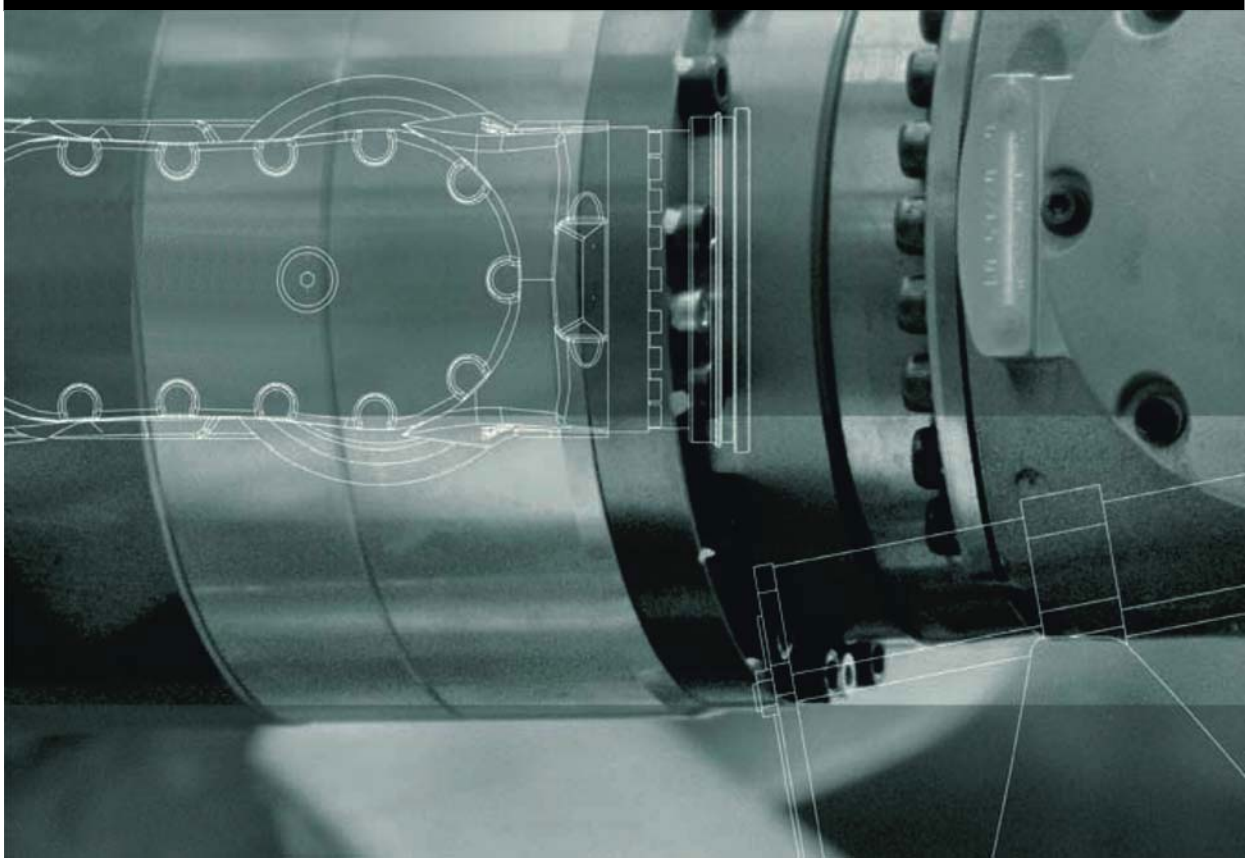
KUKA

Robots

KUKA Roboter GmbH

KR QUANTEC K prime

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

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

2 Purpose

2.1 Target group

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

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

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

2.2 Intended use

Use

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

Misuse

Any use or application deviating from the intended use is deemed to be impermissible misuse. This includes e.g.:

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

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

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

3 Product description

3.1 Overview of the robot system

A robot system comprises all the assemblies of an industrial robot, including the manipulator (mechanical system and electrical installations), control cabinet, connecting cables, end effector (tool) and other equipment. The KR QUANTEC K prime product family comprises the types:

- KR 210 R2900 K prime
- KR 180 R3100 K prime
- KR 150 R3300 K prime
- KR 120 R3500 K prime
- KR 90 R3700 K prime

An industrial robot of this type comprises the following components:

- Manipulator
- Robot controller
- Connecting cables
- KCP teach pendant (KUKA smartPAD)
- Software
- Options, accessories

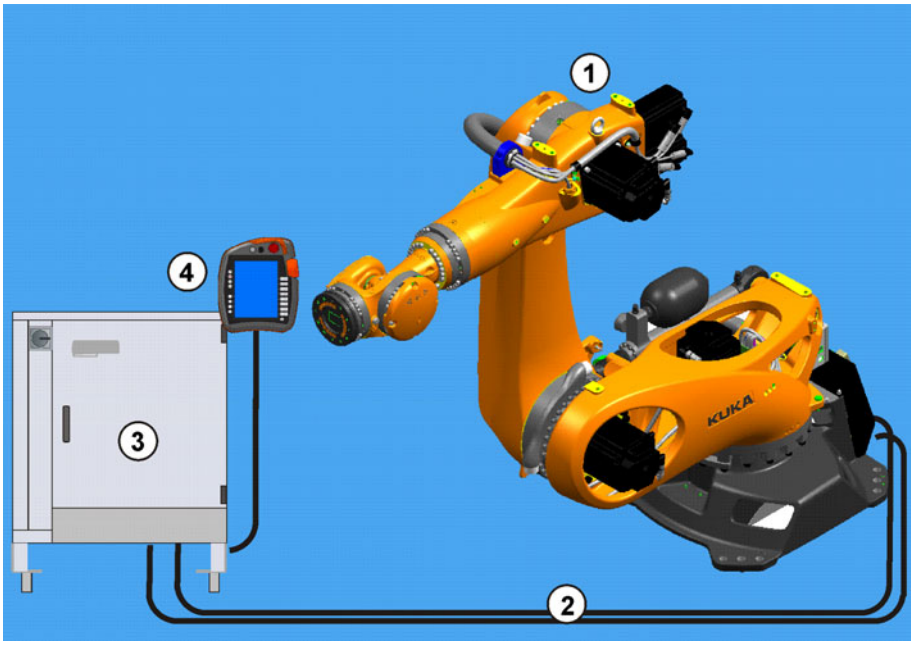


Fig. 3-1: Example of a robot system

1	Manipulator	3	Robot controller
2	Connecting cables	4	Teach pendant KCP KUKA smartPAD

3.2 Description of the manipulator

Overview

The manipulators (robot = robot arm and electrical installations) (>>> Fig. 3-2) of the “prime” shelf-mounted robot variants are designed as 6-axis jointed-arm kinematic systems. They consist of the following principal components:

- In-line wrist
- Arm

- Link arm
- Rotating column
- Base frame
- Counterbalancing system
- Electrical installations

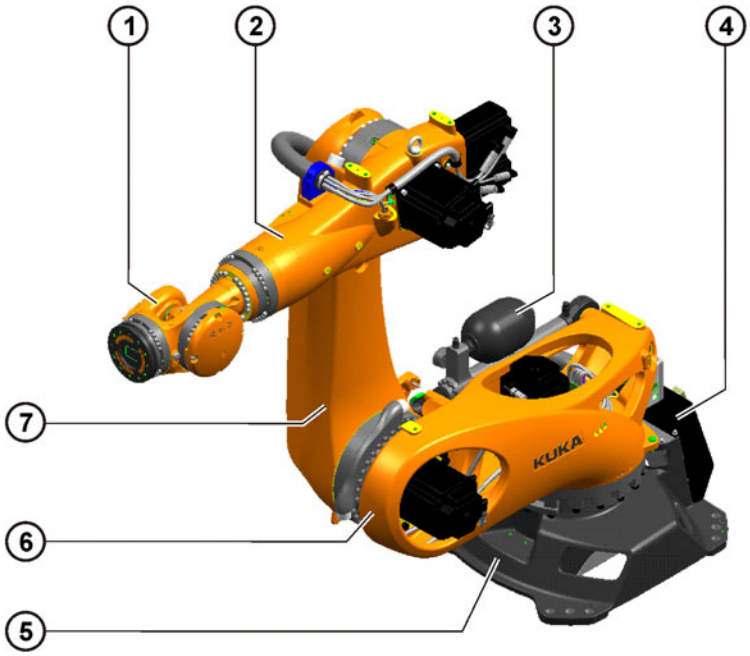


Fig. 3-2: Main assemblies of the manipulator

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

In-line wrist

The robot is fitted with a 3-axis in-line wrist. The in-line wrist contains axes 4, 5 and 6. The motor of axis 6 is located directly on the wrist, inside the arm. It drives the wrist directly, while for axes 4 and 5 the drive comes from the rear of the arm via connecting shafts. For attaching end effectors (tools), the in-line wrist has a mounting flange. For the payload categories from 210 kg to 270 kg, a mounting flange with a 160 mm hole circle is used, and for the payload categories from 90 kg to 180 kg, a mounting flange with a 125 mm hole circle is used. Both mounting flanges conform, with minimal deviations, to DIN/ISO 9409.

Arm

The arm is the link between the in-line wrist and the link arm. It houses the motors of wrist axes 4 and 5. The arm is driven by the motor of axis 3. The maximum permissible swivel angle is mechanically limited by a stop for each direction, plus and minus. The associated buffers are attached to the arm. There is an interface on the arm with 4 holes for fastening supplementary loads. In combination with the link arm, there are three variants available to obtain the specified reach.

Link arm

The link arm is the assembly located between the arm and the rotating column. It consists of the link arm body with the buffers for axis 2. In combination with the arm, there are two variants available to obtain the specified reach.

