10 bar above the specified value of 218 bar. Then lower the pump pressure to “0”.
26. After approx. 10 minutes, check the hydraulic oil pressure and reduce it to 218 bar by opening the vent valve.
27. Unscrew the hydraulic tube and screw the screw cap back onto the filler neck.
28. Unscrew the measuring tube and screw the screw cap back onto the vent connection.
29. Check the counterbalancing system for leaks.
30. Remove crane and elements securing the link arm.

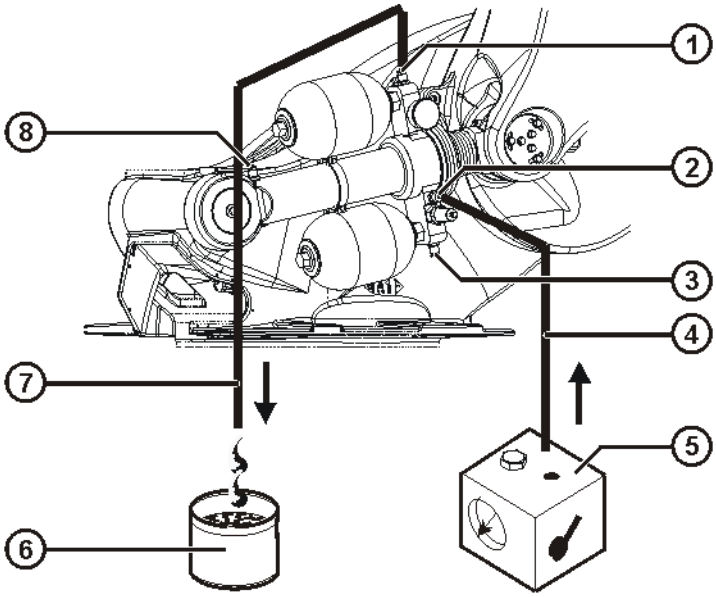

Fig. 9-13: Topping up the hydraulic oil

1	1st vent connection	5	Hydraulic pump
2	Filler neck	6	Collection receptacle
3	Sealing cap	7	Measuring tube
4	Hydraulic hose	8	2nd vent connection

9.5.1.5 Filling and adjusting the counterbalancing system on a ceiling-mounted robot (fastened to ceiling)

Description

These instructions are valid for ceiling-mounted robots (C variant) that are fastened to the ceiling when filling and setting the counterbalancing system.

The gas pressure must always be set on both diaphragm accumulators, and additional venting must be carried out on the cylinder base (on the piston side).

Precondition

- A measuring tube and collection receptacle must be available.
- A nitrogen cylinder with pressure reducer must be available. Minimum pressure 170 bar.

- An accumulator filling device must be available.
- A hydraulic pump must be available.

Procedure

1. Move the link arm to the -90° position and secure it.
   The link arm must not be able to move after reducing the hydraulic oil pressure.
2. Remove the screw cap and connect the tube to the vent valve (>>> Fig. 9-14).
3. Place a suitable receptacle under the tube and collect the hydraulic oil.

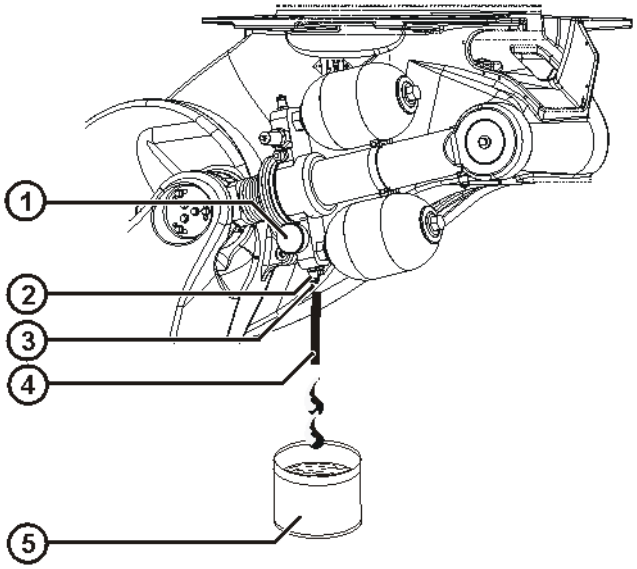

Fig. 9-14: Draining the hydraulic oil

1	Pressure gauge	4	Tube
2	Vent valve	5	Collection receptacle
3	Screw cap		

4. Drain the oil until the pressure gauge reads zero.
   The oil side of the diaphragm accumulator is now depressurized and can be vented during subsequent filling of the gas side.
5. Connect the filling and testing device (accessory) for the diaphragm accumulator to a standard commercial nitrogen cylinder via the tube and a pressure reducer.
6. Set the pressure reducer to 170 bar.

⚠ WARNING For safety reasons, the Allen screw on the accumulator may under no circumstances be unscrewed by more than a quarter of a turn without the filling and testing device being connected. The pressure in the accumulator may never be adjusted without the filling and testing device connected.

7. Remove the protective caps from the diaphragm accumulator and unscrew the Allen screw slightly (without a torque wrench, by a quarter of a turn at the most) (>>> Fig. 9-15).
   No gas must be allowed to escape. If, in spite of care being taken, gas does escape (hissing sound!), the sealing ring of Allen screw must be replaced. This must only be done when the diaphragm accumulator is completely depressurized.
8. Connect the filling and testing device to the gas connection of the diaphragm accumulator. Turn the gas valve rod counterclockwise, thereby opening the gas connection via the Allen screw; a full turn is necessary af-

ter the start of pointer deflection on the pressure gauge of the filling and testing device.

The pressure gauge on the counterbalancing system indicates the nitrogen pressure in the diaphragm accumulator. If the nitrogen pressure is greater than 150 bar, carry out step 9. If the nitrogen pressure is too low, carry out steps 10 to 11. Then in either case, continue with step 12.

9. Open the pressure relief valve and discharge nitrogen until the specified pressure of 150 bar is reached.

   The reading on the pressure gauge must be rechecked after 2 to 3 minutes and the nitrogen pressure corrected if necessary.
10. Open the shut-off valve on the nitrogen cylinder and raise the nitrogen pressure to 160 bar.
11. Close the shut-off valve.
12. Open the pressure relief valve and discharge nitrogen until the specified pressure of 150 bar is reached.

    The reading on the pressure gauge must be rechecked after 2 to 3 minutes and the nitrogen pressure corrected if necessary.
13. Turn the Allen screw clockwise by means of the gas valve rod and tighten it. Then open the pressure relief valve and discharge the remaining pressure in the tube.
14. Disconnect filling and testing device from diaphragm accumulator.

    The filling and testing device may only be disconnected if the Allen screw has been tightened by means of the gas valve rod.
15. Firmly retighten the Allen screw; M_A = 20 Nm.

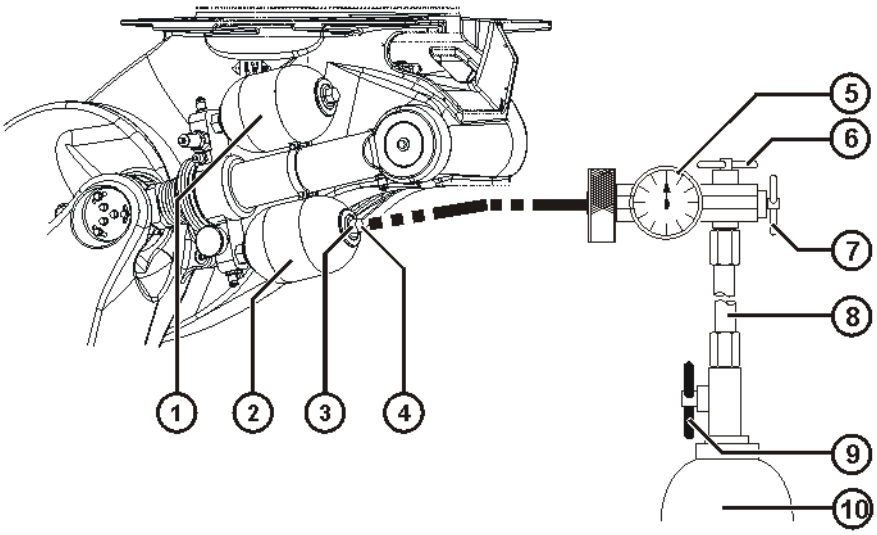

Fig. 9-15: Setting the gas pressure

1	Diaphragm accumulator 2	6	Pressure relief valve
2	Diaphragm accumulator 1	7	Gas valve rod
3	Allen screw	8	Tube
4	Protective cap	9	Shut-off valve
5	Pressure gauge	10	Nitrogen cylinder

16. Screw on the protective caps.
17. Carry out steps 7 to 15 for the 2nd diaphragm accumulator.
18. Release and remove the tube on the nitrogen cylinder.
19. Unscrew the screw cap on the filler neck and connect the hydraulic tube (>>> Fig. 9-16).

    The hydraulic tube must already be free from air.

20. Unscrew the screw cap on the vent connection and connect the measuring tube (unless the tube is still connected from the preceding tasks).
21. Dip the measuring tube into the liquid in the collection receptacle.
22. Put the hydraulic pump into operation and allow hydraulic oil to flow out into the collection receptacle until no more bubbles escape.

    The reservoir of the hydraulic pump must only be filled with filtered Hyspin ZZ 46 (filter gauge 3 µm).
23. Close the vent valve at the vent connection.
24. Continue to operate the hydraulic pump until the hydraulic oil pressure is approx. 10 bar above the specified value of 230 bar. Then lower the pump pressure to “0”.
25. After approx. 10 minutes, check the hydraulic oil pressure and reduce it to 230 bar by opening the vent valve.
26. Unscrew the hydraulic tube and screw the screw cap back onto the filler neck.
27. Unscrew the measuring tube and screw the screw cap back onto the vent connection.
28. Check the counterbalancing system for leaks.
29. Remove crane and elements securing the link arm.

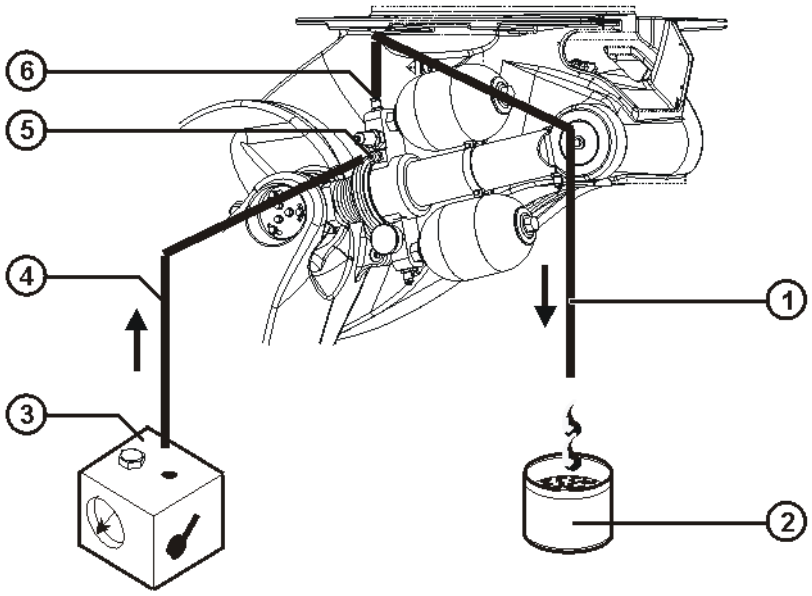

Fig. 9-16: Topping up the hydraulic oil

1	Measuring tube	4	Hydraulic hose
2	Collection receptacle	5	Filler neck
3	Hydraulic pump	6	Vent connection

9.6 Checking drive shafts A4 to A6

Description

Located in the arm housing of the robot are 2 universal shafts for motors A4 and A6 and a connecting shaft for motor A5. Described below are those tasks which must be carried out to check the axial play of universal shafts A4 and A6 and of connecting shaft A5.

Precondition

- The robot is operational and can be moved at jog velocity.

⚠ 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.

Procedure

1. Move the robot in T1 mode and listen for running noises.
2. Lower load vertically to relieve load on universal shafts.
3. Secure the robot by pressing the E-STOP button.
4. Remove the cover and O-ring (F variant only) from the installation aperture (>>> Fig. 9-17).

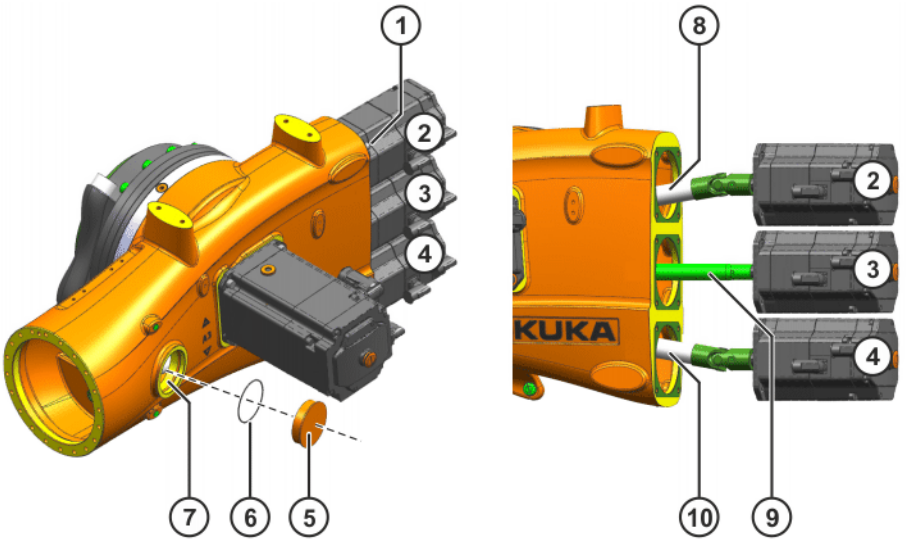

Fig. 9-17: Removing motors and drive shafts

1	Allen screw	6	O-ring (F variant only)
2	Motor A4	7	Installation aperture
3	Motor A5	8	Universal shaft A4
4	Motor A6	9	Connecting shaft A 5
5	Cover	10	Universal shaft A6

5. Inspect drive shafts A4, A5 and A6 visually for abrasion and blue coloration.
   If any abrasion and/or blue coloration is discovered, take the robot out of operation and exchange the drive shafts .
6. Check universal shafts for rotational and axial play by applying a tensile force of 20 N as illustrated (>>> Fig. 9-18). To do so, pull and turn universal shafts A4 and A6 gently by hand.
   If the rotational and axial play is greater than 0.8 mm, take the robot out of operation and exchange universal shafts A4 and A6 .
7. Check connecting shaft A5 for rotational play as illustrated (>>> Fig. 9-18). To do so, turn connecting shaft gently by hand.
   If the rotational play is greater than 0.8 mm, take the robot out of operation and exchange connecting shaft A5 .

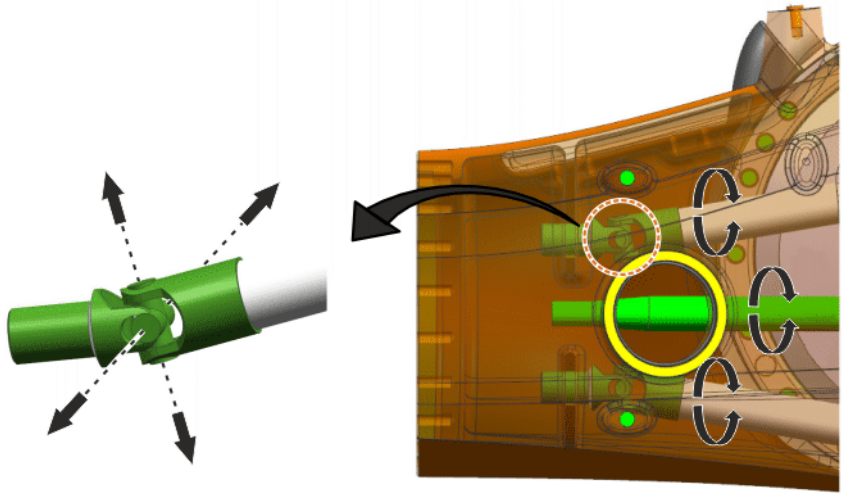

Fig. 9-18: Checking the connecting and universal shafts

8. Fasten the cover and new O-ring (F variant only) in the installation aperture.

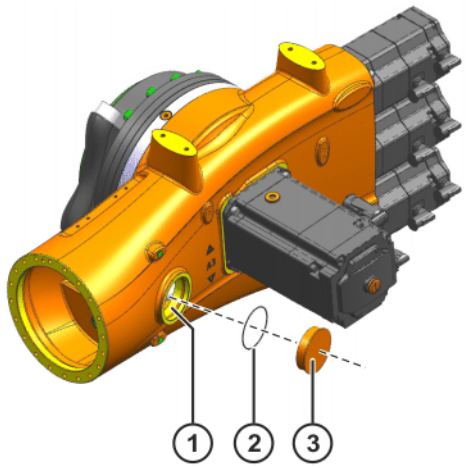

Fig. 9-19: Fastening the cover in the installation aperture

1	Installation aperture	3	Cover
2	O-ring (F variant only)		

9.7 Changing the gear oil in A1

Description

The following sections describe the gear oil change for floor-mounted robots. The description also applies to ceiling-mounted robots (C variant). If the ceiling-mounted robot is currently installed on the ceiling, the procedure is to be applied analogously, but with the filler and drain holes reversed.

In the case of ceiling-mounted robots, there is an additional oil hose for draining the oil.

Precondition

- The gear unit is at operating temperature.

⚠ CAUTION 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.

9.7.1 Draining the gear oil on A1

Procedure

1. Pull the oil drain hose out of the base frame (>>> Fig. 9-20).
2. Place a suitable receptacle under the drain hole.
3. Unscrew the union nut from the oil drain hose.
4. Remove the magnetic screw plug for venting and catch the oil as it drains out.
5. Measure the amount of oil drained and dispose of the used oil in accordance with the pertinent regulations.
6. Fit the union nut on the drain hose and tighten.

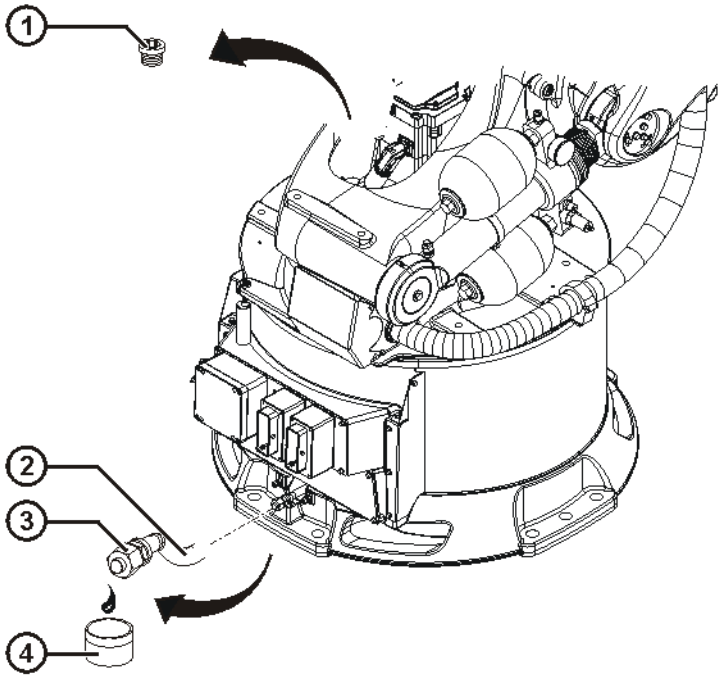

Fig. 9-20: Draining oil on A1

1	Magnetic screw plug	3	Union nut
2	Oil drain hose	4	Receptacle

9.7.2 Filling the gear oil on A1

Procedure

1. Pull the oil drain hose upwards (>>> Fig. 9-21).
   The opening of the oil drain hose must point upwards.
2. Fill the specified amount of oil via the oil drain hose using the oil pump.
3. Remove the oil pump and oil drain hose.
4. Screw the union nut onto the oil drain hose and tighten; M_A = 40 Nm.
5. Push oil drain hose back into the base frame.
6. Insert and tighten the magnetic screw plug; M_A = 25 Nm.
7. Check the union nut for leaks and exchange if necessary.

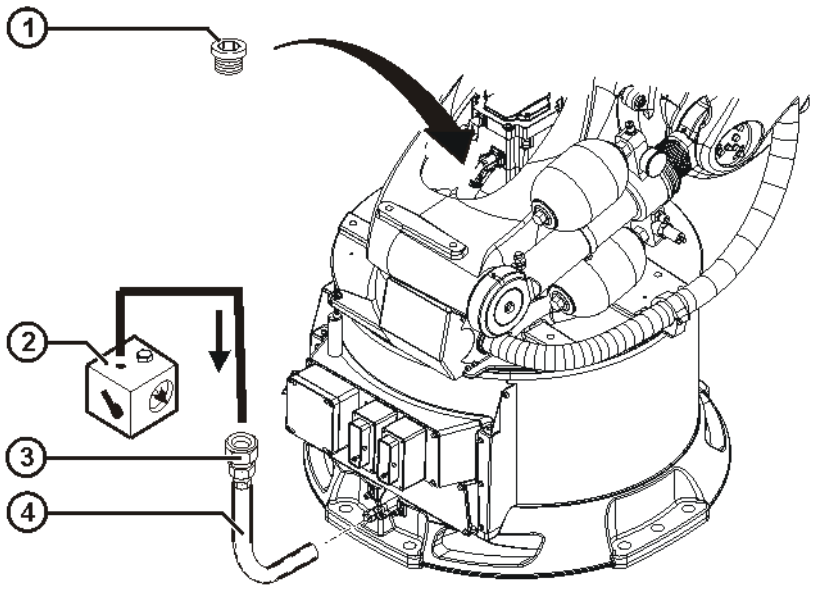

Fig. 9-21: Filling with oil on A1

1	Magnetic screw plug	3	Union nut
2	Oil pump	4	Oil drain hose

9.8 Changing the gear oil on A2

Description

The following sections describe the gear oil change for floor-mounted robots. The description also applies to ceiling-mounted robots (C variant). If the ceiling-mounted robot is currently installed on the ceiling, the procedure is to be applied analogously, but with the filler and drain holes reversed.