Rotating column

The rotating column houses the motors of axes 1 and 2. The rotational motion of axis 1 is performed by the rotating column. This is screwed to the base

frame via the gear unit of axis 1 and is driven by a motor in the rotating column. The link arm is also mounted in the rotating column.

Base frame

The base frame is the base of the robot. It is screwed to the mounting base. The push-in module and the electrical installations are fastened in the base frame. It thus forms the interface for the motor and data cable and the energy supply system.

Counterbalancing system

The counterbalancing system is installed between the rotating column and the link arm and serves to minimize the moments generated about axis 2 when the robot is in motion and at rest. A closed, hydropneumatic system is used. The system consists of an accumulator, 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 II, fluid group 2, of the Pressure Equipment Directive. This classification entails that the counterbalancing system be subjected to an inspection before start-up and again at regular intervals in compliance with the requirements of the relevant authorities.

Electrical installations

The electrical installations include all the motor and data cables for the motors of axes 1 to 6. All connections are implemented as connectors in order to enable the motors to be exchanged quickly and reliably. The electrical installations also include the RDC box and the multi-function housing (MFH). The RDC box is located in the rotating column. The MFH and the connector for the data cables are mounted on the robot base frame. The connecting cables from the robot controller are connected here by means of connectors. The electrical installations also include a protective circuit.

Options

The robot can be fitted and operated with various options, such as energy supply systems for axes 1 to 3, energy supply systems for axes 3 to 6, or working range limitation systems for A1. The options are described in separate documentation.

4 Technical data

4.1 Basic data

Basic data

Type	KR 210 R2900 K prime KR 180 R3100 K prime KR 150 R3300 K prime KR 120 R3500 K prime KR 90 R3700 K prime
Number of axes	6
Volume of working envelope	KR 210 R2900 K prime 77.90 m^3 KR 180 R3100 K prime 97.80 m^3 KR 150 R3300 K prime 120.62 m^3 KR 120 R3500 K prime 146.73 m^3 KR 90 R3700 K prime 175.26 m^3
Pose repeatability (ISO 9283)	±0.06 mm
Working envelope reference point	Intersection of axes 4 and 5
Weight	KR 210 R2900 K prime approx. 1,180 kg KR 180 R3100 K prime approx. 1,168 kg KR 150 R3300 K prime approx. 1,184 kg KR 120 R3500 K prime approx. 1,192 kg KR 90 R3700 K prime approx. 1,204 kg
Principal dynamic loads	See “Loads acting on the mounting base”
Protection classification of the robot	IP 65 ready for operation, with connecting cables plugged in (according to EN 60529)
Protection classification of the in-line wrist	IP 65
Sound level	< 75 dB (A) outside the working envelope
Mounting position	Floor Permissible angle of inclination 0°
Surface finish, paintwork	Base frame: black (RAL 9005); moving parts: KUKA orange 2567

Ambient temperature

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

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

Connecting cables

Cable designation	Connector designation robot controller - robot	Interface with robot
Motor cable	X20 - X30	Harting connectors at both ends
Data cable	X21 - X31	Rectangular connector at both ends
Ground conductor / equipotential bonding 16 mm^2 (can be ordered as an option)		M8 ring cable lug at both ends

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

Minimum bending radius	5x D

For detailed specifications of the connecting cables, see “Description of the connecting cables”.

4.2 Axis data

Axis data, KR 210 R2900 K prime

Axis	Range of motion, software-limited	Speed with rated payload
1	+/-185°	105°/s
2	-120° to +70°	107°/s
3	-120° to +155°	114°/s
4	+/-350°	136°/s
5	+/-122.5°	129°/s
6	+/-350°	206°/s

Axis data, KR 180 R3100 K prime

Axis	Range of motion, software-limited	Speed with rated payload
1	+/-185°	105°/s
2	-120° to +70°	107°/s
3	-120° to +155°	114°/s
4	+/-350°	179°/s
5	+/-125°	172°/s
6	+/-350°	219°/s

Axis data, KR 150 R3300 K prime

Axis	Range of motion, software-limited	Speed with rated payload
1	+/-185°	105°/s
2	-120° to +70°	107°/s
3	-120° to +155°	114°/s

Axis	Range of motion, software-limited	Speed with rated payload
4	+/-350°	179°/s
5	+/-125°	172°/s
6	+/-350°	219°/s

Axis data, KR 120 R3500 K prime

Axis	Range of motion, software-limited	Speed with rated payload
1	+/-185°	105°/s
2	-120° to +70°	107°/s
3	-120° to +155°	114°/s
4	+/-350°	292°/s
5	+/-125°	258°/s
6	+/-350°	284°/s

Axis data, KR 90 R3700 K prime

Axis	Range of motion, software-limited	Speed with rated payload
1	+/-185°	105°/s
2	-120° to +70°	107°/s
3	-120° to +155°	114°/s
4	+/-350°	292°/s
5	+/-125°	258°/s
6	+/-350°	284°/s

Working envelope

The following diagrams show the shape and size of the working envelope for the “prime” variants.

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

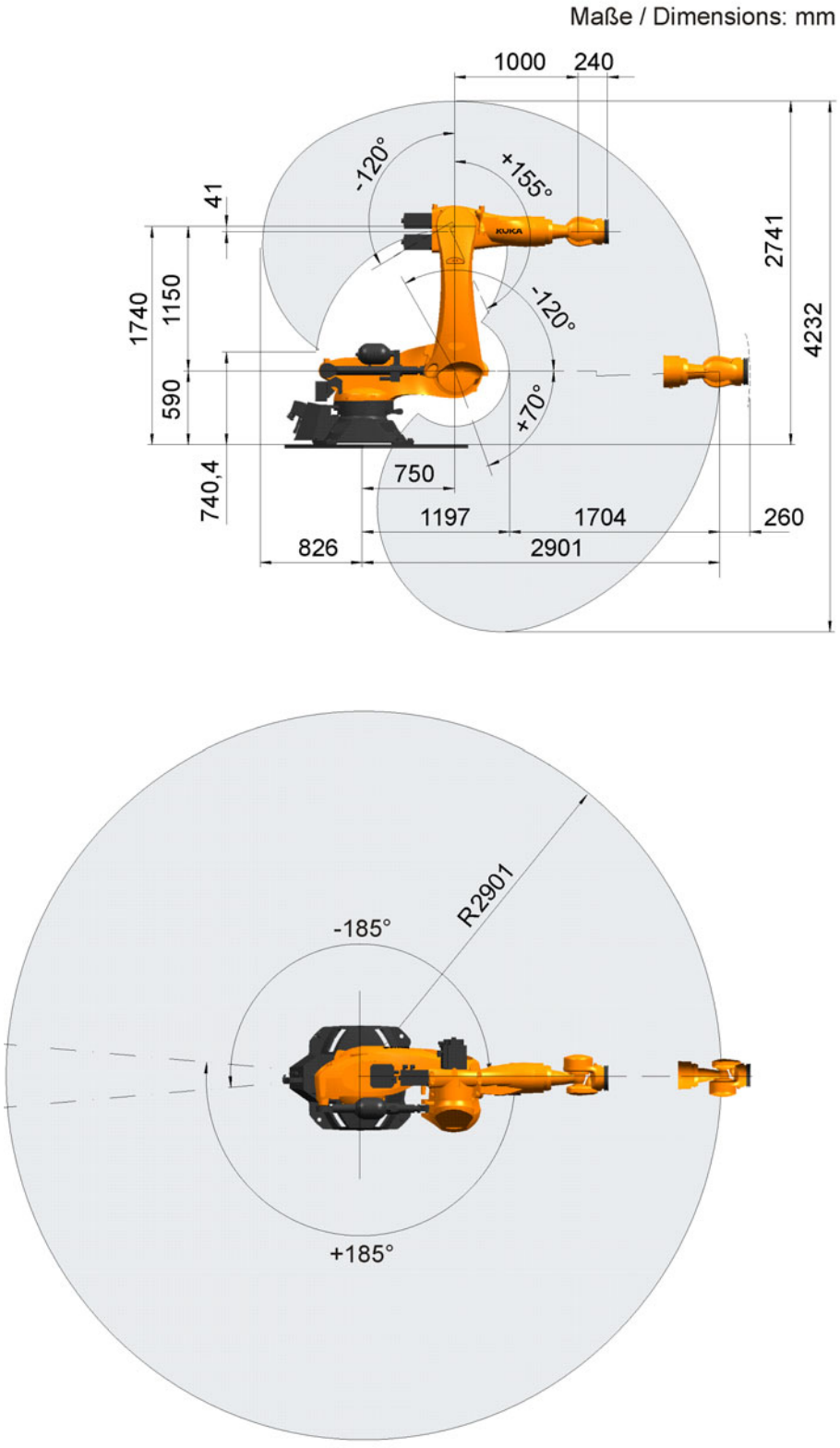


Fig. 4-1: Working envelope, KR 210 R2900 K prime

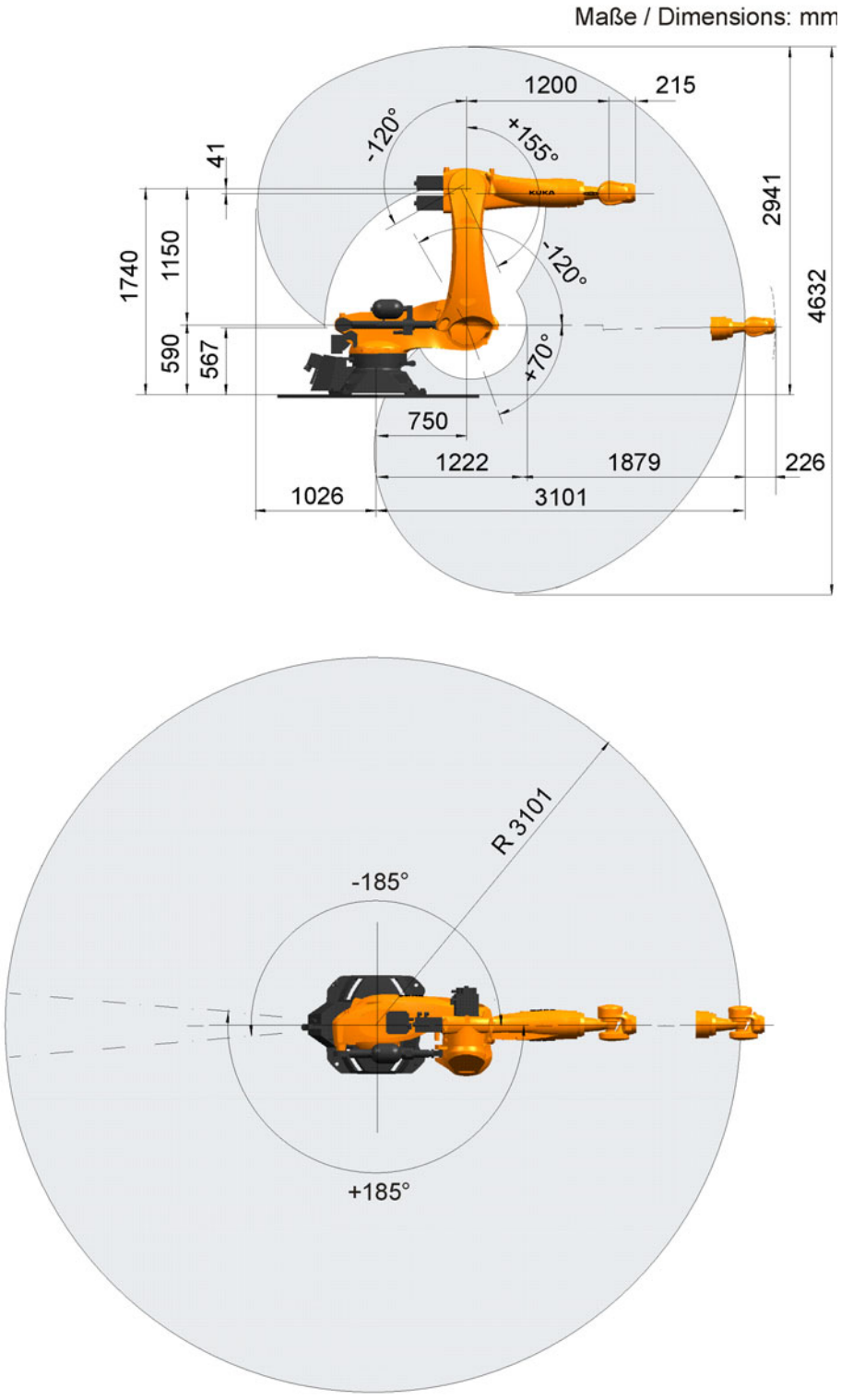


Fig. 4-2: Working envelope, KR 180 R3100 K prime

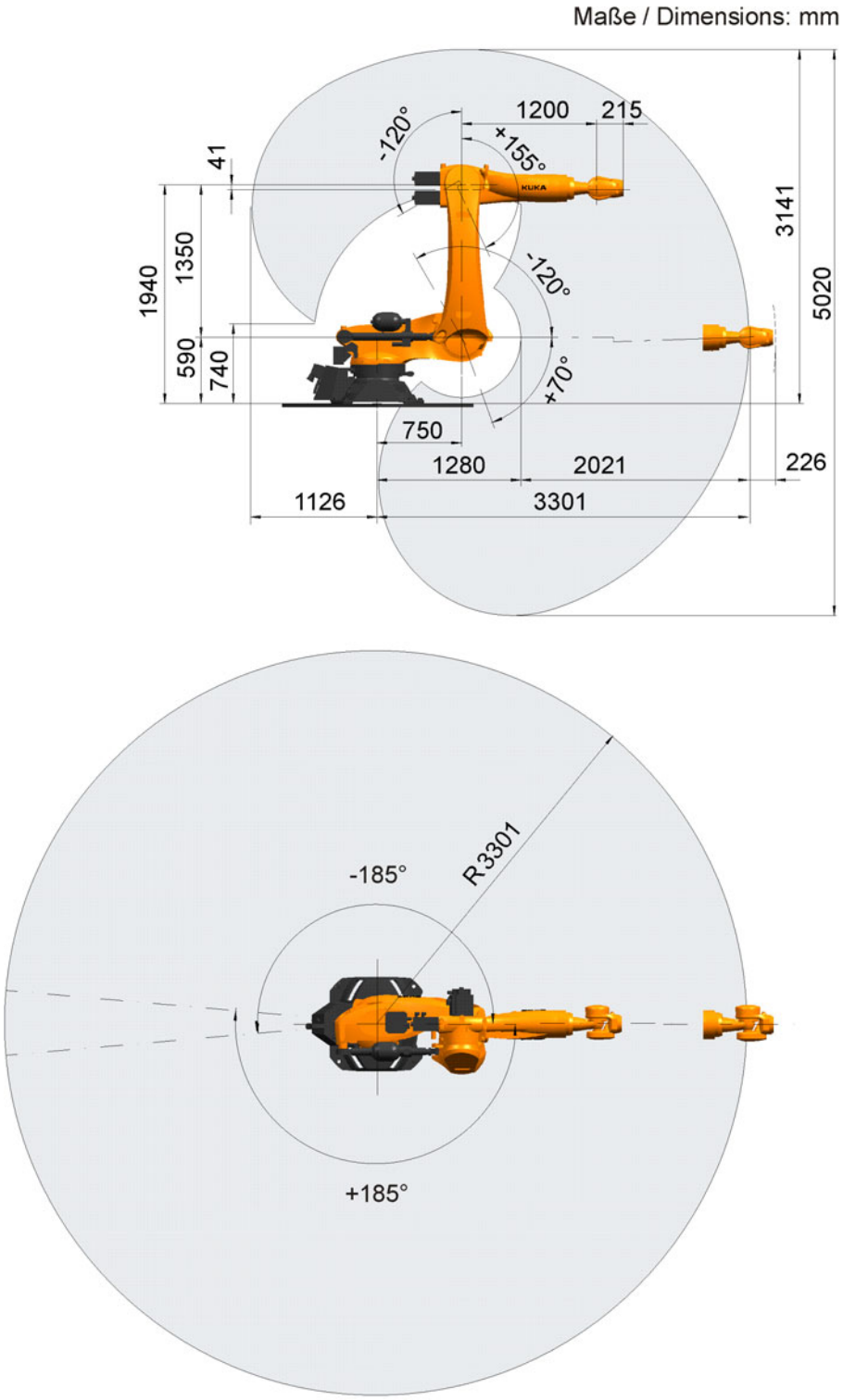


Fig. 4-3: Working envelope, KR 150 R3300 K prime

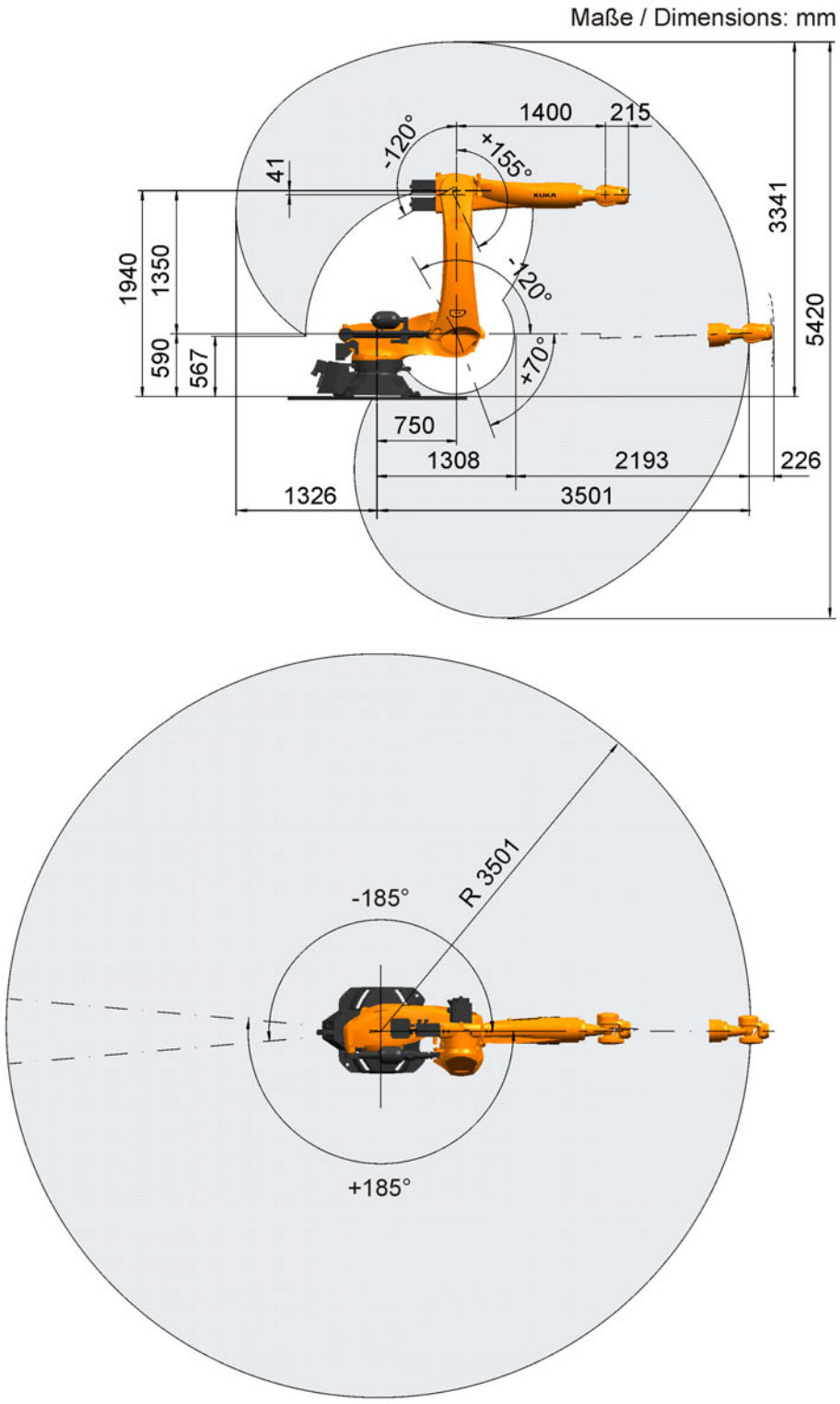


Fig. 4-4: Working envelope, KR 120 R3500 K prime

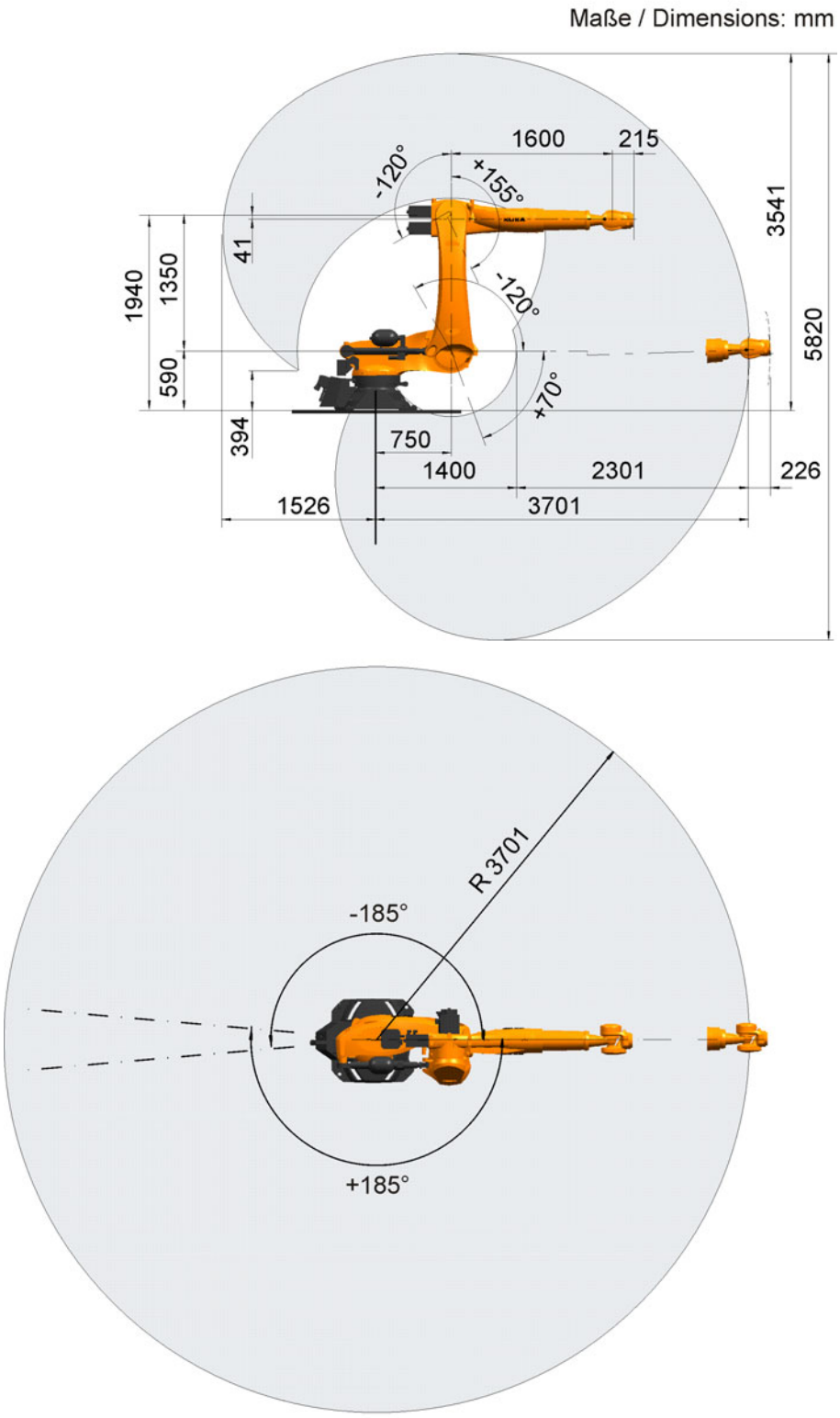


Fig. 4-5: Working envelope, KR 90 R3700 K prime

4.3 Payloads

Payloads, KR 210 R2900 K prime

Robot	KR 210 R2900 K prime
In-line wrist	IW 210/240
Rated payload	210 kg

Distance of the load center of gravity L_z (horizontal)	240 mm
Distance of the load center of gravity L_{xy} (vertical)	270 mm
Permissible mass moment of inertia	105 kgm^2
Max. total load	260 kg
Supplementary load on arm	50 kg
Supplementary load on link arm	On request
Supplementary load on rotating column	On request
Supplementary load on base frame	On request

Payloads, KR 180 R3100 K prime

Robot	KR 180 R3100 K prime
In-line wrist	IW 150/180/210
Rated payload	180 kg
Distance of the load center of gravity L_z (horizontal)	240 mm
Distance of the load center of gravity L_{xy} (vertical)	270 mm
Permissible mass moment of inertia	90 kgm^2
Max. total load	230 kg
Supplementary load on arm	50 kg
Supplementary load on link arm	On request
Supplementary load on rotating column	On request