In the case of ceiling-mounted robots, there is an additional oil hose for draining the oil.

Precondition

- The robot is in a position in which gear unit A2 is accessible.
- The gear unit is at operating temperature.

⚠ CAUTION 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.

9.8.1 Draining the gear oil on A2

Procedure

1. Pull the oil drain hose out of the rotating column (>>> Fig. 9-22).
2. Place a suitable receptacle under the drain hole.
3. Unscrew the union nut from the oil drain hose.
4. Remove the magnetic screw plug.
5. Drain the oil.
   The opening of the oil drain hose must point downwards.

6. Measure the amount of oil drained and dispose of the used oil in accordance with the pertinent regulations.

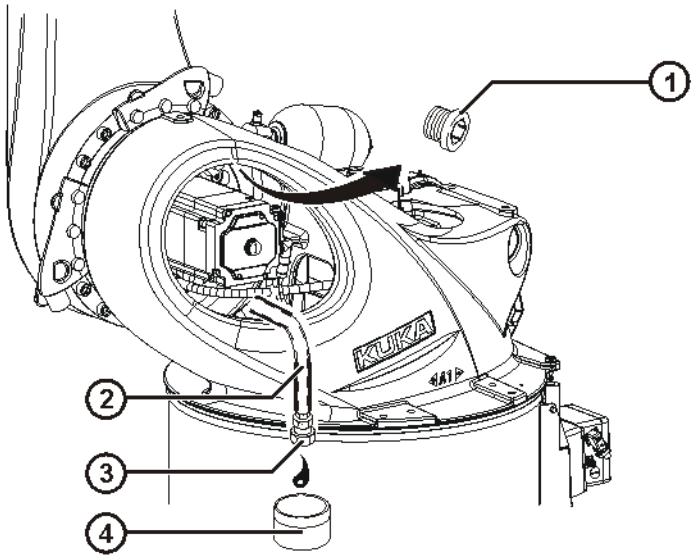

Fig. 9-22: Draining oil on A2

1	Magnetic screw plug	3	Union nut
2	Oil drain hose	4	Receptacle

9.8.2 Filling with gear oil on A2

Procedure

1. Pull the oil drain hose upwards (>>> Fig. 9-23).
   The opening of the oil drain hose must point upwards.
2. Fill the specified amount of oil via the oil drain hose using the oil pump.
3. Remove the oil pump and oil drain hose.
4. Screw the union nut onto the oil drain hose and tighten; M_A = 40 Nm.
5. Feed the oil drain hose back into the rotating column.
6. Insert and tighten the M22x1.5 magnetic screw plug; M_A = 25 Nm.
7. Check the oil drain hose at both connections for leaks; exchange if necessary.

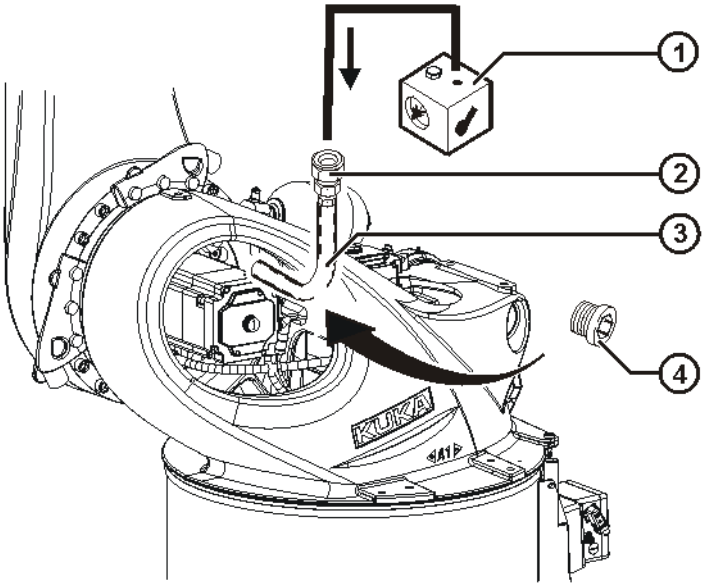

Fig. 9-23: Filling with oil on A2

1	Oil pump	3	Oil drain hose
2	Union nut	4	Magnetic screw plug

9.9 Changing the gear oil on A3

Description

The following sections describe the gear oil change for floor-mounted robots. The description also applies to ceiling-mounted robots (C variant). If the ceiling-mounted robot is currently installed on the ceiling, the procedure is to be applied analogously, but with the filler and drain holes reversed.

In the case of ceiling-mounted robots, there is an additional oil hose for draining the oil.

Precondition

- The robot is in a position in which gear unit A3 is accessible.
- The gear unit is at operating temperature.
- Axis 3 is in a horizontal position.

⚠ CAUTION 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.

9.9.1 Draining the gear oil on A3

Procedure

1. Place a suitable receptacle under the drain hole (>>> Fig. 9-24).
2. Remove the lower magnetic screw plug.
3. Screw in an oil drain hose approx. 1 m in length using an M18x1.5 union.
4. Remove the upper magnetic screw plug and drain the oil.

5. Measure the amount of oil drained and dispose of the used oil in accordance with the pertinent regulations.
6. Check both magnetic screw plug for deposits; take appropriate measures if necessary.
7. Clean both magnetic screw plugs and check the sealing element. Exchange magnetic screw plugs if damaged.

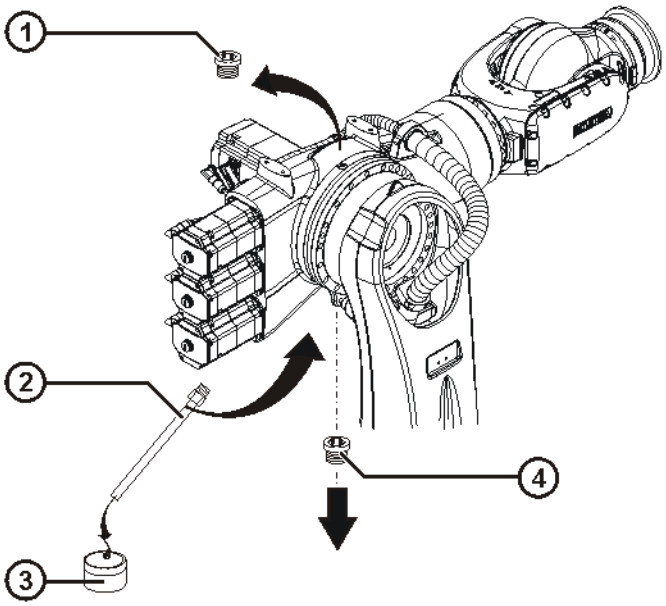

Fig. 9-24: Draining the oil on A3

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

9.9.2 Filling with gear oil on A3

Procedure

1. Fill the specified amount of oil via the oil drain hose using the oil pump (>>> Fig. 9-25).
2. Remove the oil pump and oil drain hose.
3. Insert and tighten both M18x1.5 magnetic screw plugs; M_A = 20.0 Nm.
4. Check both magnetic screw plugs for leaks and exchange if necessary.

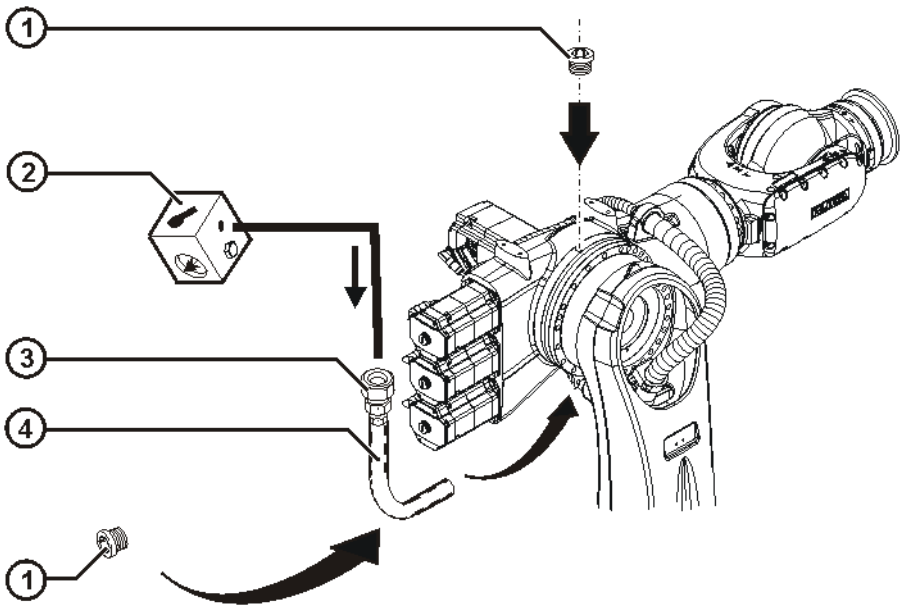

Fig. 9-25: Filling with oil on A3

1	Upper magnetic screw plug	3	Union nut
2	Oil pump	4	Oil drain hose

9.10 Changing the gear oil on A4

Precondition

- The gear unit is at operating temperature.
- The robot is in a position in which gear unit A4 is accessible.

⚠ CAUTION 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.

9.10.1 Draining the gear oil on A4

Procedure

1. Place a suitable receptacle under the drain hole (>>> Fig. 9-26).
2. Remove the upper magnetic screw plug.
3. Remove the lower magnetic screw plug and drain the oil.
4. Measure the amount of oil drained and dispose of the used oil in accordance with the pertinent regulations.
5. Check both magnetic screw plug for deposits; take appropriate measures if necessary.
6. Clean both magnetic screw plugs and check the sealing element. Exchange magnetic screw plugs if damaged.
7. Insert and tighten the lower M18x1.5 magnetic screw plug; M_A = 20.0 Nm.

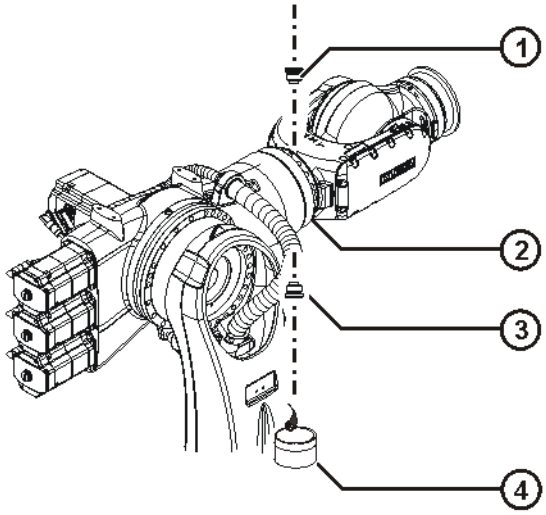

Fig. 9-26: Draining the oil on A4

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

9.10.2 Filling the gear oil on A4

Procedure

1. Pour specified amount of oil into filler hole (>>> Fig. 9-27).
   Use a funnel when filling with oil.
2. Insert and tighten the upper M18x1.5 magnetic screw plug, M_A = 20.0 Nm.
3. Check both magnetic screw plugs for leaks and exchange if necessary.

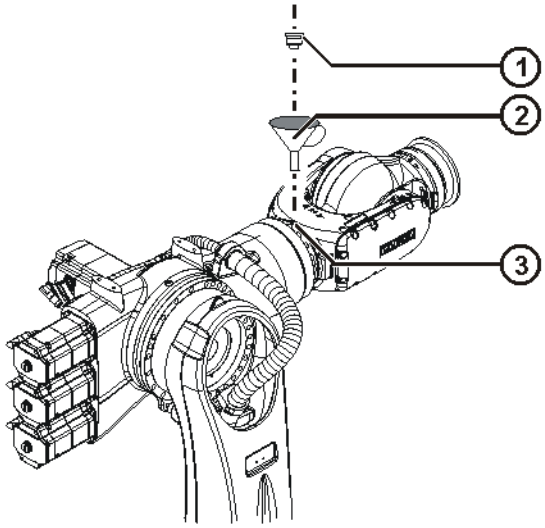

Fig. 9-27: Filling with oil on A4

1 Upper magnetic screw plug
2 Funnel
3 Filler hole

9.11 Changing the gear oil on A5

Precondition

- The gear units A5 and A6 are at operating temperature.
- The arm and wrist are positioned horizontally.

⚠ CAUTION 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 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.

9.11.1 Draining the gear oil on A5

Procedure

1. Place a suitable receptacle under the drain hole (>>> Fig. 9-28).
2. Remove the magnetic screw plug at the top for venting.
3. Remove the lower magnetic screw plug and drain the oil.
4. Measure the amount of oil drained and dispose of the used oil in accordance with the pertinent regulations.
5. Check both magnetic screw plug for deposits; take appropriate measures if necessary.
6. Clean both magnetic screw plugs and check the sealing element. Exchange magnetic screw plugs if damaged.

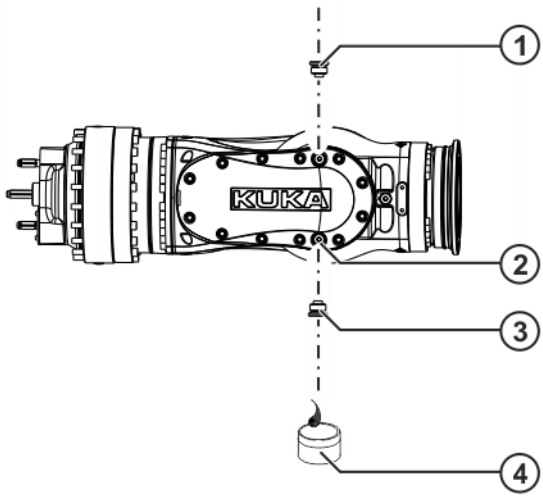

Fig. 9-28: Draining the oil from A5

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

9.11.2 Filling the gear oil on A5

Procedure

1. Move A4 into the +90° position (>>> Fig. 9-29). The cover faces upwards.
2. Pour specified amount of oil into filler hole.
   Use a funnel when filling with oil.
3. Insert and tighten both M18x1.5 magnetic screw plugs; M_A = 20.0 Nm.
4. Check both magnetic screw plugs for leaks and exchange if necessary.

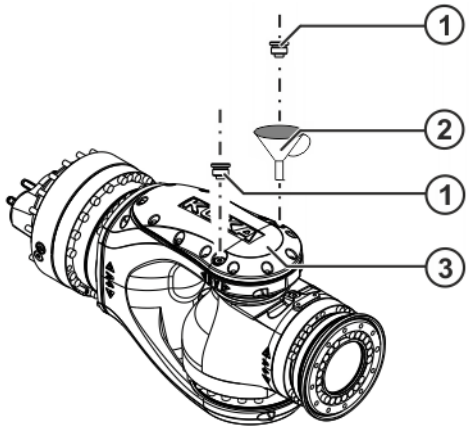

Fig. 9-29: Filling with oil on A5

1 Magnetic screw plug
2 Funnel
3 Cover

9.12 Changing the gear oil on A6

Precondition

- The gear units A5 and A6 are at operating temperature.
- The arm and wrist are positioned horizontally.

⚠ CAUTION 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 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.

9.12.1 Draining the gear oil on A6

Procedure

1. Move A5 into the -90° position. The mounting flange faces up (>>> Fig. 9-30).
2. Remove the magnetic screw plug at the side for venting.
3. Place a suitable receptacle under the drain hole.
4. Remove the magnetic screw plug on the swivel housing.

5. Catch the oil as it drains out.
6. Measure the amount of oil drained and dispose of the used oil in accordance with the pertinent regulations.
7. Inspect the side magnetic screw plug for metallic deposits and clean it.
8. Insert and tighten the magnetic screw plug at the side; M_A = 20.0 Nm.

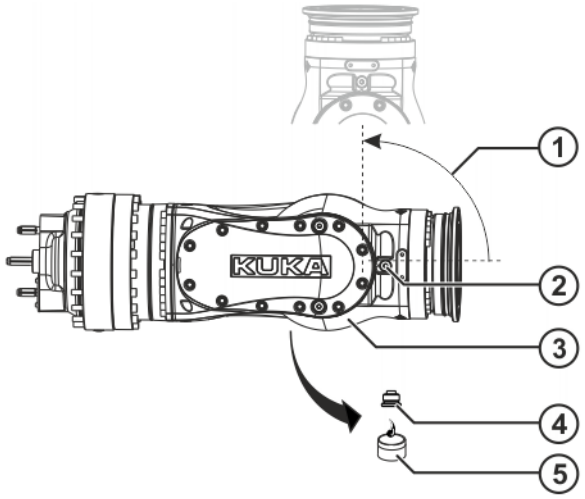

Fig. 9-30: Draining the oil from A6

1 Move to the -90° position
2 Magnetic screw plug on the side
3 Swivel housing
4 Magnetic screw plug on the swivel housing
5 Collection receptacle

9.12.2 Filling the gear oil on A6

Procedure

1. Move A5 into the +90° position. The mounting flange faces down (>>> Fig. 9-31).
2. Pour specified amount of oil into filler hole.
3. Inspect the magnetic screw plugs of the swivel housing for metallic deposits and clean them.
4. Insert and tighten the magnetic screw plug in the swivel housing; M_A = 20 Nm.
5. Check both magnetic screw plugs for leaks and exchange if necessary.

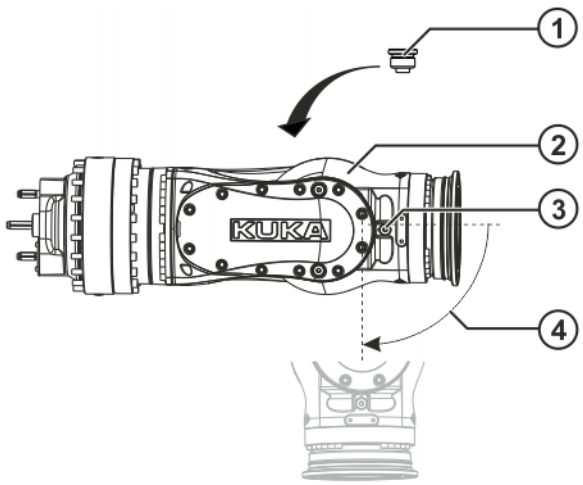

Fig. 9-31: Filling with oil on A6

1 Magnetic screw plug on the swivel housing
2 Swivel housing
3 Magnetic screw plug on the side
4 Move to the +90° position

9.13 Greasing the cable set

Precondition

- The robot is accessible in the area of axis 1

> **⚠ 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. Remove 2 M6x16 Allen screws together with conical spring washers from the cover and intermediate plate (>>> Fig. 9-32).
2. Remove 7 M6x12 Allen screws and conical spring washers, and take off the cover.
3. Apply cable grease evenly to the cables in the base frame using a brush and by hand.
   Protective gloves must be worn.
4. Dispose of used grease and grease residues in accordance with the pertinent regulations.
5. Mount the cover and fasten it with 7 M6x12 Allen screws and conical spring washers.
6. Fasten the cover to the intermediate plate with 2 M6x16 Allen screws.

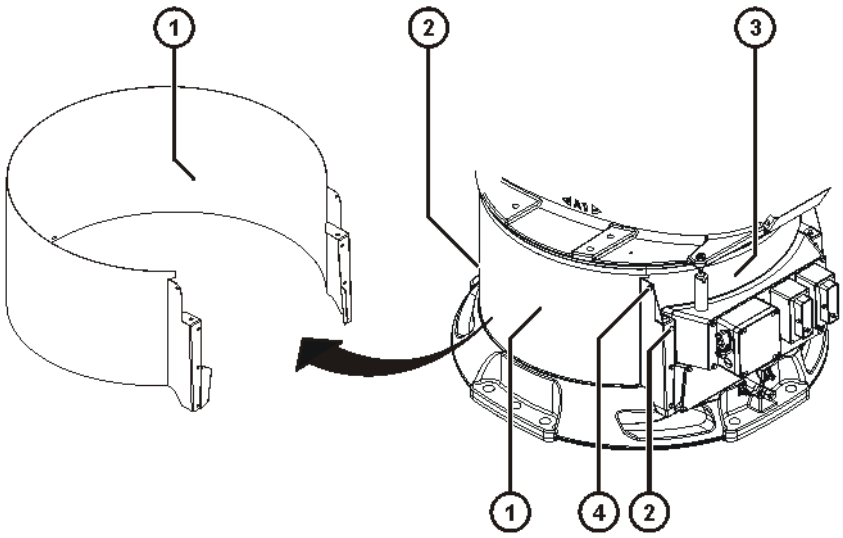

Fig. 9-32: Greasing the cable set

1	Cover	3	Intermediate plate
2	M6x12 Allen screws	4	M6x16 Allen screws

9.14 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 in accordance with the pertinent regulations.

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 Repair

⚠ CAUTION 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.

Further information about KUKA tightening torques can be found in the Appendix (>>> 12 "Appendix" Page 195).

10.1 Exchanging motor A1

Precondition

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

⚠ 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 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.

10.1.1 Removing motor A1

Description

The following describes the removal of motor A1 for floor-mounted robots. The description also applies to ceiling-mounted robots (C variant); the same procedure is to be applied analogously. The motor must be supported from beneath and the vertically hanging link arm must be secured against motion.

Procedure

1. Release and unplug connectors XM1 and XP1 at the sockets (>>> Fig. 10-1).
2. Remove 4 Allen screws.
3. Release and lift out motor A1. Do not tilt it when lifting it.
4. Remove the seal between the motor and the motor mount; for F variant only.
5. If the motor on A1 is not to be reinstalled, it must be protected against corrosion before being put into storage.
6. Cover the gear unit and protect it against fouling.