Supplementary load on base frame	On request

Payloads, KR 150 R3300 K prime

Robot	KR 150 R3300 K prime
In-line wrist	IW 150/180/210
Rated payload	150 kg
Distance of the load center of gravity L_z (horizontal)	240 mm
Distance of the load center of gravity L_{xy} (vertical)	270 mm
Permissible mass moment of inertia	75 kgm^2
Max. total load	200 kg
Supplementary load on arm	50 kg
Supplementary load on link arm	On request
Supplementary load on rotating column	On request
Supplementary load on base frame	On request

Payloads, KR 120 R3500 K prime

Robot	KR 120 R3500 K prime
In-line wrist	IW 90/120
Rated payload	120 kg
Distance of the load center of gravity L_z (horizontal)	240 mm
Distance of the load center of gravity L_{xy} (vertical)	270 mm
Permissible mass moment of inertia	60 kgm^2
Max. total load	170 kg
Supplementary load on arm	50 kg
Supplementary load on link arm	On request
Supplementary load on rotating column	On request
Supplementary load on base frame	On request

Payloads, KR 90 R3700 K prime

Robot	KR 90 R3700 K prime
In-line wrist	IW 90/120
Rated payload	90 kg
Distance of the load center of gravity L_z (horizontal)	240 mm
Distance of the load center of gravity L_{xy} (vertical)	270 mm
Permissible mass moment of inertia	45 kgm^2
Max. total load	140 kg
Supplementary load on arm	50 kg
Supplementary load on link arm	On request
Supplementary load on rotating column	On request
Supplementary load on base frame	On request

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

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

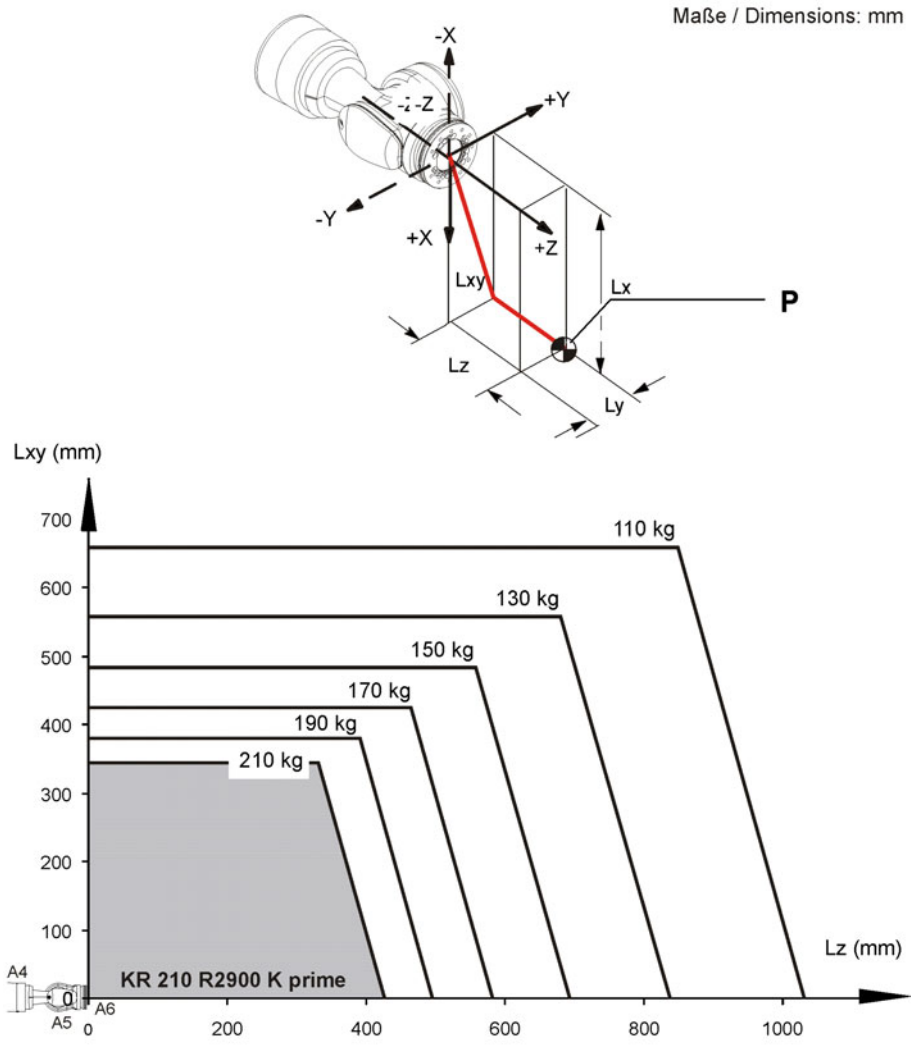


Fig. 4-6: Payload diagram

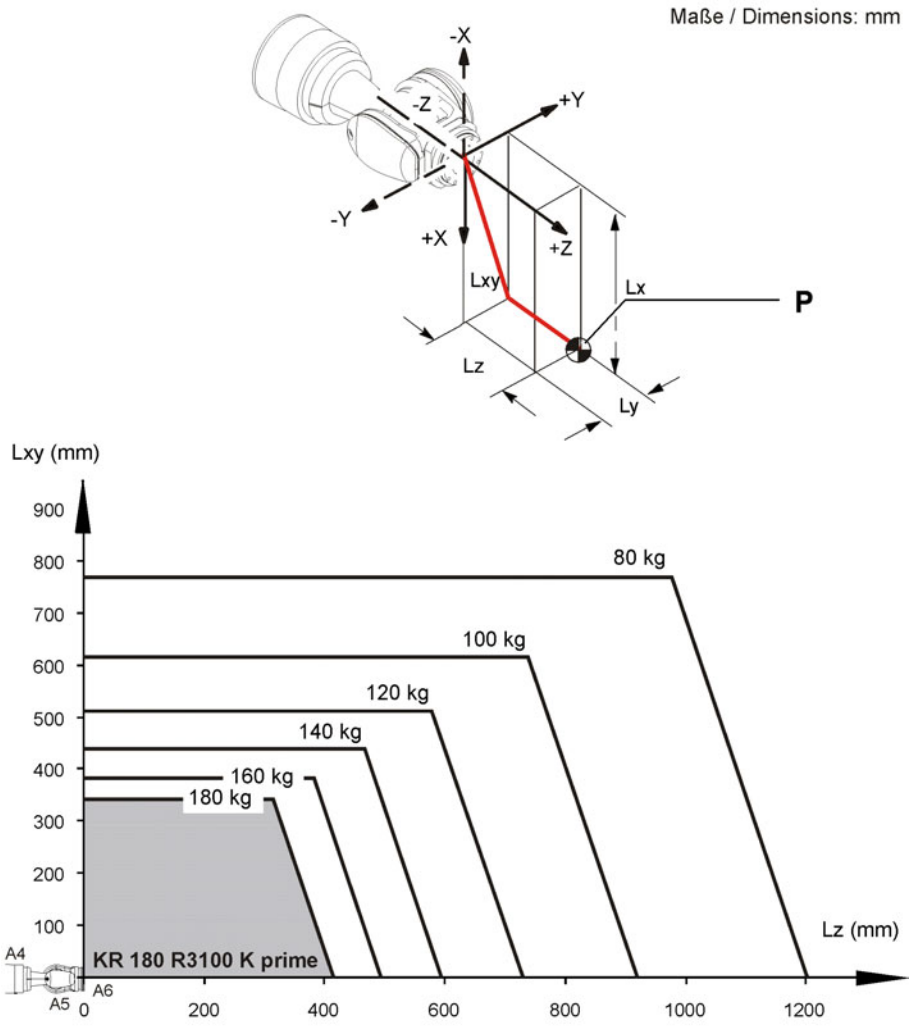


Fig. 4-7: Payload diagram

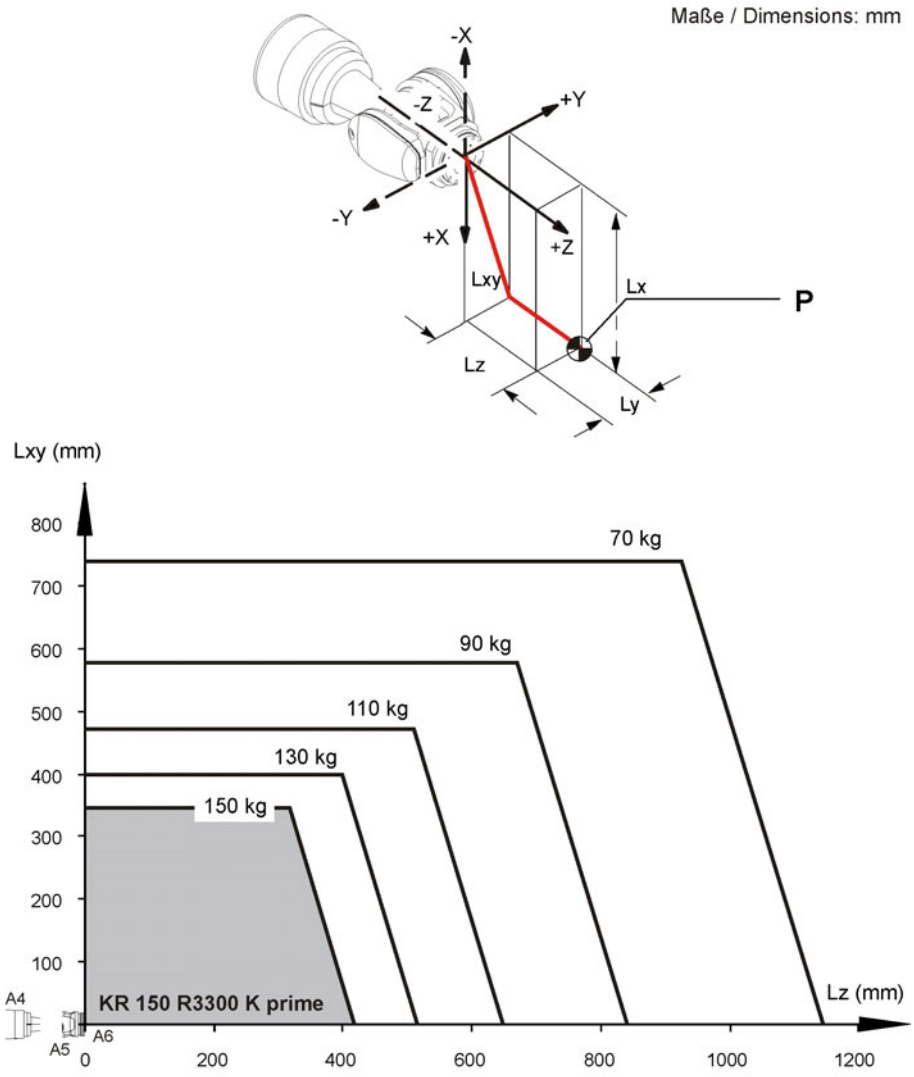


Fig. 4-8: Payload diagram

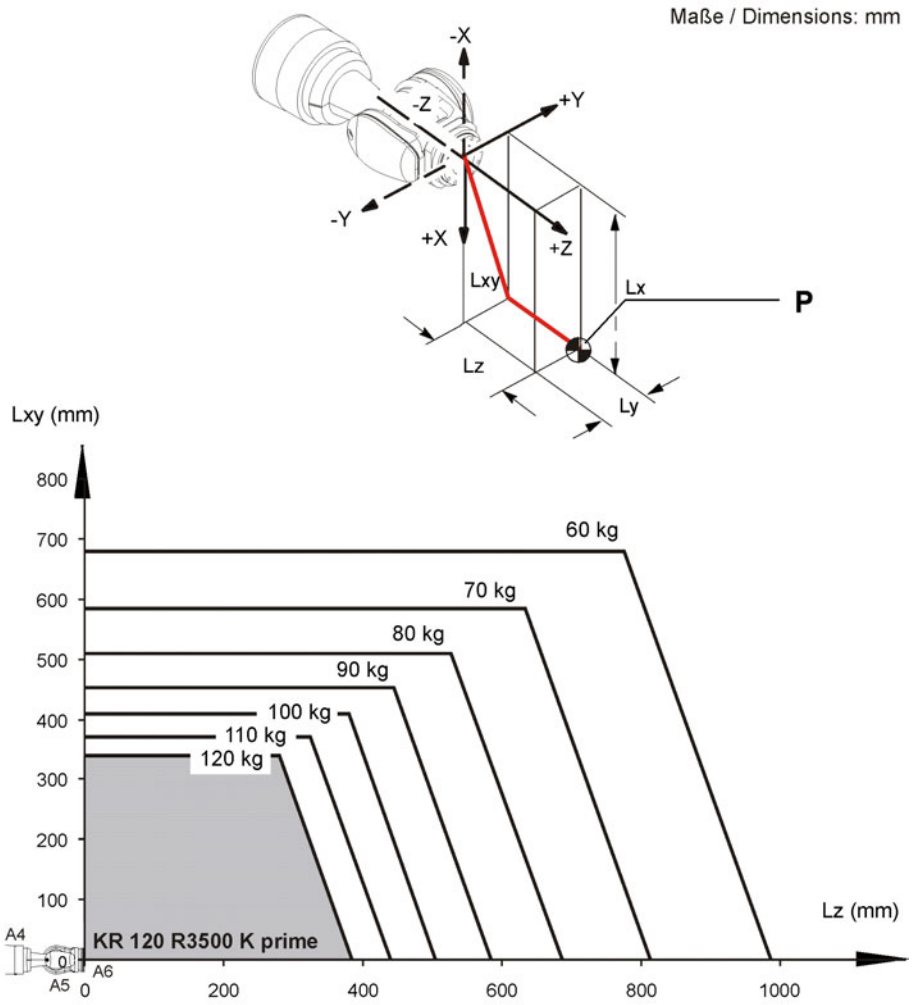


Fig. 4-9: Payload diagram

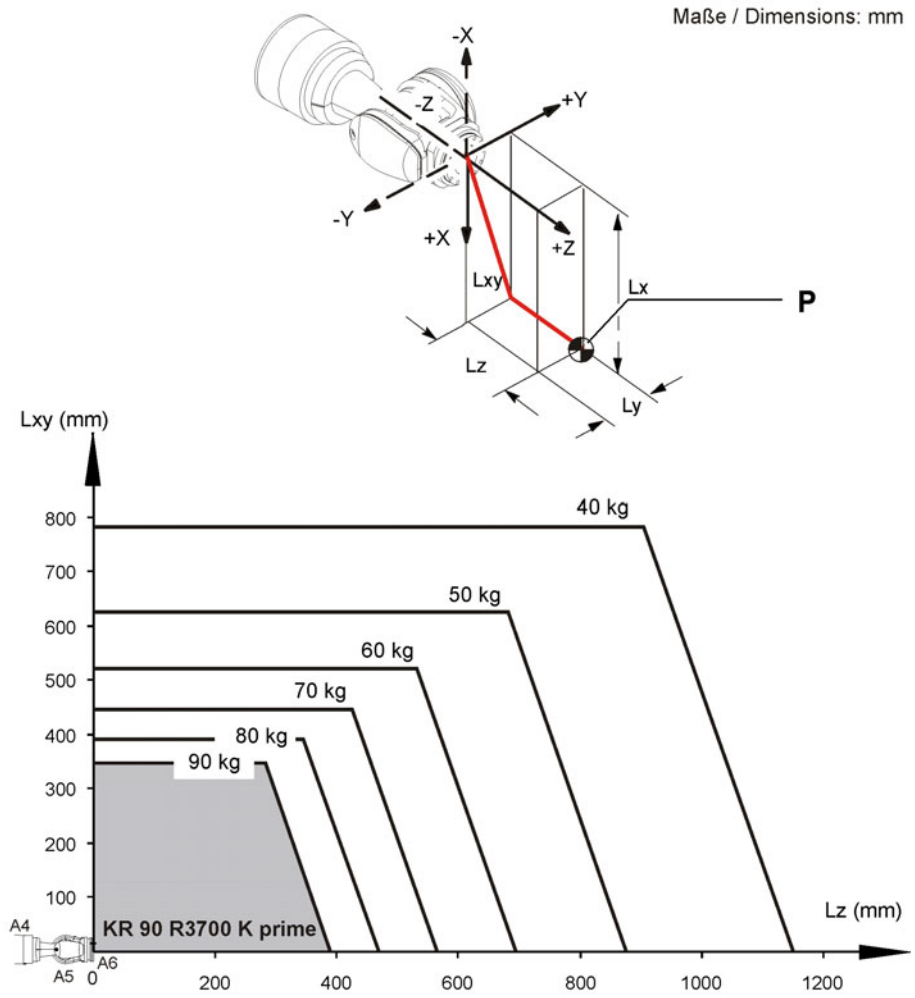


Fig. 4-10: Payload diagram

Mounting flange D=125

Robot type	KR 180 R310 K prime KR 150 R3300 K prime KR 120 R3500 K prime KR 90 R3700 K prime
In-line wrist type	IW 150/180/210 IW 90/120
Mounting flange (hole circle)	125 mm
Screw grade	10.9
Screw size	M10
Number of fastening threads	11
Grip length	1.5 x nominal diameter
Depth of engagement	min. 12 mm, max. 16 mm
Locating element	10^{H7}

The mounting flange is depicted (>>> Fig. 4-11) with axes 4 and 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

Maße / Dimensions: mm

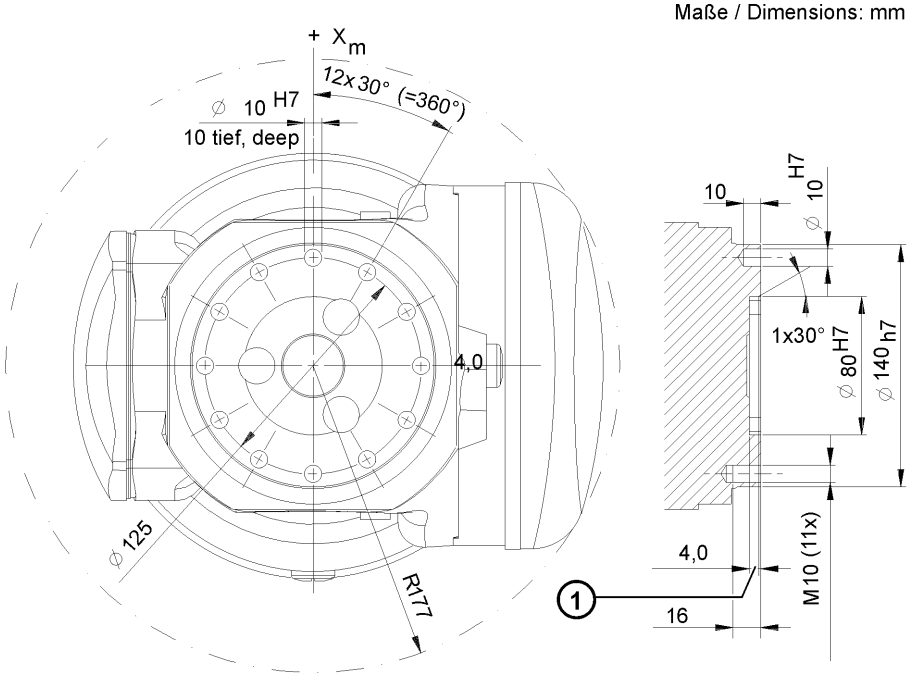


Fig. 4-11: Mounting flange D=125