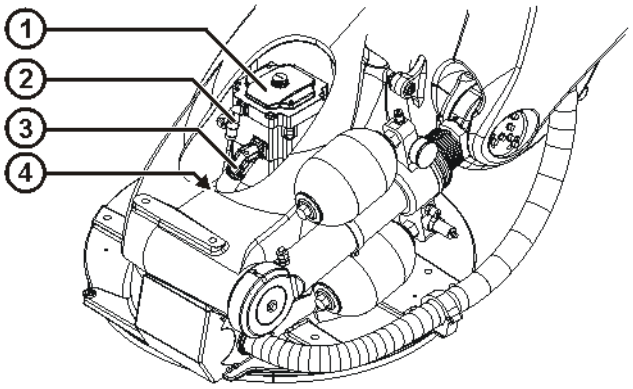

Fig. 10-1: Removing motor A1

1	Motor A1	3	Connector XP1
2	Connector XM1	4	Allen screws

10.1.2 Installing motor A1

Description

The following describes the installation of motor A1 for floor-mounted robots. The description also applies to ceiling-mounted robots (C variant); the same procedure is to be applied analogously.

Precondition

NOTICE When installing the motor, it must be ensured that the toothing of the motor and gear unit is not damaged. Increased wear and premature failure may result.

Procedure

1. Remove all protective coatings and oil from new motor A1, if applicable (>>> Fig. 10-2).
2. Clean the toothing of the motor and the gear unit before installation and apply a thin but continuous coat of Microlube GL 261 grease.
3. Clean the mounting surface of motor A1 on the gear unit.
4. Check the condition of the O-ring on the motor shaft.
5. Fit seal on motor mount; F variant only.
6. Position sockets XM1 and XP1 as shown in the illustration.
7. Insert motor A1. Do not tilt during installation.

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

8. Insert 4 M12x25 Allen screws.
9. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 78 Nm.
10. Plug connectors XM1 and XP1 into the sockets.
11. Remove safeguards against the robot turning about axis 1.
12. Carry out mastering of axis 1.

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

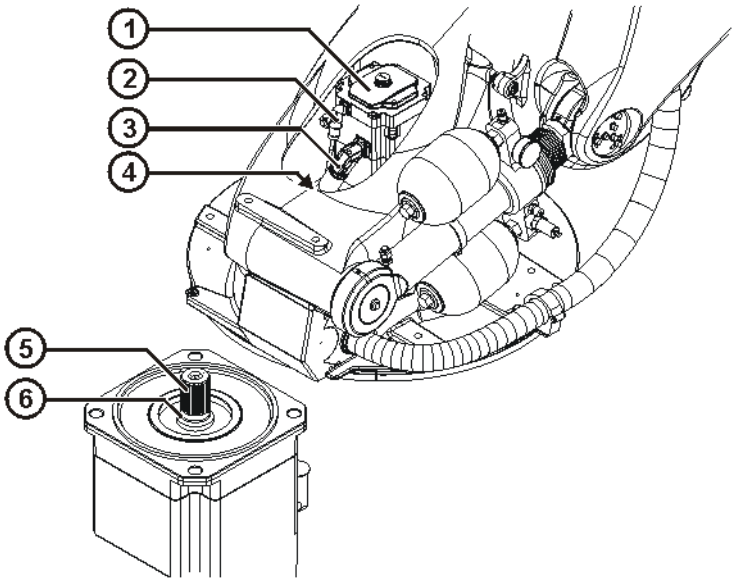

Fig. 10-2: Installing motor A1

1	Motor A1	4	Allen screws
2	Connector XM1	5	Toothing
3	Connector XP1	6	O-ring

10.2 Exchanging motor A2

Precondition

- The robot is secured against rotational motions about axis 2.

⚠ 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 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.

10.2.1 Removing motor A2

Description

The following describes the removal of motor A2 for floor-mounted robots. The description also applies to ceiling-mounted robots (C variant); the same procedure is to be applied analogously. The motor must be supported from beneath and the vertically hanging link arm must be secured against motion.

Procedure

1. Secure the link arm using a rope sling (>>> Fig. 10-3).
2. Raise the rope sling until it is ensured that the link arm cannot move after removal of the motor.

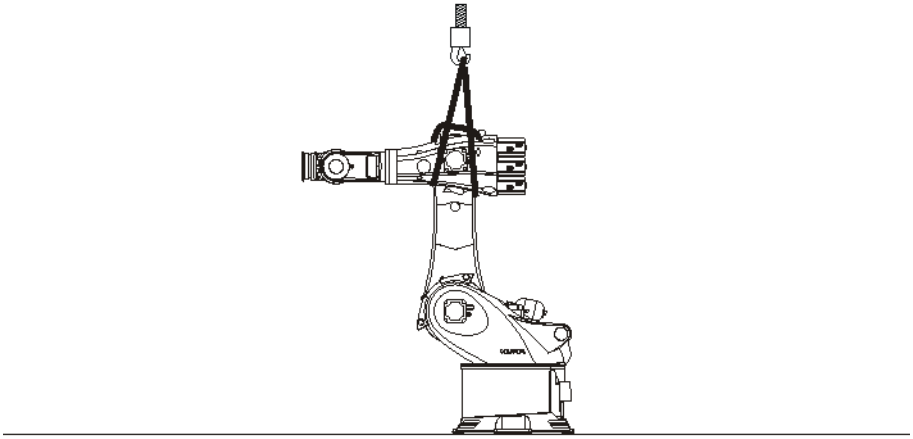

Fig. 10-3: Securing the link arm

3. Release and unplug connectors XM2 and XP2 at the sockets (>>> Fig. 10-4).
4. Place the rope sling around motor A2 and raise it using the crane until the weight of motor A2 is supported by the rope sling.
5. Remove 4 Allen screws.
6. Remove the seal between the motor and the motor mount; for F variant only.
7. Release and pull out motor A2. Do not tilt it when removing it.
8. If the motor on A2 is not to be reinstalled, it must be set down and protected against corrosion before being put into storage.

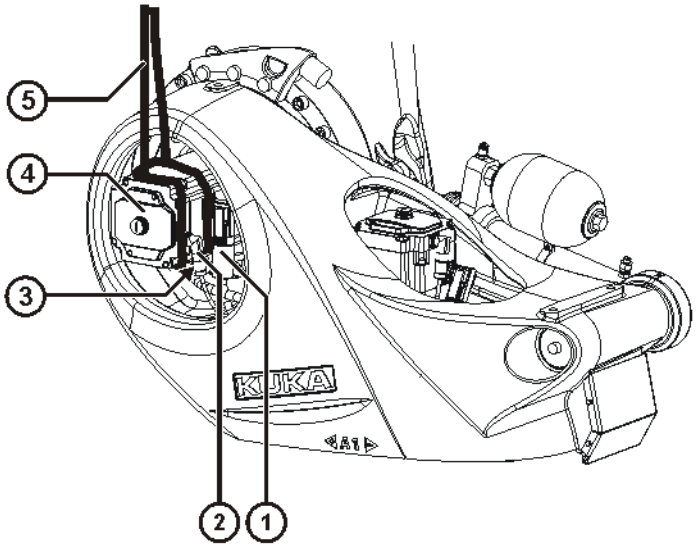

Fig. 10-4: Removing motor A2

1	Connector XP2	4	Motor A2
2	Connector XM2	5	Rope sling
3	Allen screws		

10.2.2 Installing motor A2

Description

The following describes the removal of motor A2 for floor-mounted robots. The description also applies to ceiling-mounted robots (C variant); the same procedure is to be applied analogously.

Precondition

NOTICE When installing the motor, it must be ensured that the toothing of the motor and gear unit is not damaged. Increased wear and premature failure may result.

Procedure

1. Remove all protective coatings and oil from the new motor A2.
2. Clean the toothing of motor A2 and gear unit before installation and apply a thin but continuous coat of Microlube GL 261 grease (>>> Fig. 10-5).
3. Clean the mounting surface of motor A2 on the gear unit.
4. Check the condition of the O-ring on the motor shaft.
5. Position sockets XM2 and XP2 as shown in the diagram.
6. Lift motor A2 with a rope sling and insert it (for F variant: together with seal). Do not tilt during installation.

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

7. Insert 4 M12x25 Allen screws.
8. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 78 Nm.
9. Slacken and remove the rope sling.
10. Plug connectors XM2 and XP2 into the sockets.
11. Remove elements securing the link arm.
12. Carry out mastering of axis 2.

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

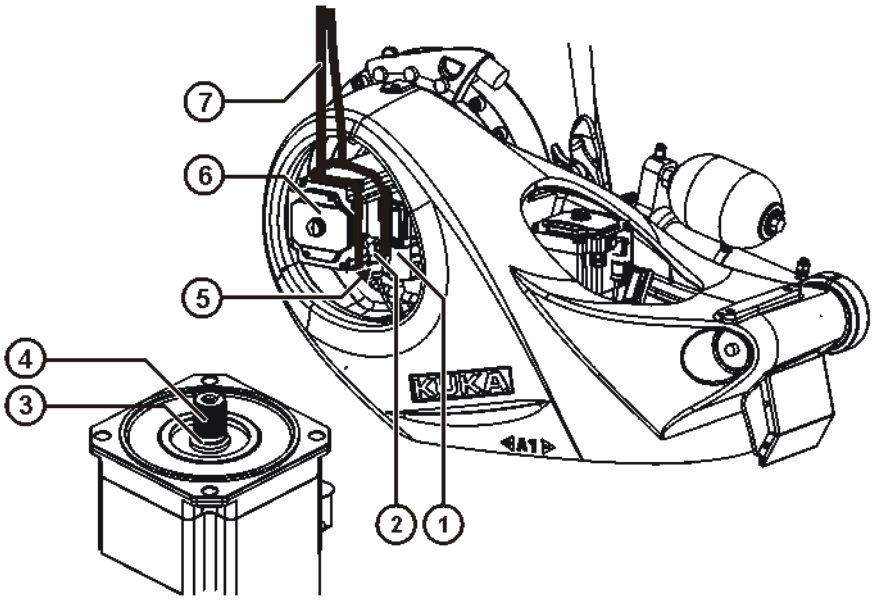

Fig. 10-5: Installing motor A2

1	Connector XP2	5	Allen screws
2	Connector XM2	6	Motor A2
3	Toothing	7	Rope sling
4	O-ring		

10.3 Exchanging motor A3

Precondition

- The robot is secured against rotational motions about axis 3.

⚠ 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 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.

10.3.1 Removing motor A3

Description

The following describes the removal of motor A3 for floor-mounted robots. The description also applies to ceiling-mounted robots (C variant); the same procedure is to be applied analogously. The motor must be supported from beneath and the arm must be secured against motion.

Procedure

1. Secure the arm using a rope sling (>>> Fig. 10-6).
2. Raise the rope sling until it is ensured that the arm cannot move after removal of the motor.

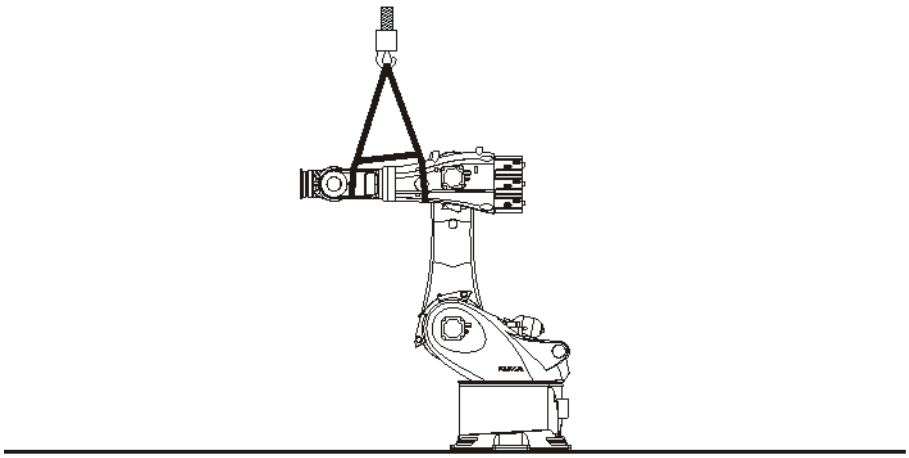

Fig. 10-6: Securing the arm

3. Release and unplug connectors XM3 and XP3 at the sockets (>>> Fig. 10-7).
4. Place the rope sling around motor A3 and raise it using the crane until the weight of motor A3 is supported by the rope sling.
5. Remove 4 Allen screws.
6. Release and pull out motor A3. Do not tilt it when removing it.
7. Remove the seal between the motor and the arm; for F variant only.
8. If the motor on A3 is not to be reinstalled, it must be set down and protected against corrosion before being put into storage.

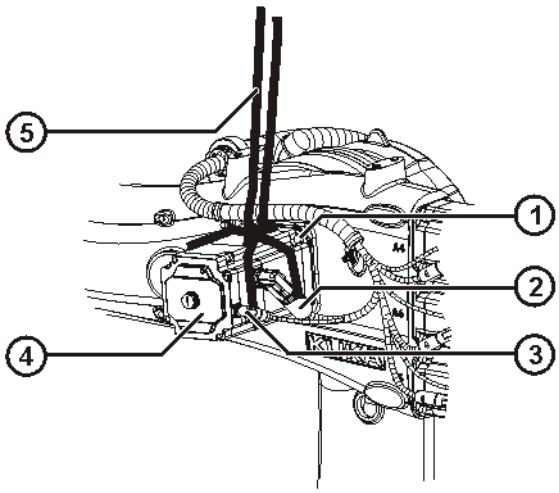

Fig. 10-7: Removing motor A3

1	Allen screws	4	Motor A3
2	Connector XP3	5	Rope sling
3	Connector XM3		

10.3.2 Installing motor A3

Description

The following describes the removal of motor A3 for floor-mounted robots. The description also applies to ceiling-mounted robots (C variant); the same procedure is to be applied analogously.

Precondition

NOTICE When installing the motor, it must be ensured that the toothing of the motor and gear unit is not damaged. Increased wear and premature failure may result.

Procedure

1. Remove all protective coatings and oil from the new motor A3.
2. Clean the toothing of motor A3 and gear unit before installation and apply a thin but continuous coat of Microlube GL 261 grease (>>> Fig. 10-8).
3. Clean the mounting surface of motor A3 on the gear unit.
4. Check the condition of the O-ring on the motor shaft.
5. Position sockets XM3 and XP3 as shown in the illustration.
6. Lift motor A2 with a rope sling and insert it (for F variant: together with seal). Do not tilt during installation.

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

7. Insert 4 M12x30 Allen screws.
8. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 78 Nm.
9. Slacken and remove the rope sling.
10. Plug connectors XM3 and XP3 into the sockets.
11. Remove elements securing the arm.
12. Carry out mastering of axis 3.

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

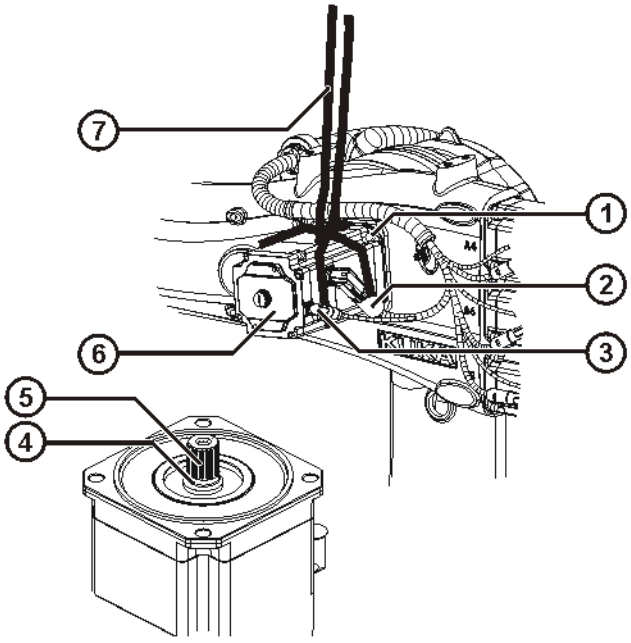

Fig. 10-8: Installing motor A3

1	Allen screws	5	Toothing
2	Connector XP3	6	Motor A3
3	Connector XM3	7	Rope sling
4	O-ring		

10.4 Exchanging motors and drive shafts A4 to A6

Description

Axes 4, 5 and 6 of the in-line wrist are driven by three motors of the same design and three drive shafts. Motors A4, A5 and A6 are located at the rear of the arm and the drive shafts are located in the arm housing.

The drive shafts are distinguished between two universal shafts (axes 4 and 6) and a connecting shaft (axis 5).

The description also applies to ceiling-mounted robots (C variant); the same procedure is to be applied analogously.

Precondition

- The arm is in the horizontal position.
- 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 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.

10.4.1 Removing motors and drive shafts A4 to A6

Procedure

1. Remove the cover and O-ring (F variant only) from the installation aperture (>>> Fig. 10-9).
2. Release and unplug the following connectors from the motors:
   - On motor A4: XM4 and XP4
   - On motor A5: XM5 and XP5
   - On motor A6: XM6 and XP6
3. Remove 4 M10x30 Allen screws and pull out motor together with drive shaft.

   When doing so, reach into the installation aperture with one hand and push the drive shaft towards the motor.

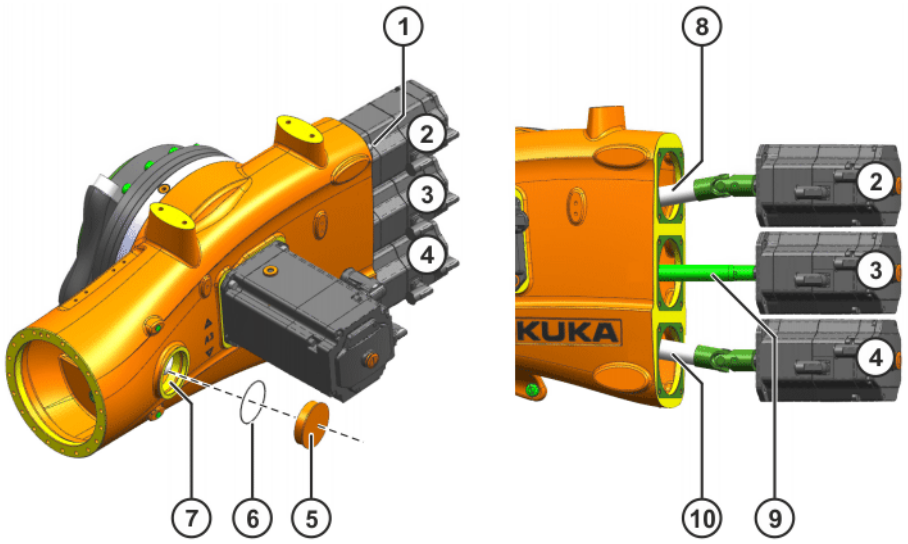

Fig. 10-9: Removing motors and drive shafts

1	M10x30 Allen screw
2	Motor A4
3	Motor A5
4	Motor A6
5	Installation aperture
6	O-ring (F variant only)
7	Cover
8	Universal shaft A4
9	Connecting shaft A 5
10	Universal shaft A6

4. Remove the seal between the motor and the arm; for F variant only.
5. Set motor with drive shaft down on a suitable support surface.
6. Slacken the following M6x10 setscrews on the drive shafts until the drive shafts are free (>>> Fig. 10-10):
   - 2 setscrews on universal shafts A4 and A6
   - 1 setscrew on connecting shaft A5

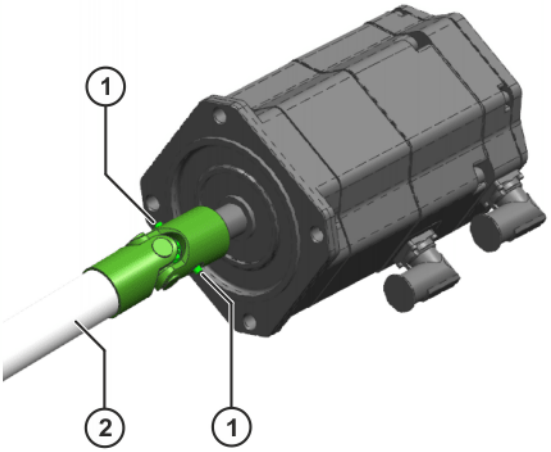

Fig. 10-10: Releasing and detaching universal shaft

1	Setscrew	2	Universal shaft

7. Pull the drive shaft off the motor.
8. Dispose of motor and/or drive shaft in accordance with the pertinent regulations.

10.4.2 Installing motors and drive shafts A4 to A6

Procedure

1. Remove all protective coatings and oil from new motor and/or new drive shaft.
2. Clean the spline shaft connection of the motor 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 universal shaft is not damaged.
> Damaged parts must be exchanged!

3. Clean the mounting surface on the arm housing.
4. Push drive shaft onto motor shaft (>>> Fig. 10-11).
5. Unscrew the following M6x10 setscrews and clean them thoroughly (grease-free):
   - 2 setscrews on universal shafts A4 and A6
   - 1 setscrew on connecting shaft A5
6. Apply Drei Bond 1342 locking agent to the M6x10 setscrews and insert and tighten them. After tightening, loosen the setscrews again by 45°.
   The setscrews must engage with the V-groove.
7. Position the following sockets as shown in the illustration:
   - Motor A4: XM4 and XP4
   - Motor A5: XM5 and XP5
   - Motor A6: XM6 and XP6
8. Insert drive shaft with motor into the arm housing (only for F variant: together with seal). Be careful not to tilt it during installation and ensure that the connecting shafts (toothing) are correctly engaged.