1 Fitting length

Mounting flange D=160

Robot type	KR 210 R2900 K prime
In-line wrist	IW 210/240
Mounting flange (hole circle)	160 mm
Screw grade	10.9
Screw size	M10
Number of fastening threads	11
Grip length	1.5 x nominal diameter
Depth of engagement	min. 12 mm, max. 16 mm
Locating element	10^{H7}

The mounting flange is depicted (>>> Fig. 4-12) with axes 4 and 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

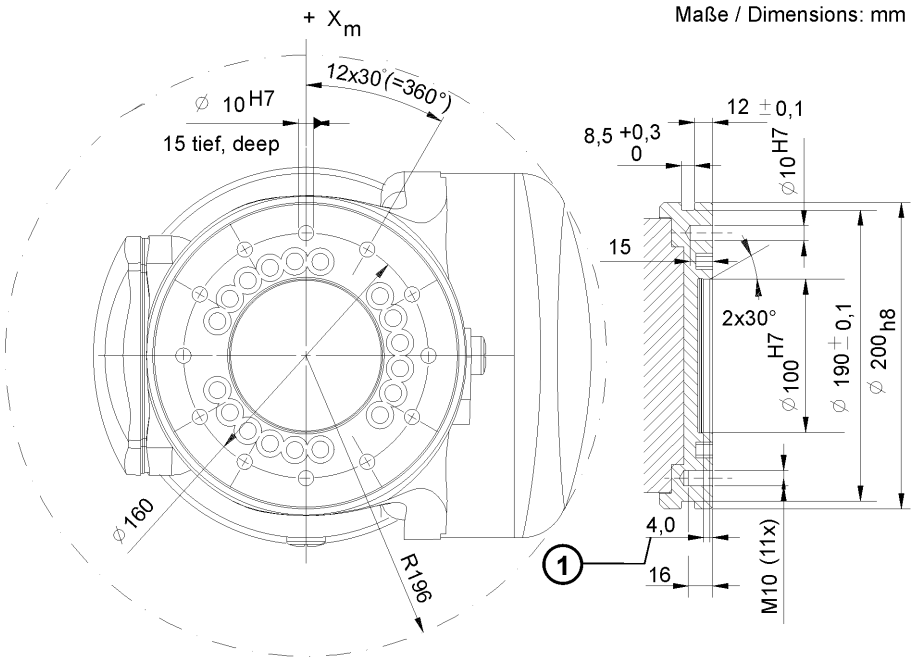


Fig. 4-12: Mounting flange D=160

1 Fitting length

Mounting flange, adapter (optional)

The mounting flange is depicted (>>> Fig. 4-13) with axes 4 and 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position. This adapter can be fitted on the in-line wrist with the D=125 mounting flange to convert it to a D=160 mounting flange. The reference point for the load center of gravity remains unchanged, i.e. the same as for the mounting flange of the in-line wrist IW 90/120.

The symbol X_m indicates the position of the locating element (bushing) in the zero position.

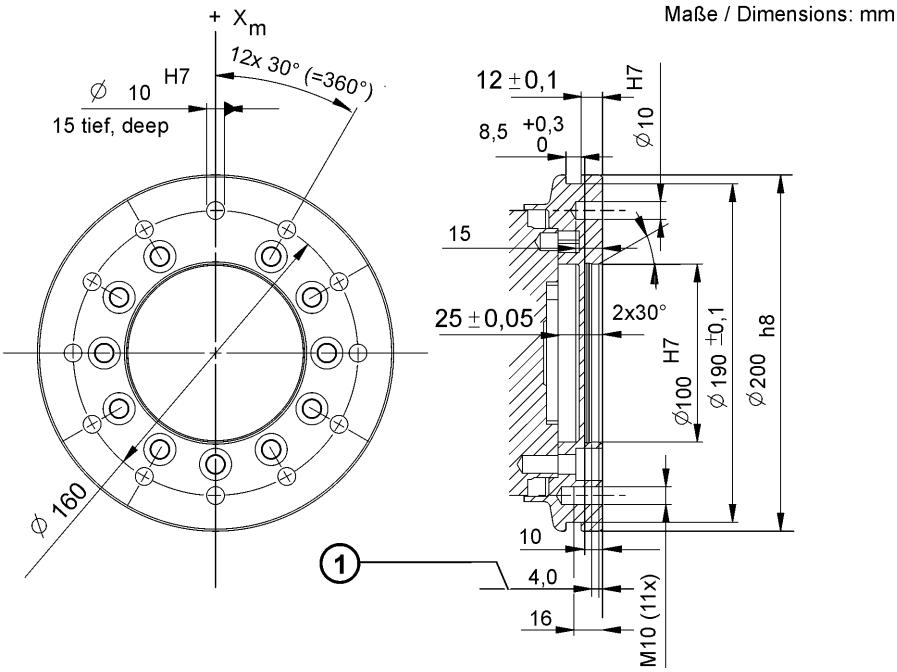


Fig. 4-13: Mounting flange, adapter

1 Fitting length

Supplementary load

The robot can carry supplementary loads (>>> Fig. 4-14) on the arm. When mounting the supplementary loads, be careful to observe the maximum permissible total load. The dimensions and positions of the installation options can be seen in the following diagram.

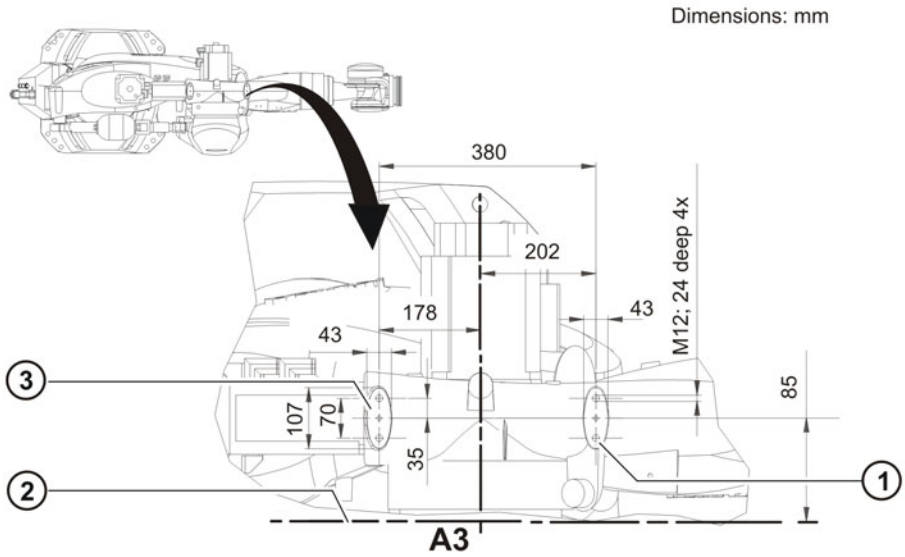


Fig. 4-14: Supplementary load on arm

1	Fastening thread	3	Mounting surface
2	Interference contour, arm		

4.4 Loads acting on the mounting base

Loads acting on the mounting base

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

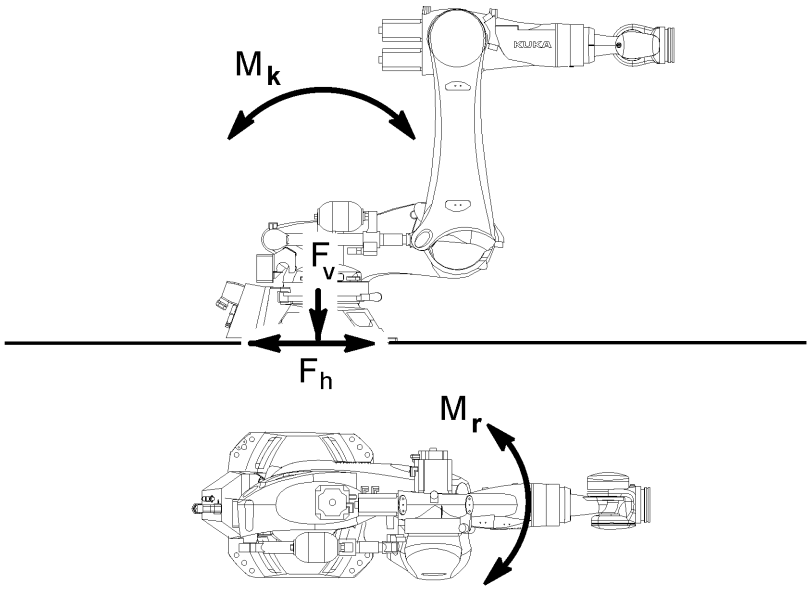


Fig. 4-15: Loads acting on the mounting base

All variants	Force/torque/mass
F_v = vertical force	F_{vmax} = 24,000 N
F_h = horizontal force	F_{hmax} = 16,000 N
M_k = tilting moment	M_{kmax} = 49,000 Nm
M_r = torque	M_{rmax} = 35,000 Nm
Total mass for load acting on the mounting base	KR 210 R2900 K prime 1,390 kg KR 180 R3100 K prime 1,389 kg KR 150 R3300 K prime 1,338 kg KR 120 R3500 K prime 1,362 kg KR 90 R3700 K prime 1,344 kg
Robot	KR 210 R2900 K prime 1,180 kg KR 180 R3100 K prime 1,168 kg KR 150 R3300 K prime 1,184 kg KR 120 R3500 K prime 1,192 kg KR 150 R3700 K prime 1,204 kg
Total load (suppl. load on arm + rated payload)	KR 210 R2900 K prime 260 kg KR 180 R3100 K prime 230 kg KR 150 R3300 K prime 200 kg KR 120 R3500 K prime 170 kg KR 90 R3700 K prime 140 kg

NOTICE The foundation loads specified in the table are the maximum loads that may occur. They must be referred to when dimensioning the foundations and must be adhered to for safety reasons. Failure to do so may result in material damage.
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 Transport dimensions

The transport dimensions (>>> Fig. 4-16) for the robot (1) can be noted from the following diagram. The position of the center of gravity (2) and the weight vary according to the specific configuration. The specified dimensions refer to the robot without equipment. The following diagram shows the dimensions of the robot when it stands on the floor without wooden transport blocks.

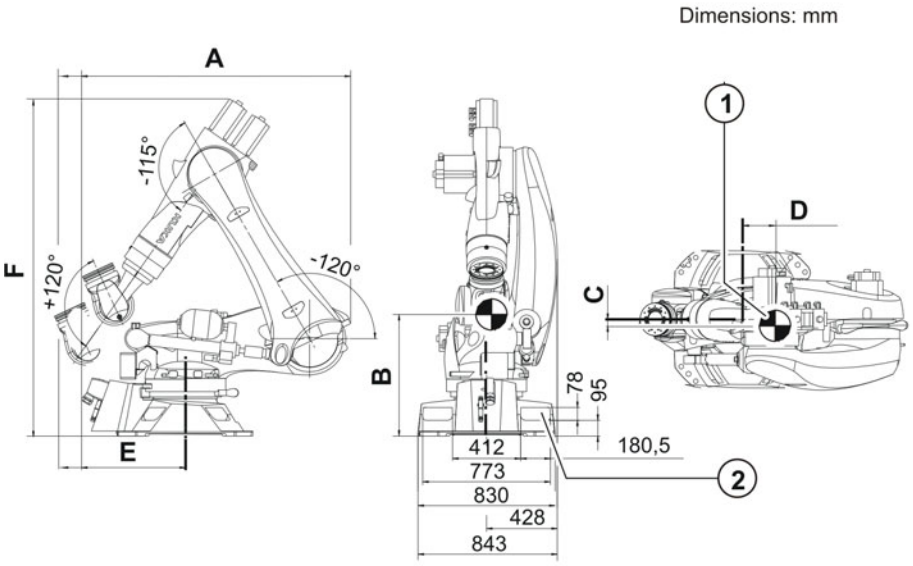


Fig. 4-16: Transport dimensions

1 Center of gravity
2 Robot

Transport dimensions and centers of gravity

Robot with reach	A	B	C	D	E	F
R2900	1628	737	41	190	630	2042
R3100	1701	722	43	187	703	2042
R3300	1801	778	46	165	803	2215
R3500	1916	766	46	151	918	2215
R3700	2031	766	45	140	1032	2215

4.6 Plates and labels

Plates and labels

The following plates and labels (>>> Fig. 4-17) are attached to the robot. They must not be removed or rendered illegible. Illegible plates and labels must be replaced.

Fig. 4-17: Plates and labels

4.7 Stopping distances and times

4.7.1 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. 4-18) 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.