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

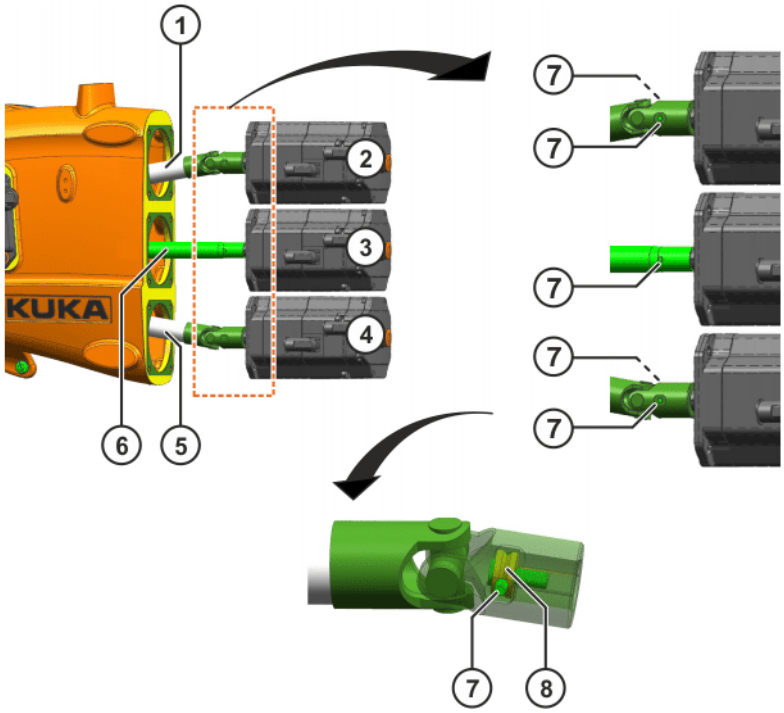

Fig. 10-11: Inserting drive shaft and motor

1	Universal shaft A4	5	Universal shaft A6
2	Motor A4	6	Connecting shaft A 5
3	Motor A5	7	Setscrew
4	Motor A6	8	V-groove

9. Align the drive shafts as shown in the illustration (>>> Fig. 10-12).

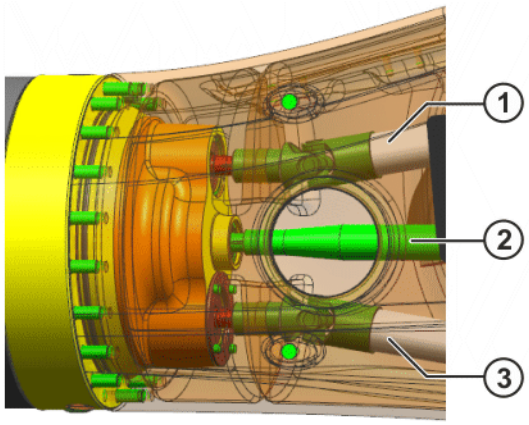

Fig. 10-12: Aligning the drive shafts

1	Universal shaft A4	3	Universal shaft A6
2	Connecting shaft A 5		

10. Insert and tighten 4 M10x30 Allen screws with the torque wrench in diagonally opposite sequence. Increase the tightening torque to M_A = 45.0 Nm.
11. Plug the following connectors into the sockets:
    - On motor A4: XM4 and XP4
    - On motor A5: XM5 and XP5
    - On motor A6: XM6 and XP6
12. Clean the installation aperture and apply Drei Bond 1118 (>>> Fig. 10-13).

13. Fasten the cover and new O-ring (F variant only) in the installation aperture.

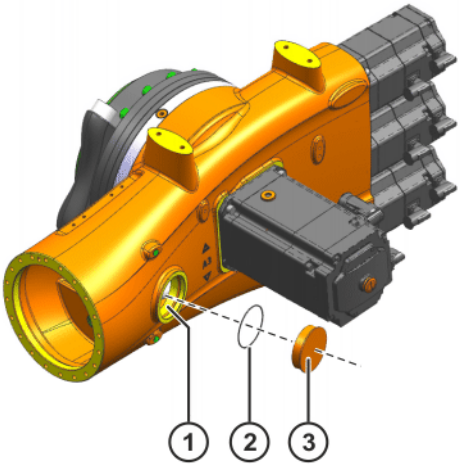

Fig. 10-13: Fastening the cover in the installation aperture

1	Installation aperture	3	Cover
2	O-ring (F variant only)		

14. Master A4, A5 and A6.

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

10.5 Exchanging the counterbalancing system on floor-mounted robots

Precondition

- It must be possible to move the robot about axis 2.
- The robot must be firmly bolted to the floor.
- Any items of equipment that are likely to impede the removal work have been removed.

⚠ 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 When removing or installing the counterbalancing system, care must be taken to avoid injury to arms, hands and fingers by crushing. Wear gloves and secure the counterbalancing system so that it cannot fall down or move unexpectedly.
The counterbalancing system weighs approx. 97 kg.
The counterbalancing system is pressurized. Particular caution must therefore be exercised and special knowledge put to effect when any work is performed on this system. Any improper handling constitutes a danger to life and limb.

10.5.1 Removing the counterbalancing system on a floor-mounted robot

Precondition

- The spacer for the piston rod must be available.
- The pin locator must be available.

Procedure

1. Slacken the worm drive clip and push the bellows backwards (>>> Fig. 10-14).
2. Move the link arm in the plus direction until the spacer can be inserted between the cylinder and the articulated head.
3. Secure the robot by pressing the E-STOP button.
4. Place spacer onto the free piston rod between the articulated head and the hydraulic cylinder.
5. Put the robot into operation and move the link arm carefully in the minus direction until the spacer is just clamped.

> **⚠ CAUTION** If the link arm is moved any further in the minus direction with the spacer inserted, this will result in damage to the counterbalancing system, link arm or rotating column.

6. Secure the counterbalancing system with a rope sling and a crane and move the crane until the weight is supported by the rope sling.
7. Remove 6 Allen screws and conical spring washers, and take off the retaining plate.

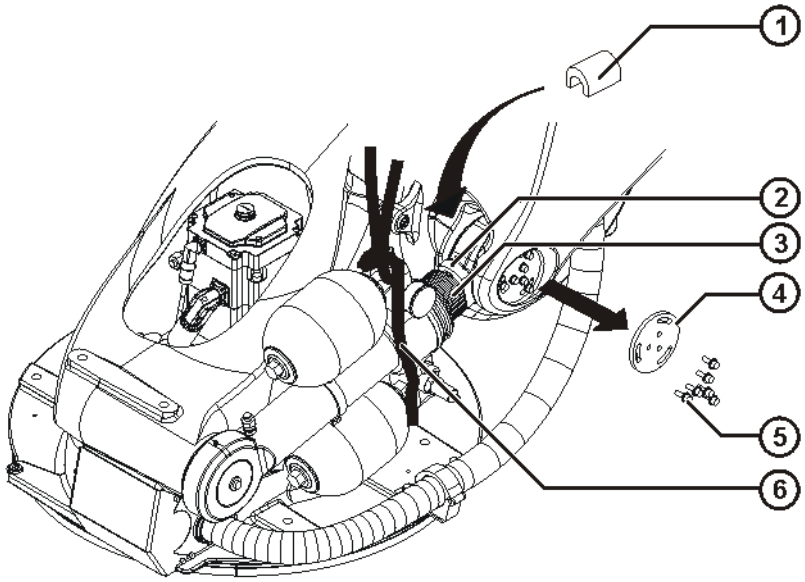

Fig. 10-14: Removing the counterbalancing system: spacer

1	Spacer	4	Retaining plate
2	Worm drive clip	5	Allen screw
3	Bellows	6	Rope sling

8. Secure link arm using a rope sling and crane (>>> Fig. 10-15).

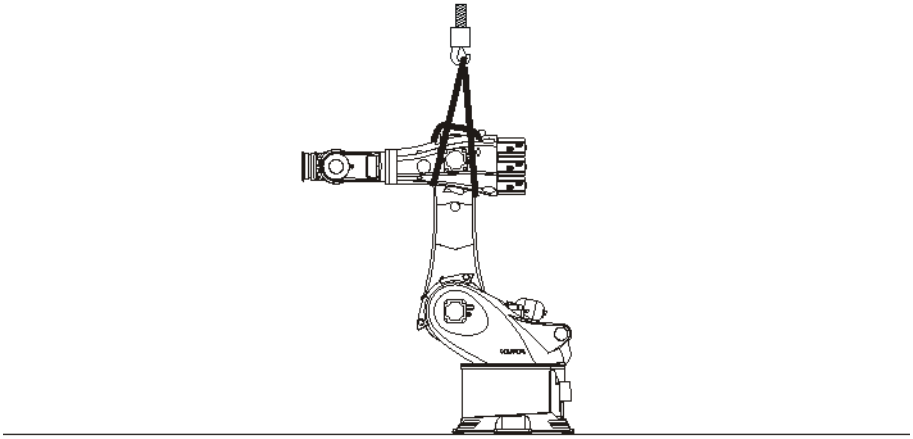

Fig. 10-15: Securing the link arm

9. Remove 1 Allen screw together with lock washer from the rotating column (>>> Fig. 10-16).

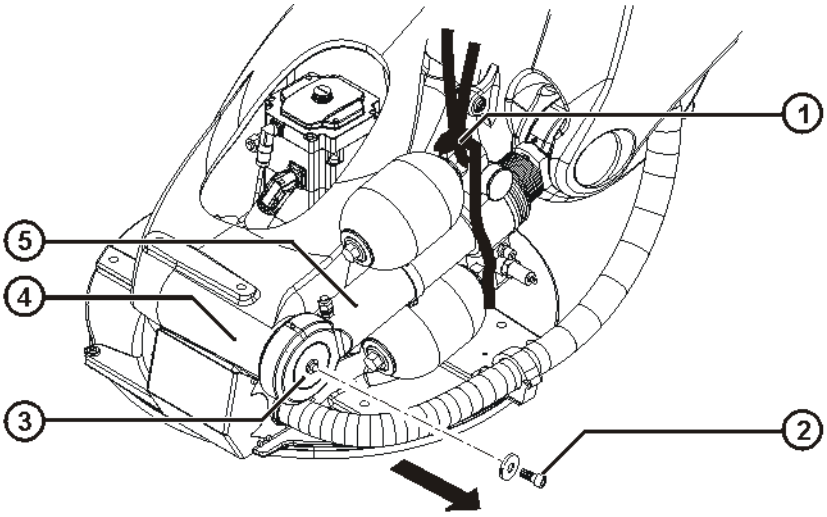

Fig. 10-16: Removing the counterbalancing system: rotating column

1	Rope sling	4	Rotating column
2	Allen screw	5	Counterbalancing system
3	Cover		

10. Insert the pin locator on the right-hand side between the articulated head and the link arm (>>> Fig. 10-17).
11. Pull the pin out of the link arm using an M16 pin extractor.

    The pin is out of the precision fit area when it has been pulled out approx. 25 mm.
12. Put the robot into operation and move the link arm carefully in the plus direction until the articulated head is free. When moving the link arm, move the crane and rope sling at the same time, so that the weight of the arm is supported by the crane.
13. Secure the robot by pressing the E-STOP button.
14. Swivel the counterbalancing system up and out of the link arm, moving the crane and rope sling at the same time.
15. Take off the pin locator, thrust ring and spacer ring that are now loose.

⚠ CAUTION When forcing the counterbalancing system off the rotating column, an unfavorable position of the center of gravity may cause the counterbalancing system to move unexpectedly. To avoid injury and damage, the tension and position of the rope must be adjusted as necessary.

16. Use an M20 jacking screw to force the counterbalancing system off the pin in the rotating column in the direction of the arrow.

    While forcing off the counterbalancing system, check the rope tension and if necessary correct it to prevent the components from being tilted.
17. Continue raising the counterbalancing system with the crane and set it down on a suitable support.
18. If the counterbalancing system is not to be reinstalled, it must be protected against corrosion before being put into storage.

If a new counterbalancing system is not being installed immediately, the robot can be moved into a safe position and the rope securing the link arm can be removed. The robot may only be moved again in order to install the new counterbalancing system.

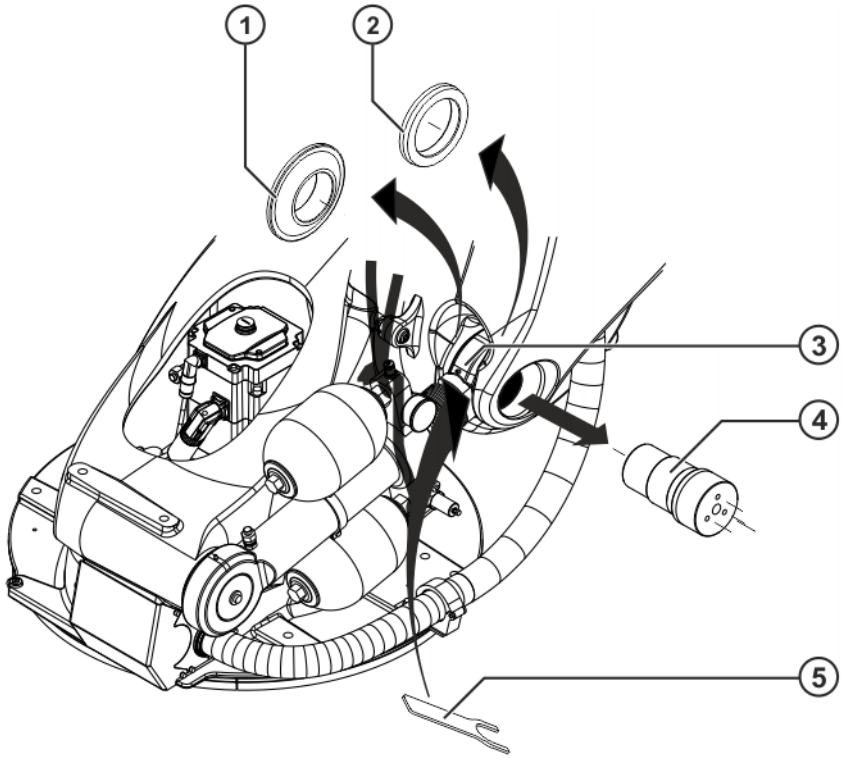

Fig. 10-17: Removing the counterbalancing system: pin

1	Thrust ring	4	Pin
2	Spacer ring	5	Pin locator
3	Articulated head		

10.5.2 Installing the counterbalancing system on a floor-mounted robot

Procedure

1. Remove all protective coatings and oil from the counterbalancing system and check that no part of it is missing.
2. If necessary, put the robot into operation and move the link arm into approximately the +5° position (>>> Fig. 10-18).
3. Secure the robot by pressing the E-STOP button.
4. Secure link arm using a rope sling and crane.

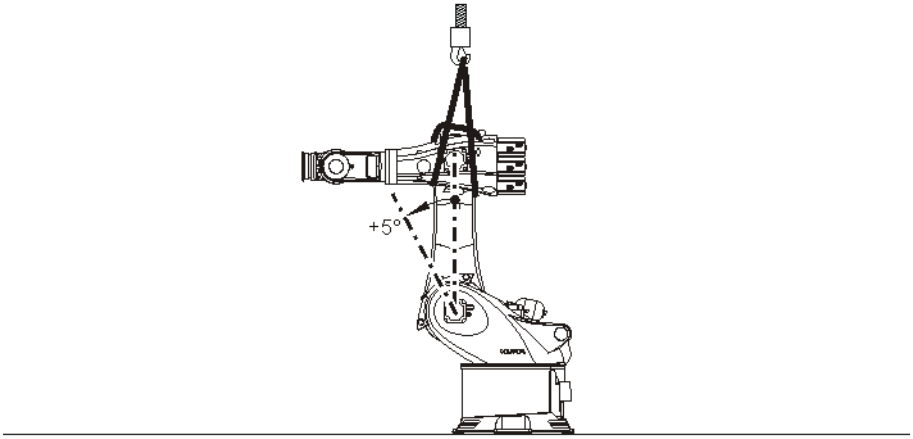

Fig. 10-18: Securing the link arm

5. Lift the counterbalancing system with a rope sling and bring it to the site of installation (>>> Fig. 10-19).
6. Mount the counterbalancing system sideways on the pin in the rotating column, and align.
7. If necessary, adjust the rope tension.
8. Coat the thread of the new M10x35-10.9 Allen screw with Drei Bond 1342 locking agent.
9. Mount the cover and fasten it to the pin using the new M10x35-10.9 Allen screw and conical spring washer.
10. Tighten M10x35-10.9 Allen screw with a torque wrench; M_A = 60 Nm.

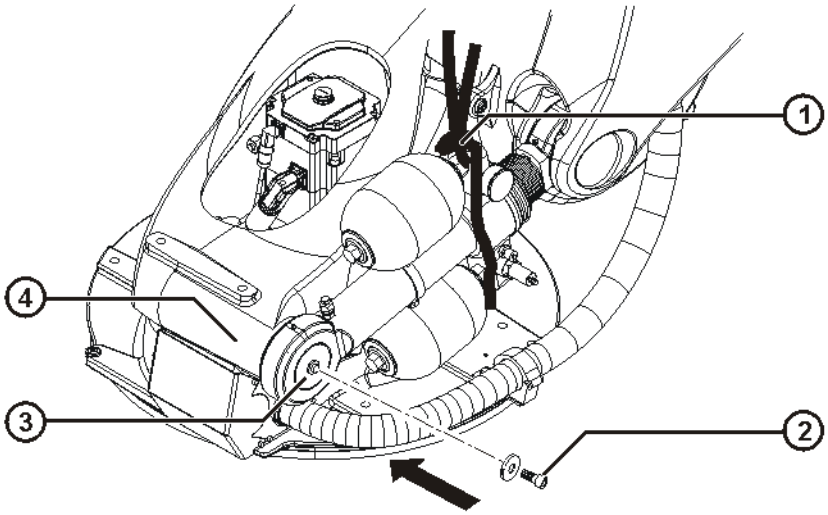

Fig. 10-19: Installing the counterbalancing system: rotating column

1	Rope sling	3	Cover
2	Allen screw	4	Rotating column

11. Put the robot into operation.
12. Move the link arm until the counterbalancing system can be inserted into the link arm. At the same time, move the element securing the link arm accordingly (>>> Fig. 10-20).
13. Lower the counterbalancing system, insert the articulated head with the thrust ring and spacer ring into the link arm, and align; observe the correct installation position.
14. Move the link arm and counterbalancing system until the holes are aligned.

15. Insert the pin with the aid of the device.

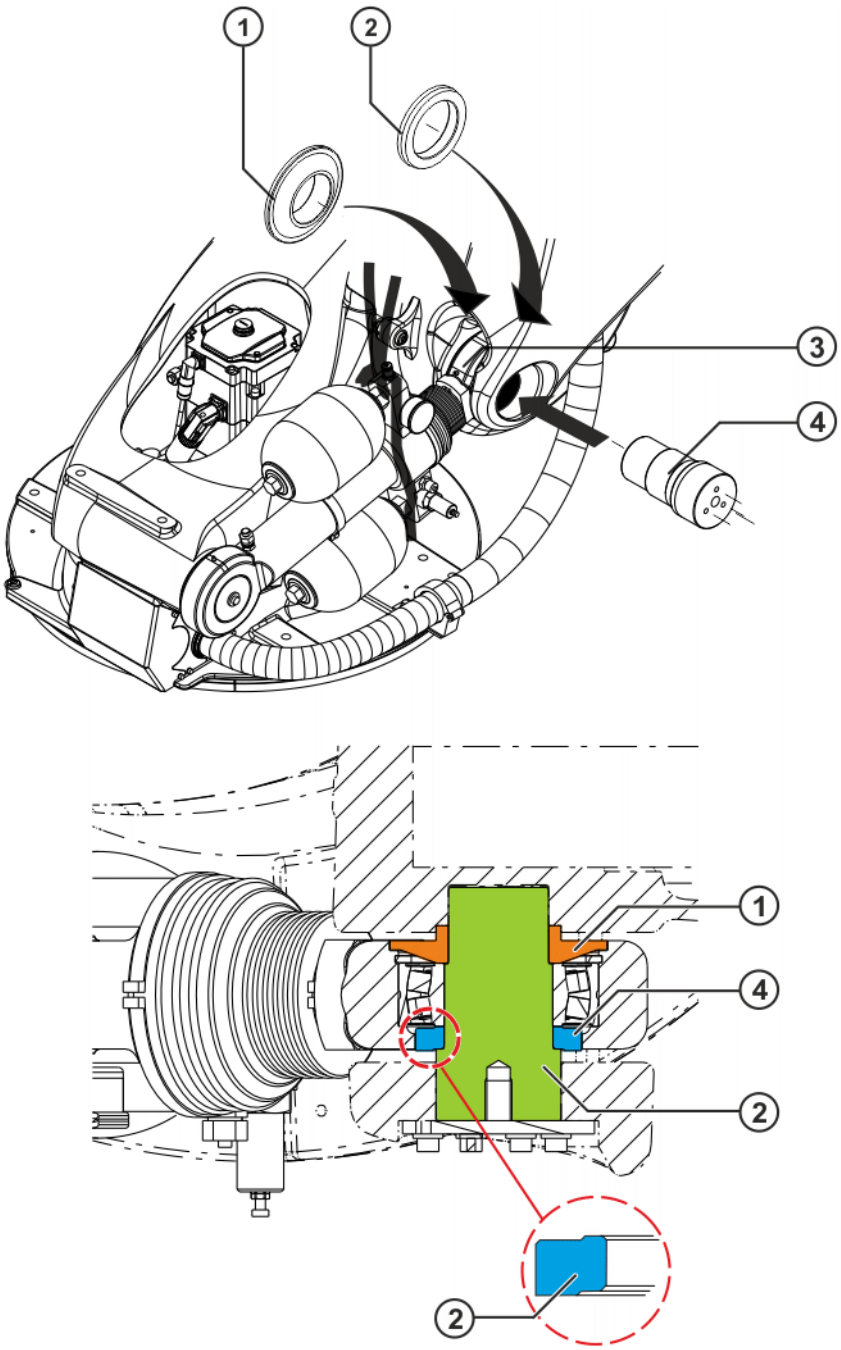

Fig. 10-20: Installing the counterbalancing system: pin

1	Thrust ring	3	Articulated head
2	Spacer ring	4	Pin

16. Mount the retaining plate and fasten with six M8x25-10.9 Allen screws and conical spring washers (>>> Fig. 10-21).
17. Tighten the 6 Allen screws with a torque wrench; M_A = 31 Nm.
18. Remove the rope sling from the counterbalancing system and the link arm.
19. Put the robot into operation.
20. Move the link arm in the plus direction until the spacer between the cylinder and the articulated head is released, and remove the spacer.

⚠ CAUTION If the link arm is moved any further in the minus direction with the spacer inserted, this will result in damage to the counterbalancing system, link arm or rotating column.

21. Secure the robot by pressing the E-STOP button.
22. Mount the bellows on the cylinder and the articulated head and fasten with worm drive clips.
23. Check the pressure on the counterbalancing system .

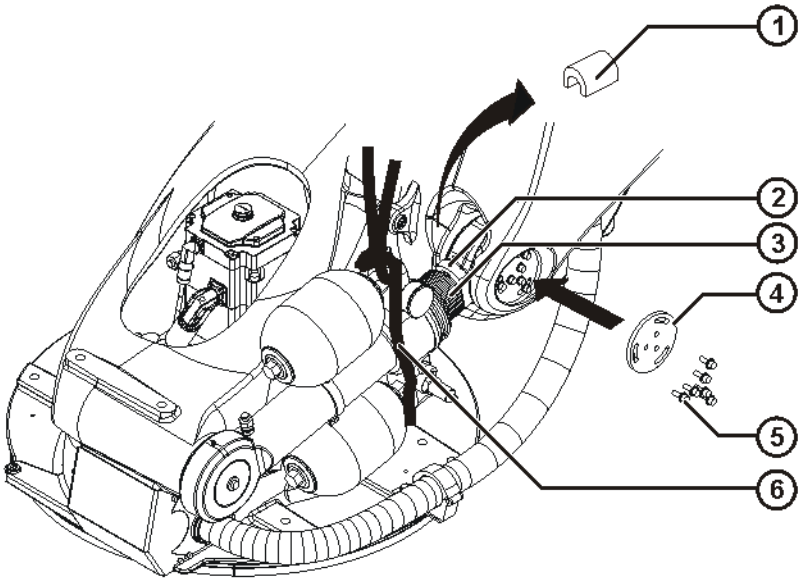

Fig. 10-21: Installing the counterbalancing system: link arm

1	Spacer	4	Lock washer
2	Bellows	5	Allen screws
3	Worm drive clip	6	Counterbalancing system

10.6 Exchanging the counterbalancing system on a ceiling-mounted robot

Description

The following instructions apply to ceiling-mounted robots (C variant). To remove and install the counterbalancing system, the ceiling-mounted robot must be removed from the ceiling and securely fastened to the floor (to the foundation).

Precondition

- The robot must be on the ground and firmly screwed to the mounting base.
- It must be possible to move the robot about axis 2.
- Tools and equipment must be removed.

⚠ 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 When removing or installing the counterbalancing system, care must be taken to avoid injury to arms, hands and fingers by crushing. Wear gloves and secure the counterbalancing system so that it cannot fall down or move unexpectedly.
The counterbalancing system weighs approx. 97 kg.
The counterbalancing system is pressurized. Particular caution must therefore be exercised and special knowledge put to effect when any work is performed on this system. Any improper handling constitutes a danger to life and limb.

10.6.1 Removing the counterbalancing system on a ceiling-mounted robot

Precondition

- The pin locator must be available.

Procedure

1. Relieve the counterbalancing system by reducing the oil pressure (>>> 9.5.1.2 "Depressurizing the counterbalancing system on a ceiling-mounted robot" Page 129).
2. Put the robot into operation and move the link arm into the -90° position (>>> Fig. 10-22).
3. Secure the robot by pressing the E-STOP button.
4. Secure the counterbalancing system using a rope sling. Move the crane until the weight is supported by the rope sling.
5. Remove 6 Allen screws and conical spring washers, and take off the retaining plate.

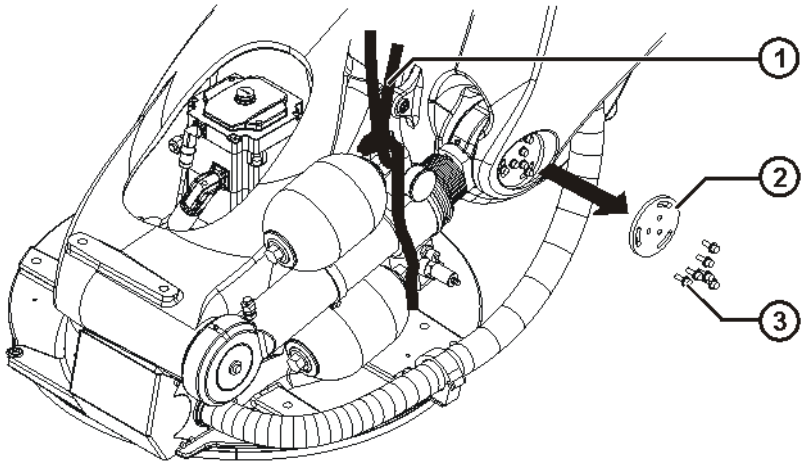

Fig. 10-22: Removing the counterbalancing system on a ceiling-mounted robot

1	Rope sling	3	Allen screw
2	Lock washer		

6. Secure link arm using a rope sling and crane (>>> Fig. 10-23).

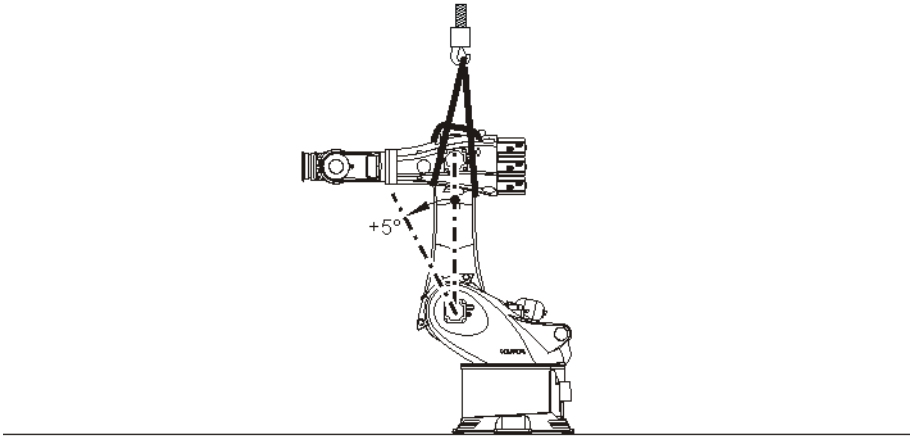

Fig. 10-23: Securing the link arm

7. Remove 1 Allen screw and lock washer, and take the cover off the rotating column (>>> Fig. 10-24).

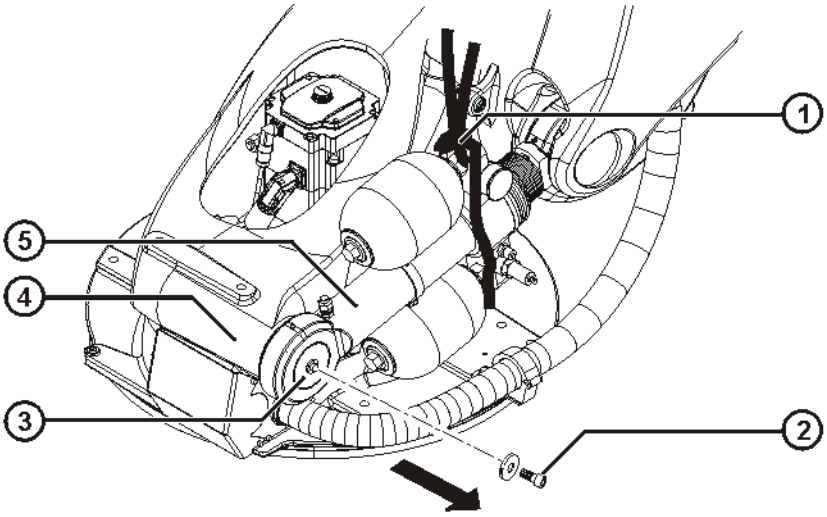

Fig. 10-24: Removing the counterbalancing system: rotating column

1	Rope sling	4	Rotating column
2	Allen screw	5	Counterbalancing system
3	Cover		

8. Insert the pin locator on the right-hand side between the articulated head and the link arm (>>> Fig. 10-25).
9. Pull the pin out of the link arm using an M16 pin extractor.
   The pin is out of the precision fit area when it has been pulled out approx. 25 mm.
10. Put the robot into operation and move the link arm carefully in the plus direction until the articulated head is free. When moving the link arm, move the crane and rope sling at the same time, so that the weight of the arm is supported.
11. Secure the robot by pressing the E-STOP button.
12. Swivel the counterbalancing system down and out of the link arm, moving the rope sling at the same time.
13. Take off the pin locator, thrust ring and spacer ring that are now loose.

⚠ CAUTION When forcing the counterbalancing system off the rotating column, an unfavorable position of the center of gravity may cause the counterbalancing system to move unexpectedly. To avoid injury and damage, the tension and position of the rope must be adjusted as necessary.

14. Force the counterbalancing system off the pin in the rotating column in the direction of the arrow.

    While forcing off the counterbalancing system, check the rope tension and if necessary correct it to prevent the components from being tilted.
15. Continue raising the counterbalancing system with the crane and set it down on a suitable support.
16. If the counterbalancing system is not to be reinstalled, it must be protected against corrosion before being put into storage.

If a new counterbalancing system is not being installed immediately, the robot can be moved into a safe position and the rope securing the link arm can be removed. The robot may only be moved again in order to install the new counterbalancing system.

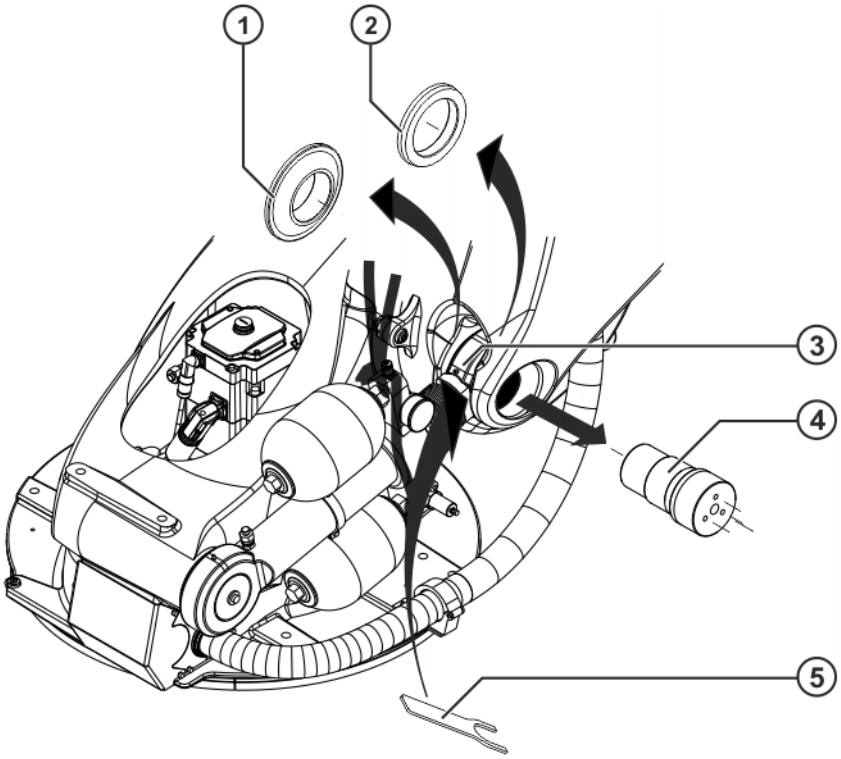

Fig. 10-25: Removing the counterbalancing system: pin

1	Thrust ring	4	Pin
2	Spacer ring	5	Pin locator
3	Articulated head		

10.6.2 Installing the counterbalancing system on a ceiling-mounted robot

Precondition

- The counterbalancing system is depressurized (oil pressure).
- The removal/installation device for CBS pins is available.

Procedure

1. Remove all protective coatings and oil from the counterbalancing system and check that no part of it is missing.

2. If necessary, put the robot into operation and move the link arm into approximately the -90° position.
3. Secure the robot by pressing the E-STOP button.
4. Secure link arm using a rope sling and crane (>>> Fig. 10-26).

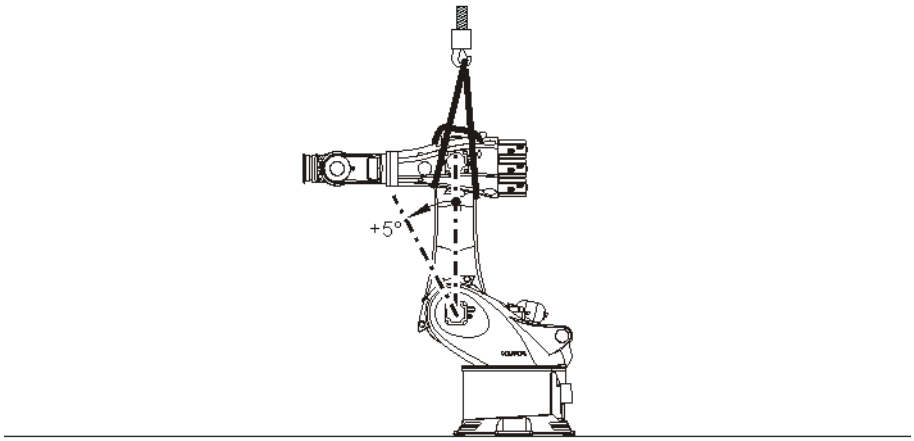

Fig. 10-26: Securing the link arm

5. Lift the counterbalancing system with a rope sling and bring it to the site of installation (>>> Fig. 10-27).
6. Mount the counterbalancing system sideways on the pin in the rotating column, and align.
7. If necessary, adjust the rope tension.
8. Coat the thread of the new M10x35-10.9 Allen screw with Drei Bond 1342 locking agent.
9. Mount the cover and insert in pin with the new M10x35-10.9 Allen screw and conical spring washer.
10. Tighten the Allen screw with a torque wrench; M_A = 60 Nm.

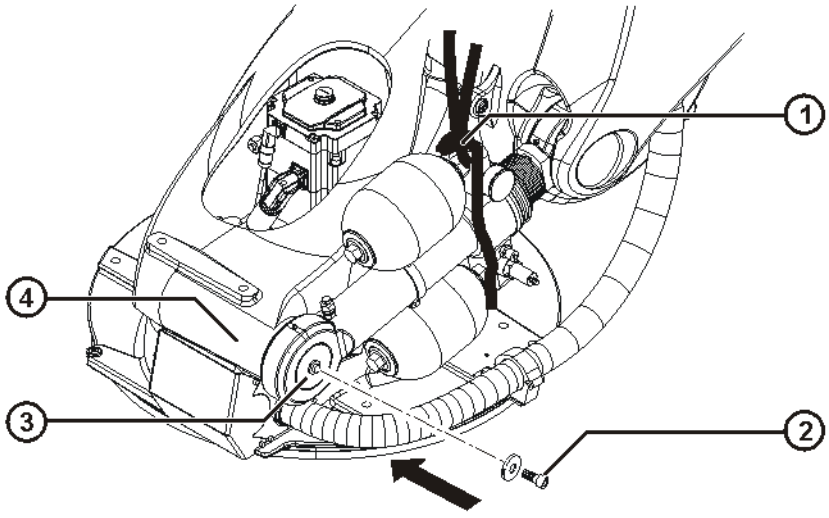

Fig. 10-27: Installing the counterbalancing system: rotating column

1	Rope sling	3	Cover
2	Allen screw	4	Rotating column

11. Put the robot into operation.
12. Move the link arm until the counterbalancing system can be inserted into the link arm. At the same time, move the element securing the link arm accordingly (>>> Fig. 10-28).

13. Lower the counterbalancing system, insert the articulated head with the thrust ring and spacer ring into the link arm, and align.
14. Move the link arm and counterbalancing system until the holes are aligned.
15. Insert the pin with the aid of the device.

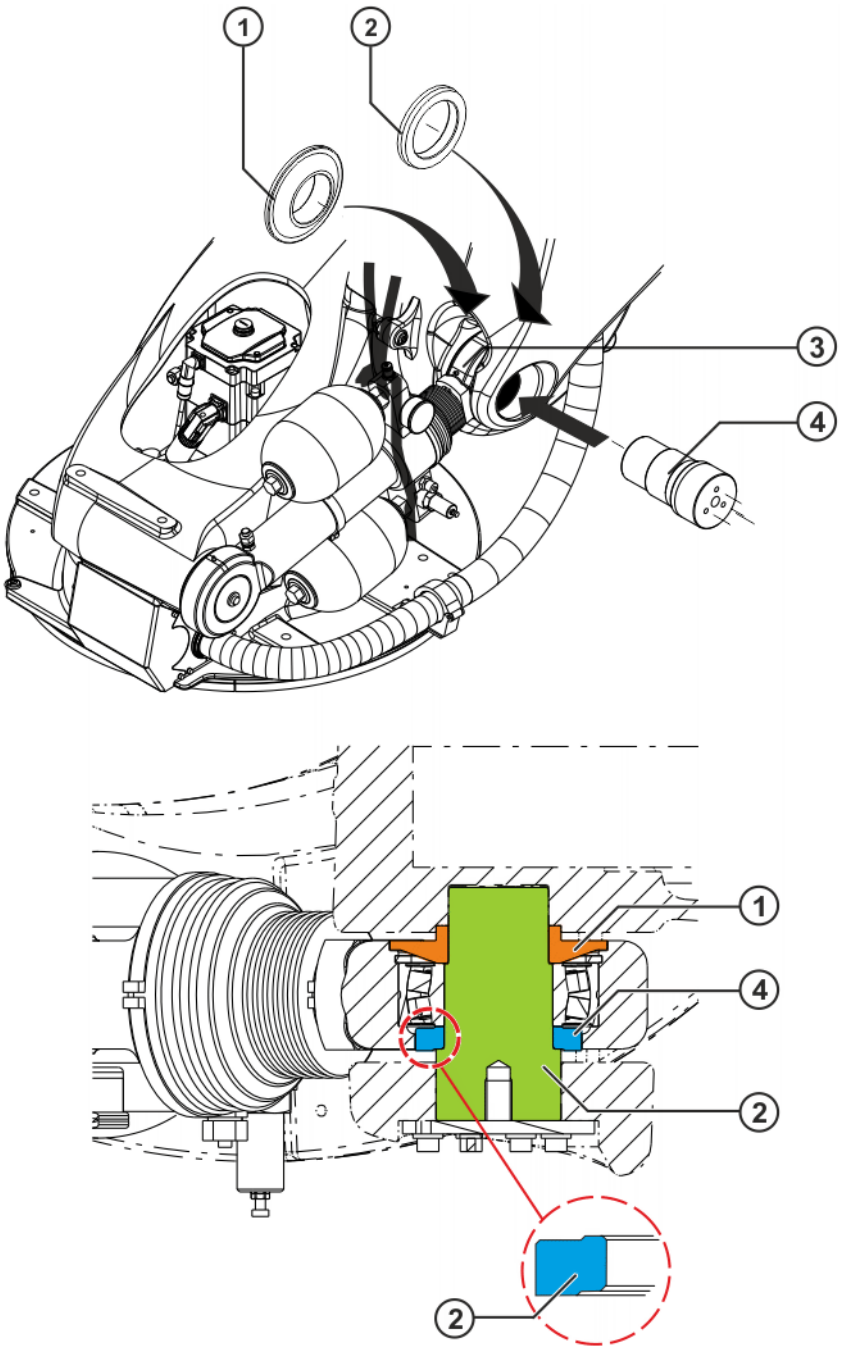

Fig. 10-28: Installing the counterbalancing system: pin

1	Thrust ring	3	Articulated head
2	Spacer ring	4	Pin

16. Mount the retaining plate and fasten with six M8x25-10.9 Allen screws and conical spring washers (>>> Fig. 10-29).
17. Tighten the 6 Allen screws with a torque wrench; M_A = 31 Nm.
18. Remove the rope sling from the counterbalancing system and the link arm.
19. Put the robot into operation and move the link arm into the -130° position.

20. Secure the robot by pressing the E-STOP button.
21. Fill with hydraulic oil and adjust oil pressure (>>> 9.5.1.4 "Filling and adjusting the counterbalancing system on a ceiling-mounted robot (fastened to floor)" Page 133).

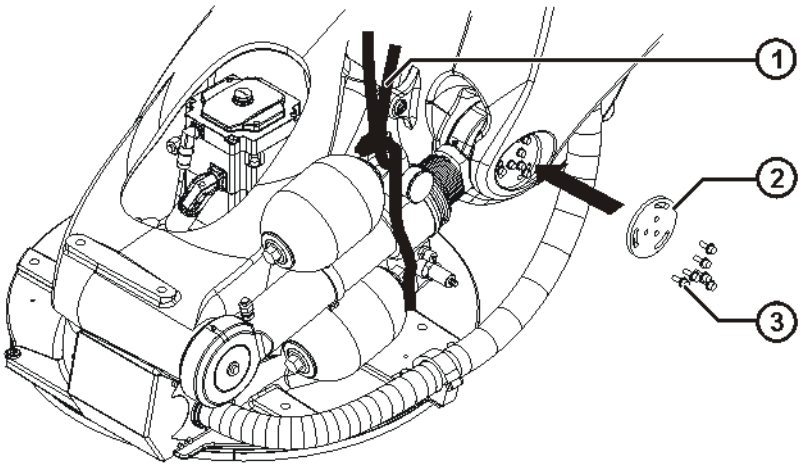

Fig. 10-29: Installing the counterbalancing system on a ceiling-mounted robot: link arm

1	Rope sling	3	Allen screw
2	Lock washer		

10.7 Description of the electrical installations

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) and the RDC box. The interface for the connecting cables is located at the back of the base frame. The motor and control cables are connected here via plug-in connections. The control and motor cables are routed from the RDC box and the multi-function housing to the motors (XM and XP connectors).

The protective circuit is also integrated into the cable set. The ground conductor is connected to the adapter plate via the ground conductor bolts.

All the motor cables, control cables and ground conductors are routed through the flexible tubes A1 and A2-A3. 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.

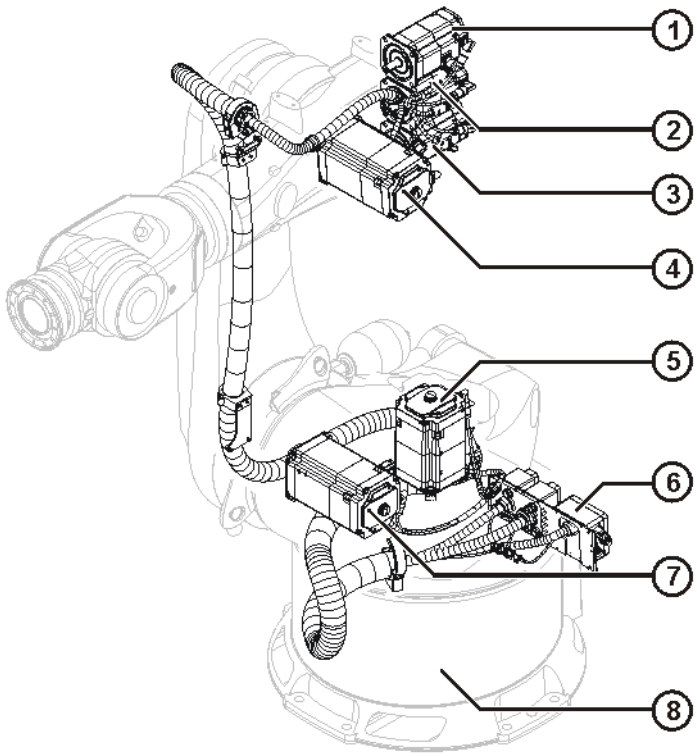

Fig. 10-30: Electrical installations, overview

1	Motor, axis 4	5	Motor, axis 1
2	Motor, axis 5	6	RDC box
3	Motor, axis 6	7	Motor, axis 2
4	Motor, axis 3	8	Base frame

Wiring diagrams

Designation	Connection	Figure
Wiring diagram A1	XM1	(>>> Fig. 10-31)
Wiring diagram A2	XM2	(>>> Fig. 10-32)
Wiring diagram A3	XM3	(>>> Fig. 10-33)
Wiring diagram A4	XM4	(>>> Fig. 10-34)
Wiring diagram A5	XM5	(>>> Fig. 10-35)
Wiring diagram A6	XM6	(>>> Fig. 10-36)
Control cable	Wiring diagram, RDC X31	(>>> Fig. 10-37)
Control cable	Wiring diagram, RDC X32	(>>> Fig. 10-38)
Protective circuit	Ring cable lug	(>>> Fig. 10-39)

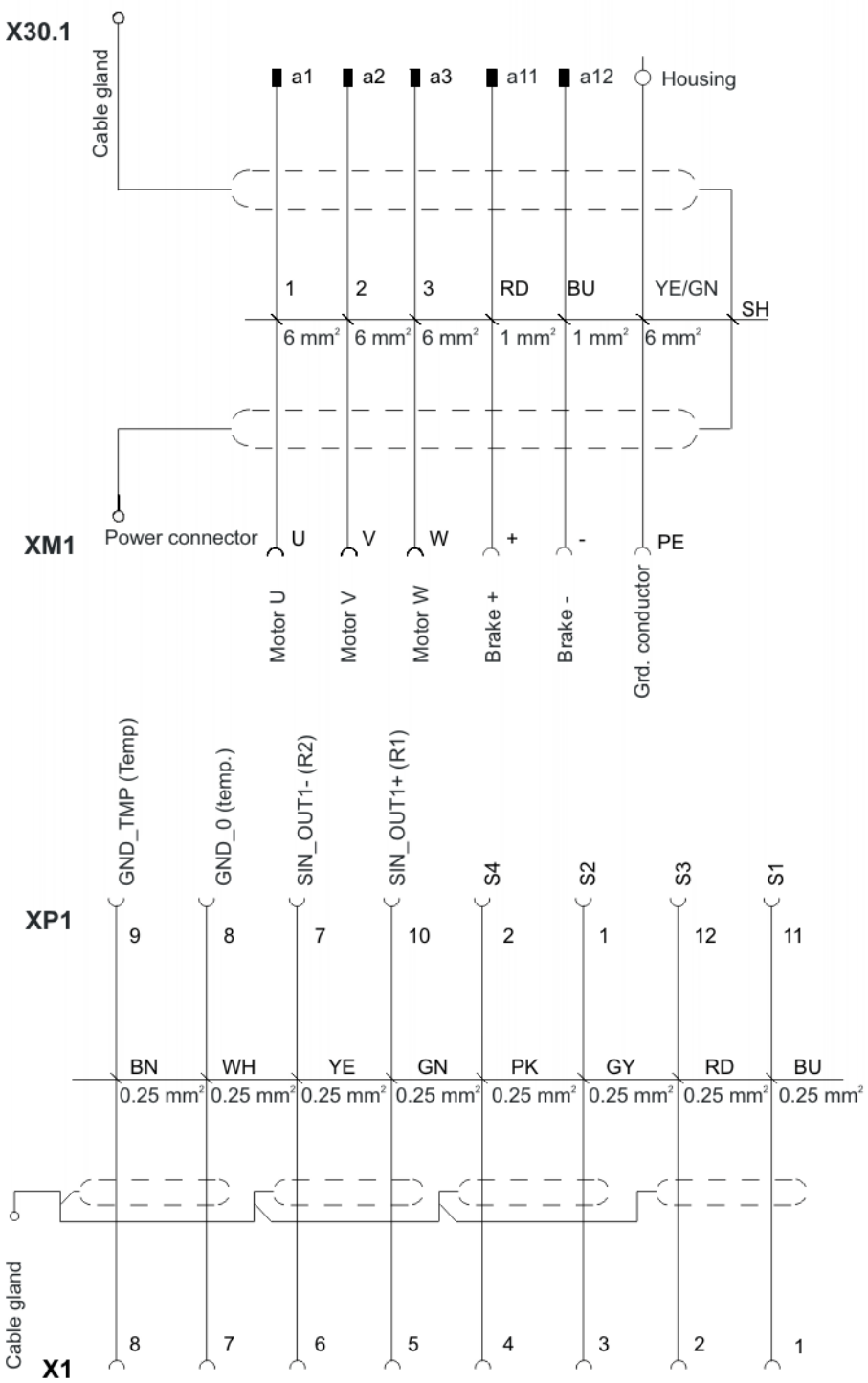

Fig. 10-31: Wiring diagram A1

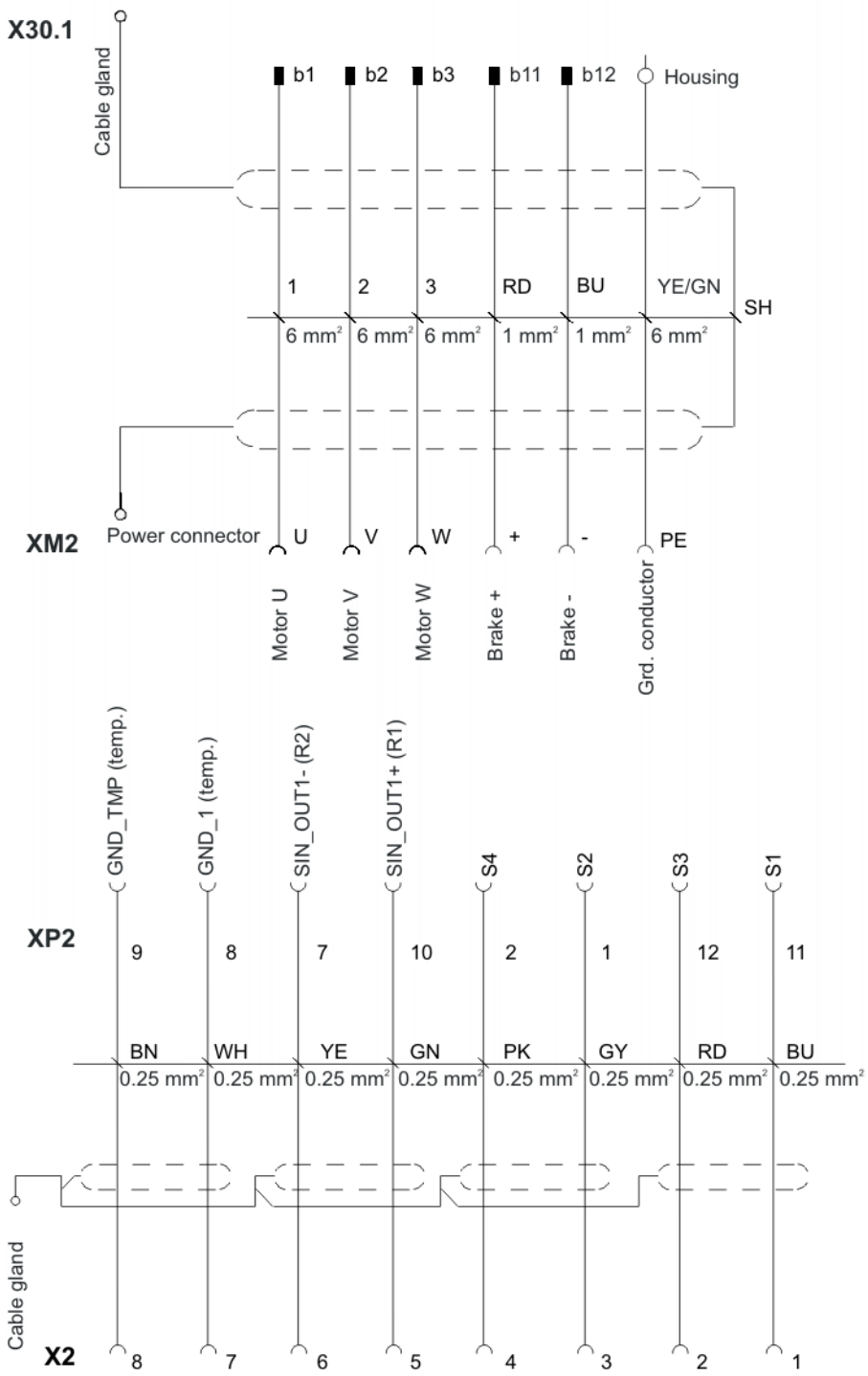

Fig. 10-32: Wiring diagram A2

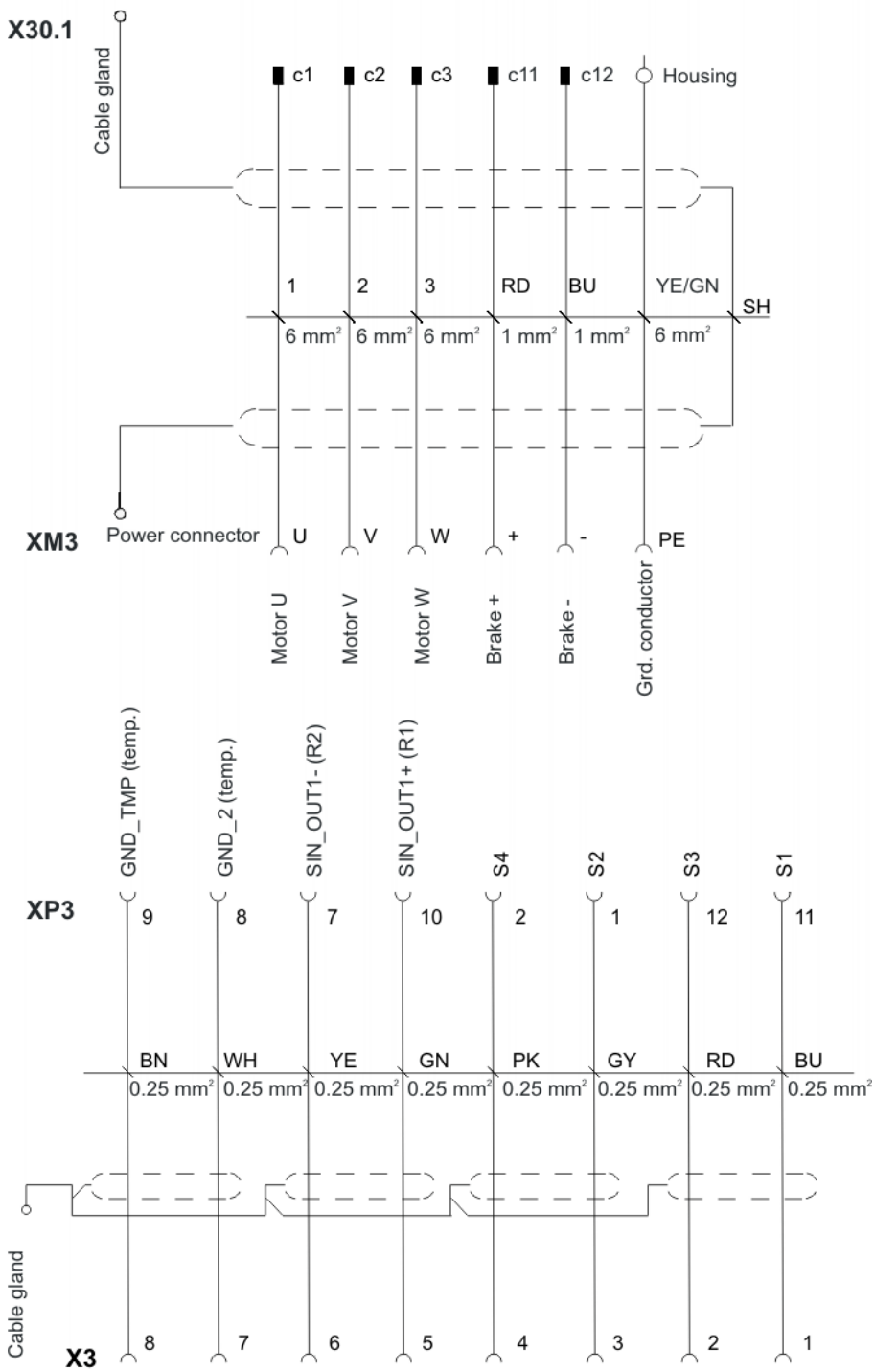

Fig. 10-33: Wiring diagram A3

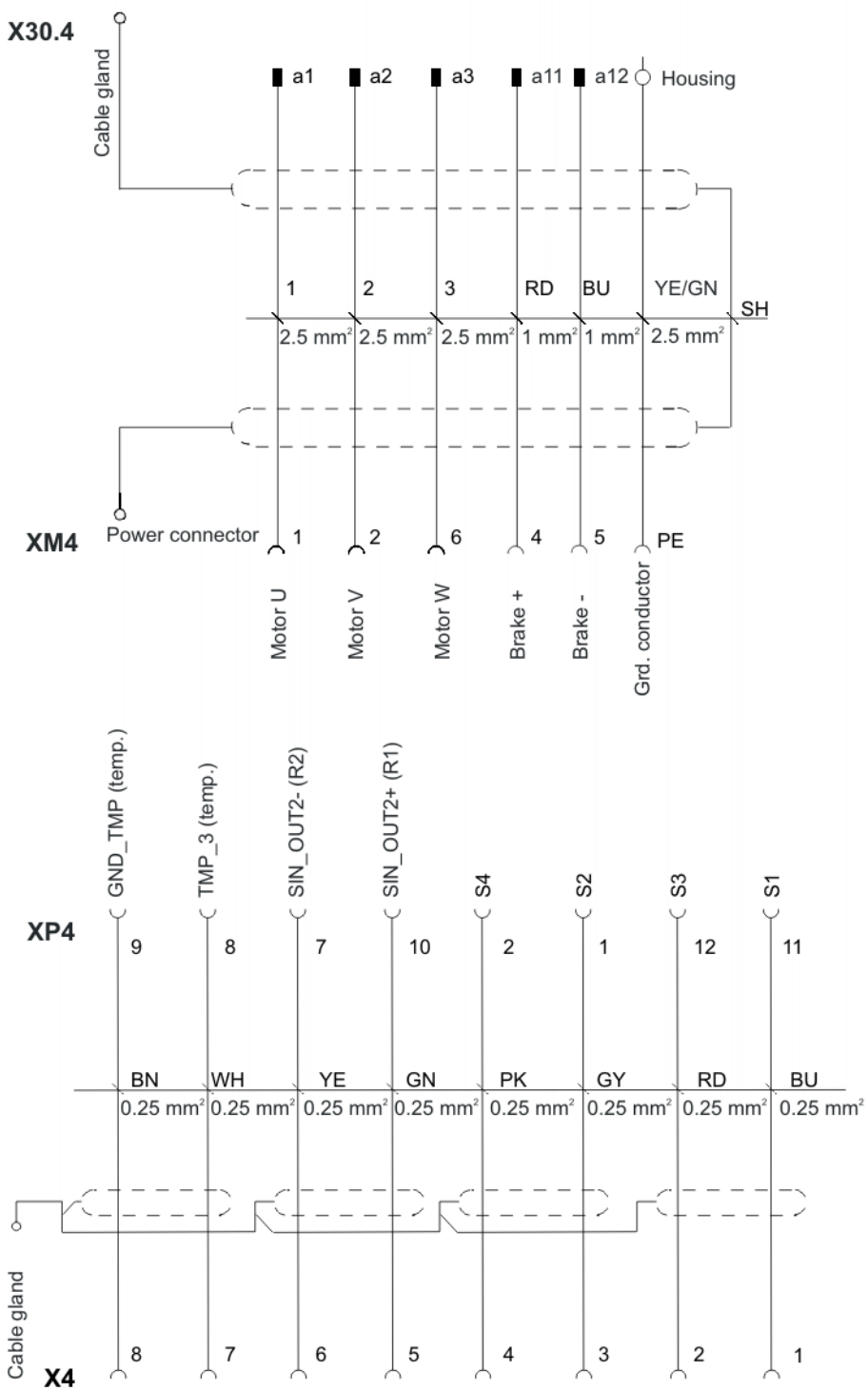

Fig. 10-34: Wiring diagram A4

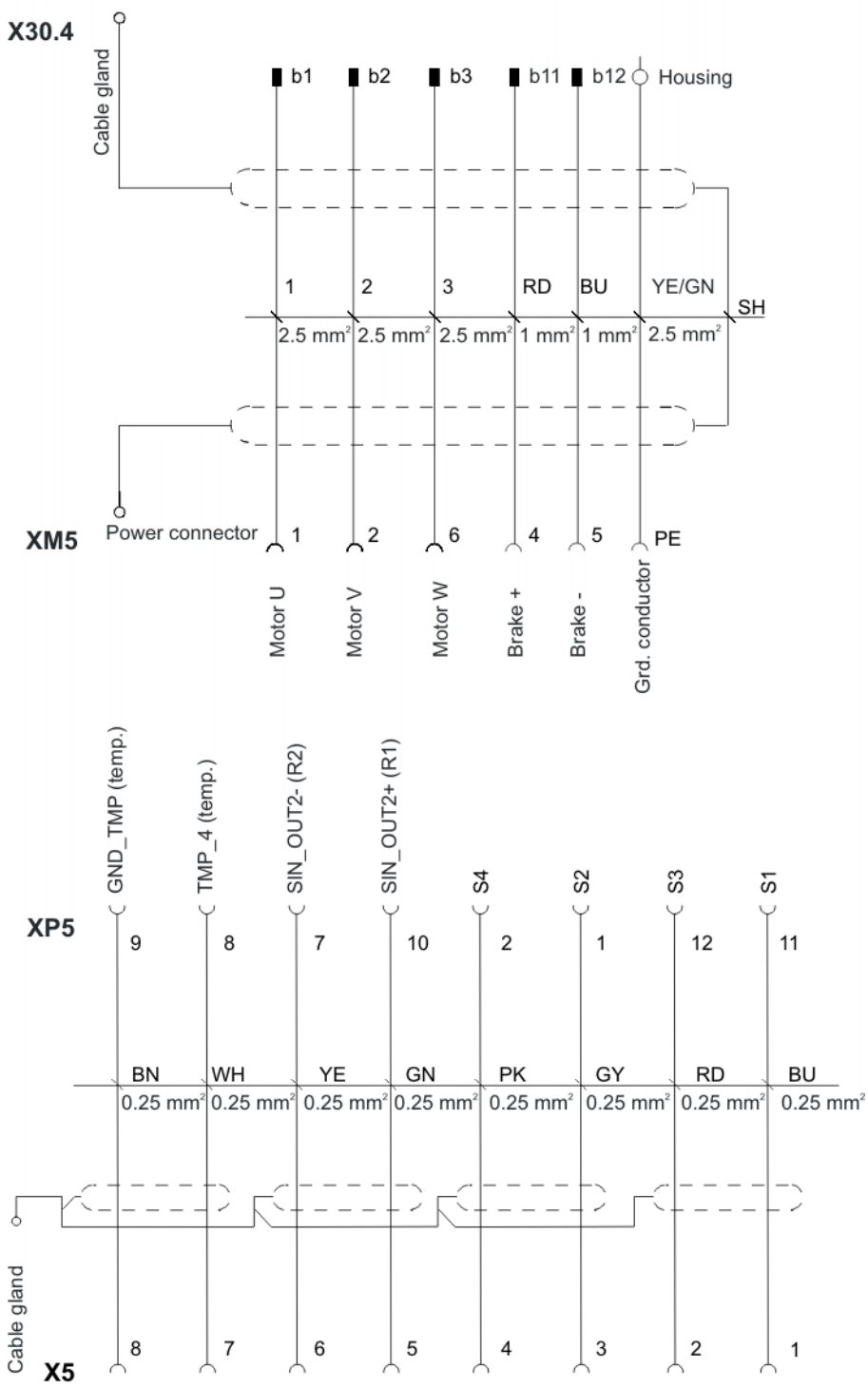

Fig. 10-35: Wiring diagram A5

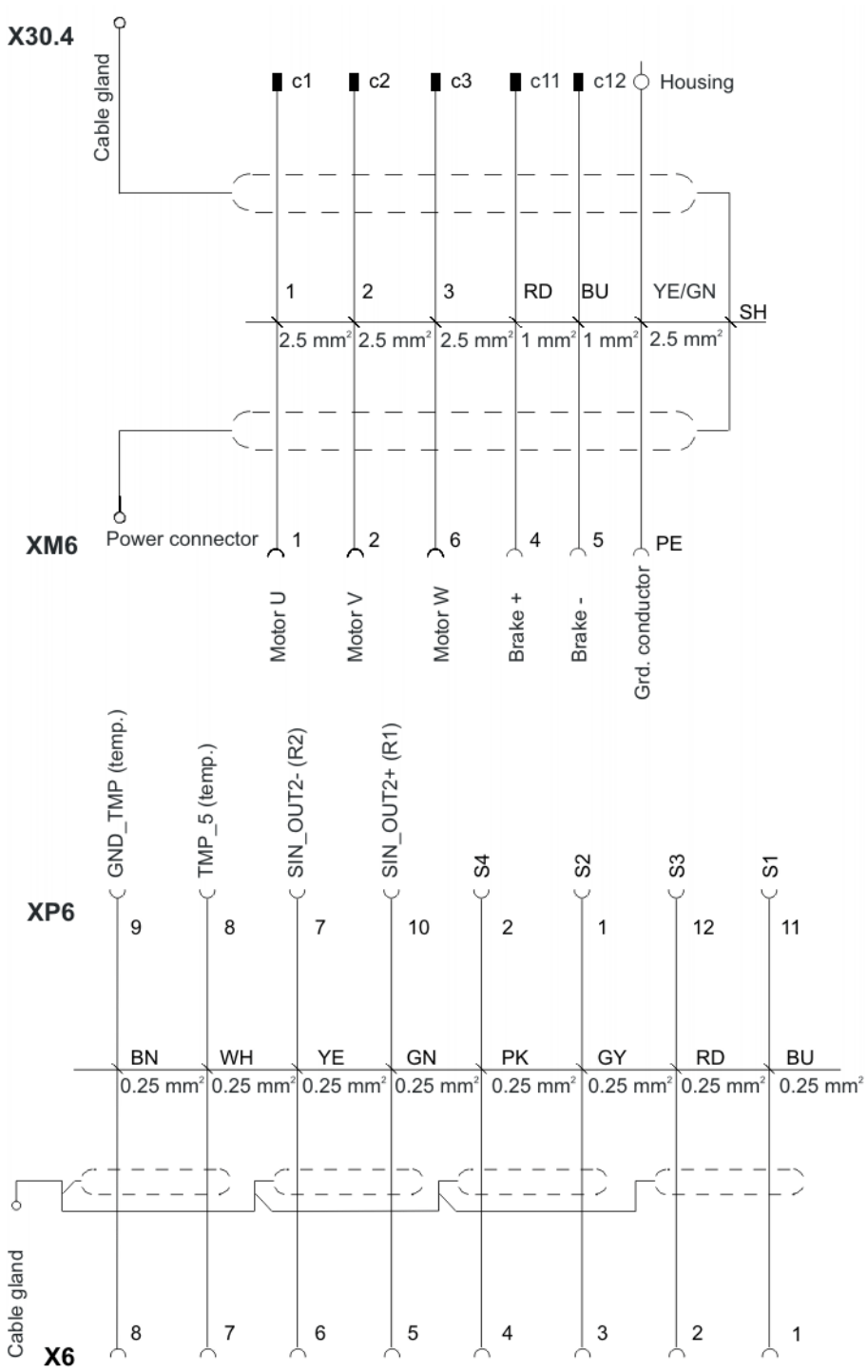

Fig. 10-36: Wiring diagram A6

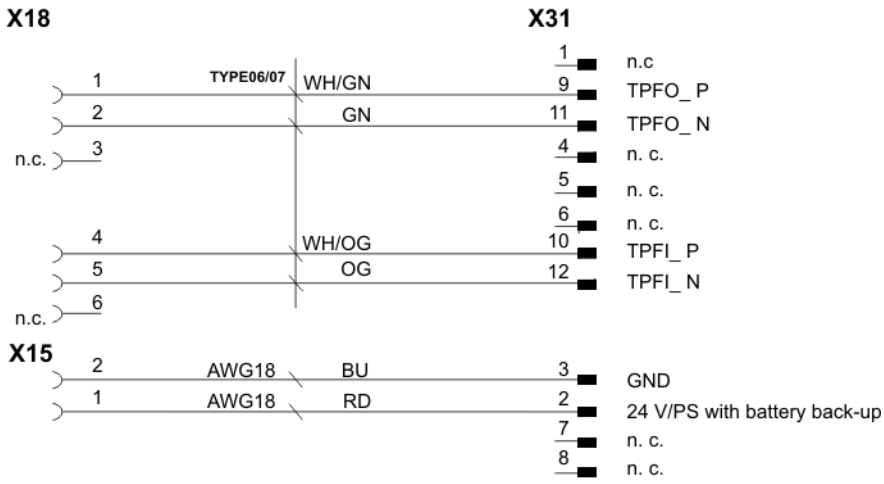

Fig. 10-37: Wiring diagram, RDC X31

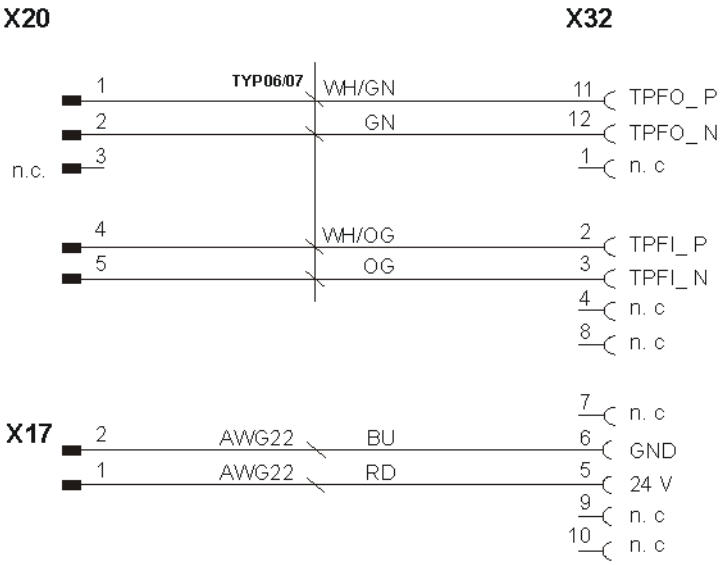

Fig. 10-38: Wiring diagram, RDC X32

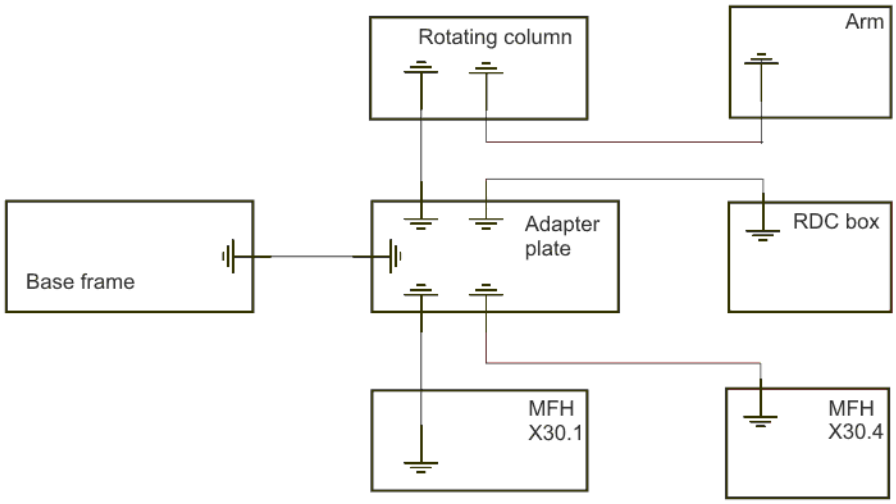

Fig. 10-39: Wiring diagram, protective circuit

11 Decommissioning, storage and disposal

11.1 Decommissioning, floor-mounted robots

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.

Precondition

- 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

1. Secure the robot.

> **⚠ 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.

2. Remove tools and equipment.
3. Put the robot into operation and move it into the transport position (>>> Fig. 11-1).

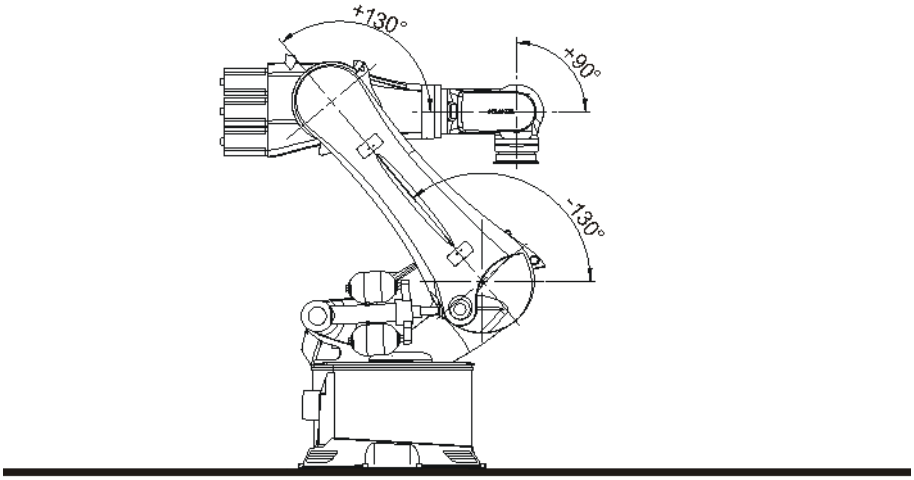

Fig. 11-1: Transport position

4. Secure the robot again by pressing the E-STOP button.
5. Release and unplug all peripheral connections.
6. Release and unplug the motor cable and control cable connectors.
7. Unscrew the hexagon nut from the ground conductor and pull off washers, lock washers and ground conductor.
8. Shut off the compressed air supply to the robot, disconnect the hose and remove it from the pressure regulator; F variant only.
9. Attach lifting tackle to the 3 eyebolts or prepare the robot for transportation with the fork lift truck. Minimum payload capacity for transportation: 3,500 kg.
10. Unscrew and remove the 8 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 centering 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.

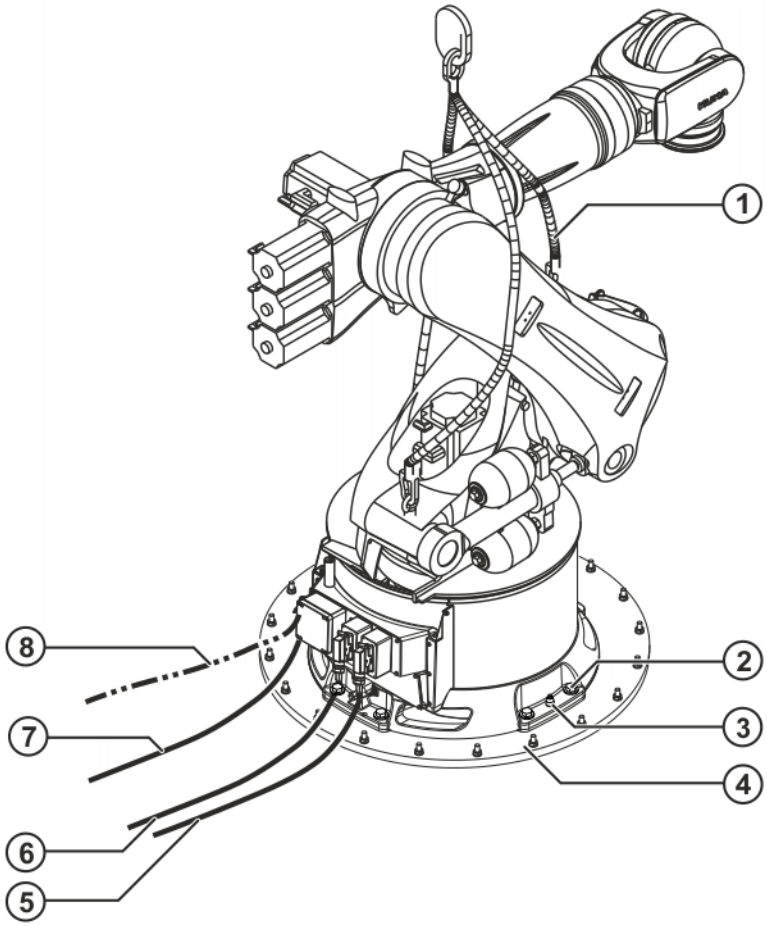

Fig. 11-2: Removing the robot from mounting base 175 mm

1	Lifting tackle	5	Motor cable X30.4
2	Hexagon bolts	6	Motor cable X30.1
3	Pin	7	Control cable
4	Bedplate	8	Ground conductor, threaded bolt

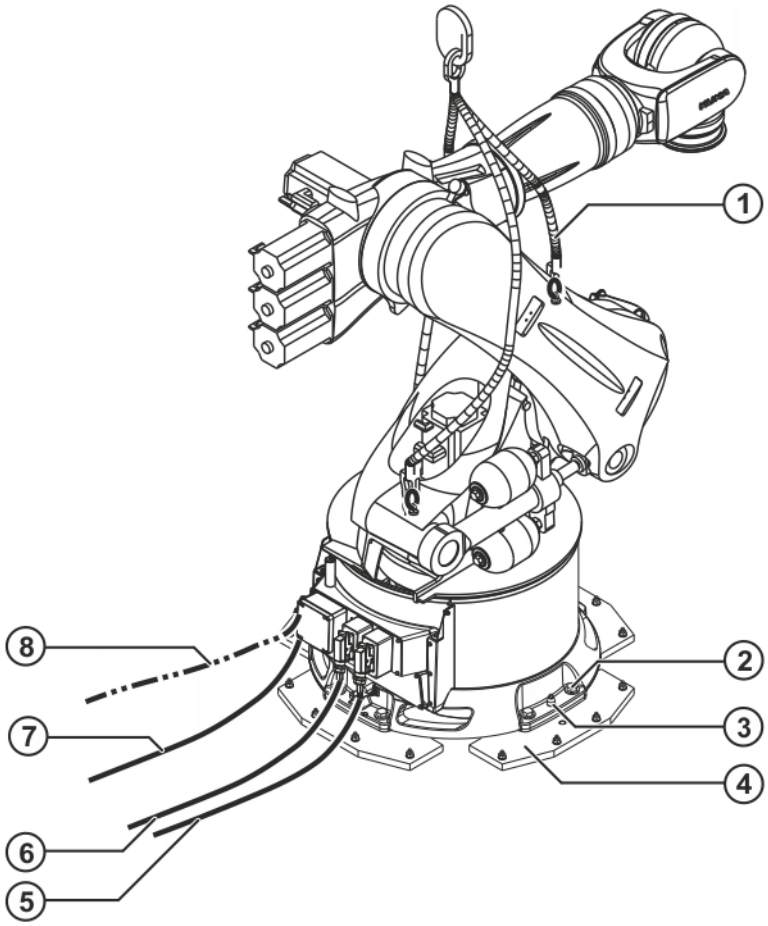

Fig. 11-3: Removing the robot from mounting base 200 mm

1	Lifting tackle	5	Motor cable X30.4
2	Hexagon bolts	6	Motor cable X30.1
3	Pin	7	Control cable
4	Bedplate	8	Ground conductor, threaded bolt

12. Prepare the robot for storage.

11.2 Decommissioning, ceiling-mounted robots

Description

This section describes all the work required for decommissioning the ceiling-mounted 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.

The robot can only be transported by fork lift truck after removal .

Precondition

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

Procedure

1. Secure the robot.

⚠ 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.

2. Remove tools and equipment.

3. Put the robot into operation and move it into the transport position (>>> Fig. 11-4).

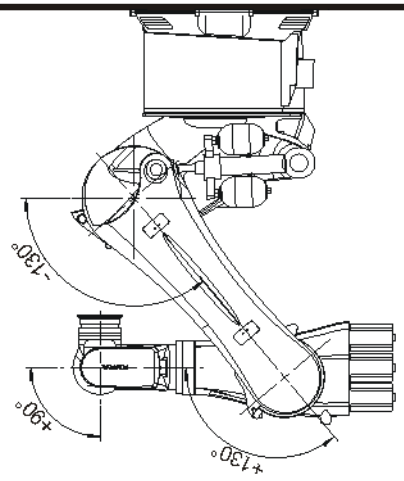

Fig. 11-4: Transport position for ceiling-mounted robots

4. Secure the robot again by pressing the E-STOP button.
5. Release and unplug all peripheral connections (>>> Fig. 11-5).
6. Release and unplug the motor cable and control cable connectors.
7. Unscrew the hexagon nut from the ground conductor and pull off washers, lock washers and ground conductor.
8. Shut off the compressed air supply to the robot, disconnect the hose and remove it from the pressure regulator; F variant only.
9. Move the forks of the fork lift truck into the fork slots in the base frame and press the robot against the ceiling. The fork lift truck must support the weight of the robot. Minimum payload capacity of the fork lift truck: approx. 3,500 kg.
10. Slacken the 8 hexagon bolts with conical spring washers until the conical spring washers are free.
11. Lower the robot a few millimeters.

⚠ WARNING 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.

12. Completely remove the 8 hexagon bolts and conical spring washers.
13. Lower the robot vertically and transport it away.

    Take care not to damage the two pins when lowering the robot.

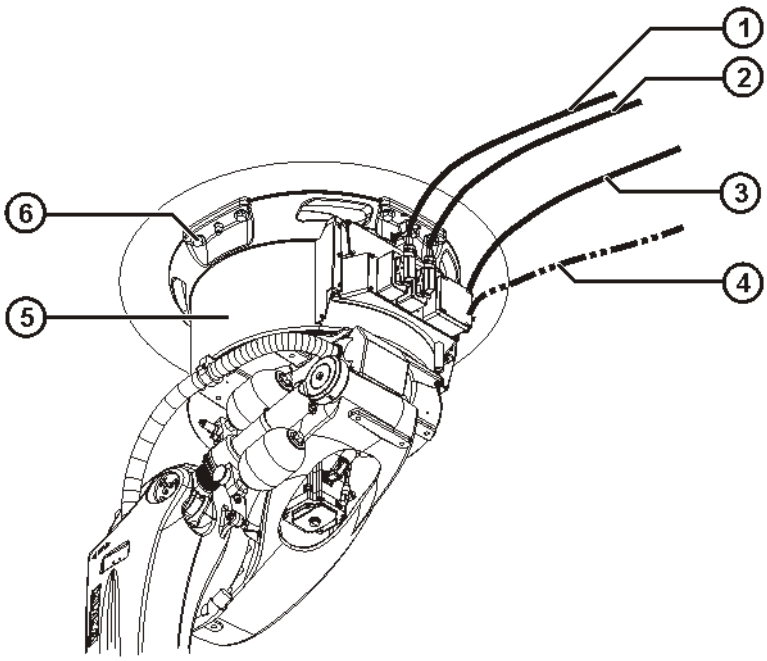

Fig. 11-5: Removing ceiling-mounted robots

1	Motor cable X30.4	4	Ground conductor
2	Motor cable X30.1	5	Base frame
3	Control cable	6	Hexagon bolts

14. Prepare the robot for storage.

11.3 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.

11.4 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.

⚠ WARNING The hydropneumatic counterbalancing system on the robot is filled with nitrogen and hydraulic oil under pressure; improper handling can lead to personal injury and damage to property. If the hydropneumatic counterbalancing system to be disposed of, it must first be properly depressurized. Only pressure-free counterbalancing systems may be authorized for disposal.

Material, designation	Subassembly, component	Remark
Light alloy casting	Main body, spur gear housing, cover, arm extension	
Cast-iron material	Base frame, rotating column, link arm, arm	
ABS	Panels, covers	
Steel	Gear units, screws and washers	
	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 (>>> 12.2.5 "Safety data sheet for Optitemp RB1 cable grease" Page 219)
Oil	Gear units	See safety data sheet, consumables (>>> 12.2.3 "Safety data sheet for Optigear Synthetic RO 150 oil" Page 208)
	Counterbalancing system	See safety data sheet, consumables (>>> 12.2.2 "Safety data sheet for Castrol Hyspin ZZ 46 hydraulic oil" Page 202)

Material, designation	Subassembly, component	Remark
Lubricating grease	Gear teeth	See safety data sheet, consumables (>>> 12.2.4 "Safety data sheet for Microlube GL 261 lubricating grease" Page 215)
	Counterbalancing system, bearing on arm / link arm	See safety data sheet, consumables (>>> 12.2.1 "Safety data sheet for LGEV 2 lubricating grease" Page 195)
PA	Hinged clamps	
NBR	O-rings	
PE	End stop buffer	

12 Appendix

12.1 Tightening torques

Tightening torques

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	3.8 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.

12.2 Safety data sheets

12.2.1 Safety data sheet for LGEV 2 lubricating grease

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

Section 1 **Identification of the substance/mixture and of the company**

- 1.1 Product identifier

Trade name:	LGEV 2

- 1.2 Relevant identified uses of the substance or mixture and uses advised against

Recommended use:	Lubricant/grease

- 1.3 Details of the supplier of the safety data sheet

Manufacturer designation	
Supplier:	**SKF Maintenance Products** Postboks 1008 NL-3430, BA Nieuwegein Netherlands
Telephone:	+31 30 6307200
Fax:	+31 30 6307205

Manufacturer designation	
e-mail address:	sebastien.david@skf.com
Contact person:	Sébastien David

- 1.4 Emergency number

Emergency hotline	+49 (0)30 19240

Section 2 Possible hazards

- 2.1 Classification of the substance or mixture

DPD classification:	The product shall not be classified as hazardous according to the classification and labeling rules for substances and mixtures.
Most serious harmful effects:	May cause slight irritation to the skin and eyes. Degreases the skin. Long-term exposure may cause irritation and possible inflammation.

- 2.2 Label elements

Hazard designation:	The product shall not be classified as hazardous according to the classification and labeling rules for substances and mixtures.
Other labeling:	Safety data sheet available on request for professional users.

- 2.3 Other hazards

  Assessment to determine PBT and vPvB has not been made.

Section 3 Composition / Information about the components

- 3.1 Substances

  -

- 3.2 Mixtures

Registration number	CAS/EC no.	Substance	DSD classification/CLP classification	w/w%	Note
-	-	Dialkyl polysulfide derivatives	R53	1 - 2,5	-
-	80939-62-4 279-632-6	Amines, C11-14 branched alkyl, monohexyl and dihexyl phosphates	Xi; R36/38 N; R51/53	< 1	-

For full text of R-phrases and H-phrases, see Section “Other information” (>>> "Section 16" Page 202).

Section 4 First aid measures

- 4.1 Description of first aid measures

Inhalation:	Ensure plenty of fresh air. Seek medical advice in case of persistent discomfort.
Ingestion:	Rinse out mouth thoroughly and drink 1-2 glasses of water in small sips. Seek medical advice in case of persistent discomfort.

Skin:	Remove contaminated clothing. Wash skin with soap and water. Seek medical advice in case of persistent discomfort.
Eyes:	Flush with water (preferably using eye wash equipment) until irritation subsides. Seek medical advice if symptoms persist.
Other information	When obtaining medical advice, show the safety data sheet or label.

- 4.2 Most important symptoms and effects, both acute and delayed

  May cause slight irritation to the skin and eyes. Degreases the skin. Long-term exposure may cause irritation and possible inflammation.
- 4.3 Indication of any immediate medical attention and special treatment needed

  Treat symptoms. No special immediate treatment required.

Section 5 Fire-fighting measures

- 5.1 Extinguishing agents

Suitable extinguishing agents:	Extinguish with powder, foam, carbon dioxide or water mist. Use water or water mist to cool non-ignited stock.
Unsuitable extinguishing agents:	Do not use a water stream, as it may spread the fire.

- 5.2 Special hazards arising from the substance or mixture

  Not flammable, but combustible. Product decomposes in fire conditions or when heated to high temperatures, and flammable and toxic gases may be released.
- 5.3 Advice for firefighters

  Remove containers from fire area if this can be done without risk. Do not inhale vapors and fumes. Ensure plenty of fresh air. Wear self-contained breathing apparatus (SCBA) with chemical resistant gloves.

Section 6 Measures after unintended release

- 6.1 Personal precautions, protective equipment and emergency procedures

For non-emergency personnel:	Wear gloves. Wear safety goggles if there is a risk of splashing.
For emergency responders:	Wear gloves. Wear safety goggles if there is a risk of splashing. Normal protective clothing equivalent to EN 469 is recommended.

- 6.2 Environmental precautions

  Prevent spillage from entering drains and/or surface water.
- 6.3 Methods and material for containment and cleaning up

  Contain and absorb spill with sand or other absorbent material and transfer to suitable waste containers. Wipe up minor spills with a cloth.
- 6.4 Reference to other sections

  See Section “Limitation and monitoring of exposure / Personal protective equipment” (>>> "Section 8" Page 198) for type of protective equipment.

  See Section “Disposal information” (>>> "Section 13" Page 200) for instructions on disposal.

Section 7 Handling and storage

- 7.1 Precautions for safe handling

  The product should be used under well-ventilated conditions and preferably under process ventilation. Avoid contact with skin and eyes. Running

water and eye wash equipment should be available. Wash hands before breaks, before using restroom facilities, and at the end of work.

- 7.2 Conditions for safe storage, including any incompatibilities

  The product should be stored safely, out of reach of children and away from food, animal feeding stuffs, medicines, etc. Keep in tightly closed original packaging. Storage temperature: approx. 20 °C. Do not store with the following: Oxidizing agents.

  Storage class in accordance with VCI: 12

- 7.3 Specific end use(s)

  No

Section 8 Limitation and monitoring of exposure / Personal protective equipment

- 8.1 Control parameters

Legal basis:	Technical regulations for hazardous substances, occupational exposure limits TRGS 900, issued January 2006. Last amended: GMBI 2012 Contains no substances subject to reporting requirements.

- 8.2 Limitation and monitoring of exposure

Appropriate engineering controls:	Wear the personal protective equipment specified below. See also Section .
Personal protective equipment, eye/face protection:	Wear safety goggles if there is a risk of splashing. Eye protection must conform to EN 166.
Personal protective equipment, skin protection:	In the event of direct skin contact, wear protective gloves. Type of material: nitrile rubber. Breakthrough time has not been determined for the product. Change gloves often. Gloves must conform to EN 374.
Personal protective equipment, respiratory protection:	Not required. In case of insufficient ventilation, wear respiratory protective equipment. Filter type: A/P2. Respiratory protection must conform to one of the following standards: EN 136/140/145.
Environmental exposure controls:	Ensure compliance with local regulations for emissions.

Section 9 Physical and chemical properties

- 9.1 Information on basic physical and chemical properties

State:	Paste/grease
Color:	Gray
Odor:	Characteristic
Odor threshold:	No data
pH (solution for use):	No data
pH (concentrate):	No data
Melting point/freezing point:	No data
Boiling point and boiling range:	No data
Flash point:	> 200°C
Evaporation rate:	No data
Flammability (solid, gas):	No data
Upper/lower flammability limits:	No data
Upper/lower explosive limits:	No data
Vapor pressure:	No data

Vapor density:	No data
Relative density:	0,95 (20°)
Solubility:	Insoluble in the following: Water
Partition coefficient (n-octanol/ water):	No data
Auto-ignition temperature:	Not spontaneously flammable
Decomposition temperature:	No data
Viscosity:	No data
Explosive properties:	Non-explosive
Oxidizing properties:	No data

- 9.2 Other information

  Pour point: approx. 180 °C

Section 10 Stability and reactivity

- 10.1 Reactivity

  Reacts with the following: Strong oxidizing agents/strong acids.
- 10.2 Chemical stability

  The product is stable when used in accordance with the manufacturer's instructions.
- 10.3 Possibility of hazardous reactions

  Not known.
- 10.4 Conditions to be avoided

  Avoid heating and contact with ignition sources.
- 10.5 Incompatible materials

  Strong oxidizing agents/strong acids.
- 10.6 Hazardous decomposition products

  Product decomposes in fire conditions or when heated to high temperatures, and flammable and toxic gases may be released.

Section 11 Toxicological information

- 11.1 Information on toxicological effects

Acute toxicity - oral:	The product does not have to be classified. Test data are not available. Ingestion of large quantities may cause discomfort.
Acute toxicity - dermal:	The product does not have to be classified. Test data are not available.
Acute toxicity - inhalation:	The product does not have to be classified. Test data are not available.
Skin corrosion/irritation:	The product does not have to be classified. Test data are not available. Degreases the skin. Long-term exposure may cause irritation and possible inflammation.
Serious eye damage/eye irritation:	The product does not have to be classified. Test data are not available. Temporary irritation.
Sensitization:	The product does not have to be classified. Test data are not available.
Mutagenicity:	The product does not have to be classified. Test data are not available.
Carcinogenic properties:	The product does not have to be classified. Test data are not available.
Reproductive toxicity:	The product does not have to be classified. Test data are not available.

Toxicity in case of single exposure:	The product does not have to be classified. Test data are not available. Inhalation of vapors/spray mist may cause irritation to the upper airways.
Toxicity in case of repeated or prolonged exposure:	The product does not have to be classified. Test data are not available.
Aspiration hazard:	The product does not have to be classified. Test data are not available.
Other toxicological effects:	Not known.

Section 12 Ecological information

- 12.1 Toxicity

  The product does not have to be classified. Test data are not available. The product contains small quantities of environmentally hazardous substances.
- 12.2 Persistence and degradability

  Not expected to be biodegradable. Test data are not available.
- 12.3 Bioaccumulative potential

  The product contains at least one substance that is bioaccumulative in organisms. Test data are not available.
- 12.4 Mobility in soil

  Test data are not available.
- 12.5 Results of PBT and vPvB assessment

  No assessment has been made.
- 12.6 Other adverse effects

  Oil products may cause ground and water pollutants.

Section 13 Disposal information

- 13.1 Waste treatment methods

  Avoid discharge to drain or surface water. Collect spills and waste in closed, leak-proof containers for disposal at the local hazardous waste site.

  EWC code: Depends on line of business and use, for instance 12 01 12 spent waxes and fats.

  Absorbent/cloth contaminated with the product:

  EWC code: 15 02 02 absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances

  Contaminated packaging is to be disposed of via the local waste-removal scheme. Empty, cleaned packaging should be disposed of for recycling.

Section 14 Transport information

- ADR/RID

  Not included.
  - 14.1 UN number

    -
  - 14.2 UN proper shipping name

    -
  - 14.3 Transport hazard class(es)

    -
  - 14.4 Packing group

    -
  - Hazard identification number

-

- Tunnel restriction code:

  -

- 14.5 Environmental hazards

  -

- ADN

  Not included.

  - 14.1 UN number

    -

  - 14.2 UN proper shipping name

    -

  - 14.3 Transport hazard class(es)

    -

  - 14.4 Packing group

    -

  - 14.5 Environmental hazards

    -

    Environmental hazard in tank vessels

    -

- IMDG

  Not included.

  - 14.1 UN number:

    -

  - 14.2 UN proper shipping name

    -

  - 14.3 Transport hazard class(es)

    -

  - 14.4 Packing group

    -

  - 14.5 Environmental hazards

    -

  - IMDG Code segregation group:

    -

- ICAO/IATA

  Not included.

  - 14.1 UN number

    -

  - 14.2 UN proper shipping name

    -

  - 14.3 Transport hazard class(es)

    -

  - 14.4 Packing group

    -

- 14.6 Special precautions for user

  -

- Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code

  -

Section 15 Regulatory information

- 15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Special provisions:	No Statutory Order on Hazardous Incidents: Not included
Water hazard classification:	2: Water-hazardous
Components of the product listed in TRGS 905:	None

- 15.2 Chemical safety assessment

  Chemical safety assessment has not been performed.

Section 16 Other information

Changes have been made in the following sections:		1 to 16
Abbreviation explanations:	PBT	Persistent, Bioaccumulative and Toxic
	vPvB	Very Persistent and Very Bioaccumulative
Risk (R) phrases:	R36/38	Irritating to eyes and skin.
	R51/53	Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
	R53	May cause longer-term adverse effects in the aquatic environment.
H-phrases:	No H-phrases.	
Training:	Thorough knowledge of this safety data sheet is a prerequisite.	
More information:	This safety data sheet is in accordance with regulation 1907/2006/EC (REACH) and subsequent amendments.	

12.2.2 Safety data sheet for Castrol Hyspin ZZ 46 hydraulic oil

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

12.2.2.1 Designation of substance/formulation and manufacturer

Name of substance/preparation	
Product name:	**Castrol Hyspin ZZ 46**
SDS no.:	450828
Use of substance or formulation:	Hydraulic oil For specific instructions for use, see the corresponding technical data sheet or contact a company representative.

Manufacturer designation	
Company:	**Deutsche Castrol Vertriebsgesellschaft mbH**
Address:	Max-Born-Str. 2, D-22761 Hamburg
Country:	Germany
Phone:	Central customer service/environment/product safety: +49 (0)40 3594-01
Emergency hotline:	Carechem: +44 (0)208 762 8322 (24 hours)

12.2.2.2 Composition / Information about the components

Highly refined base oil (IP 346 DMSO extract < 3%). Additives.

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

12.2.2.3 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:	Not classified as dangerous.
Environmental hazards:	Unlikely to be harmful to aquatic organisms.

Effects and symptoms	
Eyes:	No significant health hazards identified.
Skin:	No significant health hazards identified. Sign: high-pressure applications. Injection into the skin due to contact with a product under high pressure constitutes a major medical emergency. See Notes to physician under “First aid measures” in this safety data sheet.
Inhalation:	No significant health hazards identified.
Ingestion:	No significant health hazards identified.

12.2.2.4 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:	In case of contact, rinse skin immediately with plenty of water. 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. Sign: high-pressure applications. Injection into the skin due to contact with a product under high pressure constitutes a major medical emergency. The injuries appear minor at first, but 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.

12.2.2.5 Fire-fighting measures

Suitable extinguishing agents:	In the event of a fire, use foam, dry-chemical or carbon dioxide extinguisher or spray.
Unsuitable extinguishing agents:	Do NOT use water jets.
Hazardous decomposition products:	These products are carbon oxides (CO, CO_2).
Unusual fire/explosion hazards:	Not specified.
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.

12.2.2.6 Measures after unintended release

Personal safety precautions:	Contact emergency personnel immediately. Keep unnecessary personnel away. Use suitable protective equipment (see section: “Exposure limits and personal protective equipment”). Follow all fire-fighting procedures (see section: “Fire-fighting measures”).
Environmental precautions and clean-up methods:	If no emergency personnel are available, contain spilled material. For small spills add an absorbent (soil may be used in the absence of other suitable materials) and scoop up material. Place it in a sealed watertight container for subsequent disposal. For larger spills, take steps to contain the material to ensure that runoff cannot reach a waterway. Place spilled material in an appropriate container for disposal. Prevent spilled material from coming into contact with soil and surface waters. See Section “Disposal information” for disposal information.
Personal protection in the event of a large spill:	Splash goggles, full suit, boots, gloves.

12.2.2.7 Handling and storage

Handling:	Wash thoroughly after handling.
Storage:	Keep containers tightly sealed. Keep containers in a cool, well-ventilated area.
Unsuitable:	Prolonged exposure to increased temperatures.

12.2.2.8 Exposure limits and personal protective equipment

Ingredient name:	**Threshold limit values (TLV) acc. to ACGIH (USA)**
Base oil – unspecified	STEL: 10 mg/m^3 15 minute(s). Form: mineral oil mist TWA: 5 mg/m^3 8 hour(s). Form: mineral oil mist

Where no exposure limits exist in law, the ACGIH values are included for information and as reference. For further information, please consult your supplier. It must be noted that all mists, vapors and dusts also contain other components of this preparation. For this reason, the specific limit values given in the safety data sheet for particular components may not be applicable to the product and are given here only as a guideline.

Protective measures	Provide exhaust ventilation or other engineering controls to keep the relevant airborne concentrations below their respective occupational exposure limits. All chemicals should be assessed with regard to their risks to health and appropriate control measures put in place to prevent or adequately control exposure. A hierarchy of control measures exists (e.g. elimination, substitution, general ventilation, containment, systems of work, changing the process or activity) which must be considered before using personal protective equipment. Personal protective equipment should conform to the applicable standards. For this purpose, please consult your supplier of personal protective equipment. Relevant information can be obtained from the European Committee for Standardization: http://www.cenorm.be/cenorm/index.htm. The final choice of protective equipment will depend on a risk assessment. It must always be ensured that all items of personal protective equipment are compatible with one another.
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 organs:	Respiratory protection is not normally required where there is adequate natural or local exhaust ventilation to control exposure. Where there is insufficient ventilation, wear suitable respiratory equipment. Respiratory protection equipment must be checked in order to ensure a correct fit every time it is used. Air-filtering respirators, also called air-purifying respirators, are not adequate under conditions of oxygen deficiency (e.g. low oxygen concentration) and are not suitable where airborne concentrations of chemicals with a significant hazard are present. In these cases, air-supplied breathing apparatus is required. Provided an air-filtering or air-purifying respirator is suitable, a particulate filter for mist or fumes can be used. Use filter type P or comparable standard. A combination filter for particles and organic gases and vapors (boiling point >65 °C) may be necessary if vapor or abnormal odor is also present due to high product temperature. Use filter type AP or comparable standard.
Skin and body:	Use of protective clothing is good industrial practice. Cotton or polyester/cotton overalls only provide protection against light, superficial contamination which will not soak through to the skin. Overalls should be laundered on a regular basis. When the risk of skin exposure is high (e.g. when cleaning up spillages or if there is a risk of splashing), then chemical-resistant aprons and/or impervious chemical suits and boots will be required.
Hands:	Wear protective gloves if prolonged or repeated contact is likely. Wear chemical-resistant gloves. Recommended: nitrile gloves. Cold-resistant clothing is required when handling ice-cold products.
Eyes:	Protective goggles with side shields to guard against splashing.

12.2.2.9 Physical and chemical properties

Flash point:	220 °C (closed cup).
Pour point:	-21 °C.
Color:	Straw-colored.
Odor:	Oily.
Physical state:	Liquid.
Density:	876 kg/m^3 (0.876 g/cm^3) at 15 °C.
Solubility:	Insoluble in water.
LogK_{OW}:	The product is much more soluble in octanol; log(octanol/water) >3.
Viscosity:	Kinematic: 46 mm^2/s (46 cSt) at 40 °C. Kinematic: 6.65 mm^2/s (6.65 cSt) at 100 °C.

12.2.2.10 Stability and reactivity

Incompatible with various substances:	Reacts with oxidizing agents.
Hazardous polymerization:	Will not occur.
Hazardous decomposition products:	These products are carbon oxides (CO, CO_2).

12.2.2.11 Toxicological information

Acute toxicity:	Unlikely to cause more than transient stinging or redness if accidental eye contact occurs. Unlikely to cause harm to the skin on brief or occasional contact. Prolonged or repeated exposure may dry out the skin and lead to dermatitis. Unlikely to cause harm if accidentally swallowed in small doses. Larger quantities may cause nausea and diarrhea. At normal ambient temperatures this product is unlikely to present an inhalation hazard because of its low volatility. May be harmful by inhalation if exposure to vapor, mists or fumes resulting from thermal decomposition products occurs.

Chronic toxicity:	
Carcinogenic effects:	No component of this product at levels greater than or equal to 0.1% is identified as a carcinogen by ACGIH, the International Agency for Research on Cancer (IARC) or the European Commission (EC).

12.2.2.12 Ecological information

Persistence / degradability:	Inherently biodegradable.
Mobility:	Spilled substance can enter the ground and contaminate soil and groundwater.
Bioaccumulative potential:	This product is not expected to bioaccumulate through food chains in the environment.

Environmental hazards:	Unlikely to be harmful to aquatic organisms.
Other ecological information:	Spilled product can lead to formation of a film on the surface of water; this can reduce the oxygen exchange, thereby causing organisms to die.

12.2.2.13 Disposal information

Disposal information	
Disposal information / waste specifications:	Disposal must be carried out by an authorized waste disposal contractor.

Used/contaminated product	
European Waste Catalog (EWC):	13 01 10* Non-chlorinated hydraulic oils with a mineral oil base.

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.

12.2.2.14 Transport information

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

12.2.2.15 Regulations

Labeling requirements	
Risk (R) phrases:	This product is not classified according to the Dangerous Substances Order / EU regulations.
EU regulations:	Classification and labeling have been performed according to EU directives 1999/45/EC and 67/548/EEC as amended and adapted.

Miscellaneous provisions	
Inventories:	**Australian inventory (AICS):** In compliance. **Canadian inventory (DSL):** In compliance. **Chinese inventory (IECS):** Not determined. **EC inventory (EINECS/ELINCS):** In compliance. **Japanese inventory (ENCS):** In compliance. **Korean inventory (ECL):** Not listed. **Philippine inventory (PICCS):** Not determined. **US inventory (TSCA):** In compliance.
Water hazard classification (WGK):	1 (low hazard to waters), classification acc. to the German Administrative Regulation on the Classification of Substances Hazardous to Waters into Water Hazard Classes (VwVwS)
Statutory Order on Hazardous Incidents (StörfallV):	12th ordinance of the German Immission Control Act (StörfallV): Not listed.

12.2.2.16 Other information

History	
Date of issue:	29/03/2006.
Date of previous issue:	No previous validation.
Created by:	Product Stewardship Group.

Notes for the reader
(#) Indicates information altered since the last version. 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.

12.2.3 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.

12.2.3.1 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
Phone:	+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

12.2.3.2 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 (>>> 12.2.3.11 "Toxicological information" Page 212) and (>>> 12.2.3.12 "Ecological information" Page 212) contain more detailed information on health hazards, symptoms and environmental risks.

12.2.3.3 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 (>>> 12.2.3.16 "Other information" Page 214) for the full text of the above R-phrases.

The occupational exposure limit values, where available, are specified in Section (>>> 12.2.3.8 "Exposure limits and personal protective equipment" Page 211).

12.2.3.4 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. Sign: 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.

12.2.3.5 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.

12.2.3.6 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 (>>> 12.2.3.8 "Exposure limits and personal protective equipment" Page 211)).
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 (>>> 12.2.3.13 "Disposal information" Page 213)). Disposal should be entrusted to a recognized waste disposal company. Contaminated absorbents can be just as dangerous as spilled material. Sign: See (>>> 12.2.3.1 "Designation of substance/formulation and manufacturer" Page 208) for contact in emergencies and (>>> 12.2.3.13 "Disposal information" Page 213) 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.

12.2.3.7 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

12.2.3.8 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.

12.2.3.9 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.

12.2.3.10 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.

12.2.3.11 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.

12.2.3.12 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.

12.2.3.13 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.

12.2.3.14 Transport information

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

12.2.3.15 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.

12.2.3.16 Other information

List of R-phrases referred to in Section (>>> 12.2.3.11 "Toxicological information" Page 212) and Section (>>> 12.2.3.3 "Composition / Information about the components" Page 209)	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 with:	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.

12.2.4 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.

12.2.4.1 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 Munich
Country:	Germany
Phone:	+49 (0)89 7876-0
Fax:	+49 (0)89 7876-333
Information center:	Material Compliance Management
Emergency hotline:	+49 (0)89 7876-700

12.2.4.2 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.

12.2.4.3 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).

12.2.4.4 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.

12.2.4.5 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.

12.2.4.6 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.

12.2.4.7 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

12.2.4.8 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.

12.2.4.9 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

12.2.4.10 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.

12.2.4.11 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.

12.2.4.12 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.

12.2.4.13 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.

12.2.4.14 Transport information

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

12.2.4.15 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

12.2.4.16 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.

12.2.5 Safety data sheet for Optitemp RB1 cable grease

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

12.2.5.1 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
Phone:	+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

12.2.5.2 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.

12.2.5.3 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).

12.2.5.4 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.

12.2.5.5 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.

12.2.5.6 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.

12.2.5.7 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

12.2.5.8 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.

12.2.5.9 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

12.2.5.10 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.

12.2.5.11 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.

12.2.5.12 Ecological information

Persistence / degradability:	Biodegradable.

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

12.2.5.13 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

Verpackung	
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.

12.2.5.14 Transport information

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

12.2.5.15 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

12.2.5.16 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 KUKA Service

13.1 Requesting support

Introduction

This documentation provides information on operation and operator control, 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 manipulator
- Model and serial number of the controller
- Model and serial number of the linear unit (if present)
- Model and serial number of the energy supply system (if present)
- Version of the system software
- Optional software or modifications
- Diagnostic package **KrcDiag**:

  Additionally for KUKA Sunrise: Existing projects including applications

  For versions of KUKA System Software older than V8: Archive of the software (**KrcDiag** is not yet available here.)
- Application used
- External axes used
- Description of the problem, duration and frequency of the fault

13.2 KUKA Customer Support

Availability

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

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