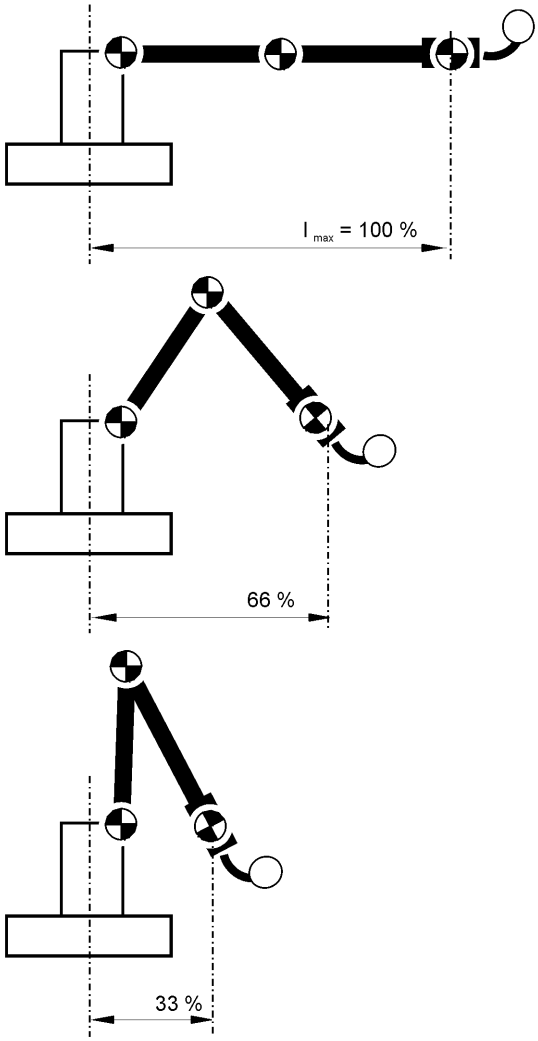


Fig. 4-18: Extension

4.7.2 Stopping distances and times, KR 210 R2900 K prime

4.7.2.1 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	64.29	1.115
Axis 2	67.60	1.169
Axis 3	50.36	0.654

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

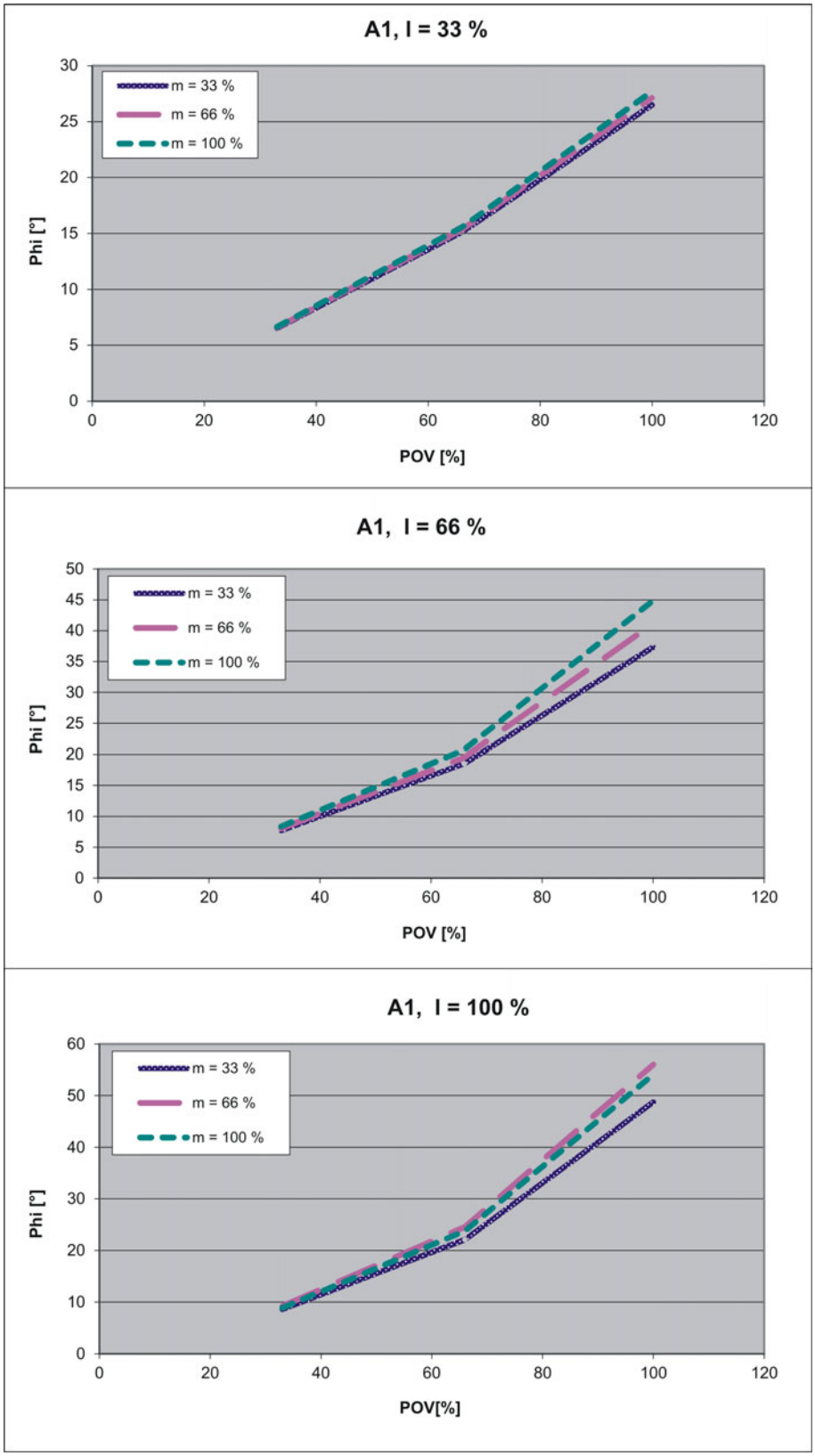


Fig. 4-19: Stopping distances for STOP 1, axis 1

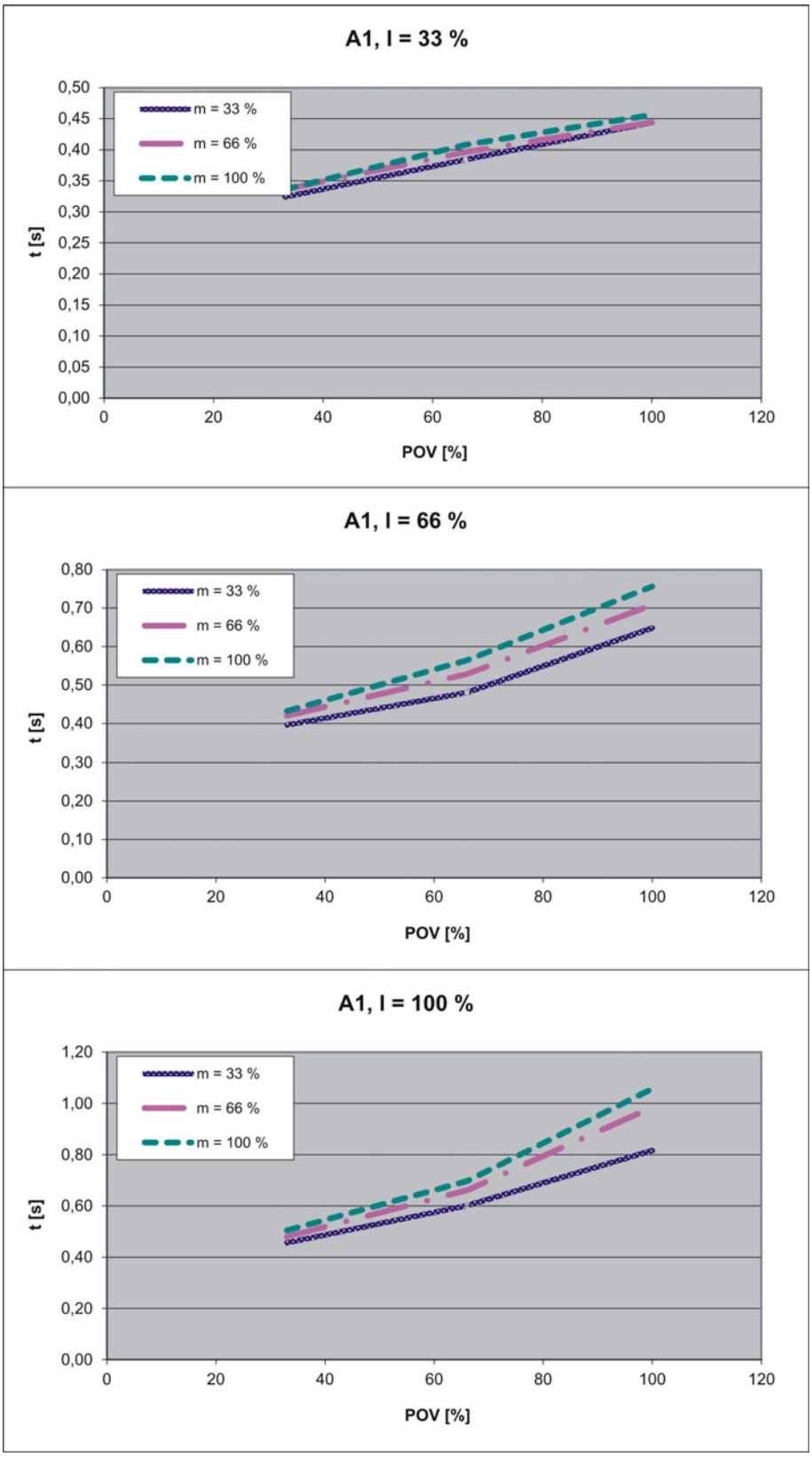


Fig. 4-20: Stopping times for STOP 1, axis 1

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

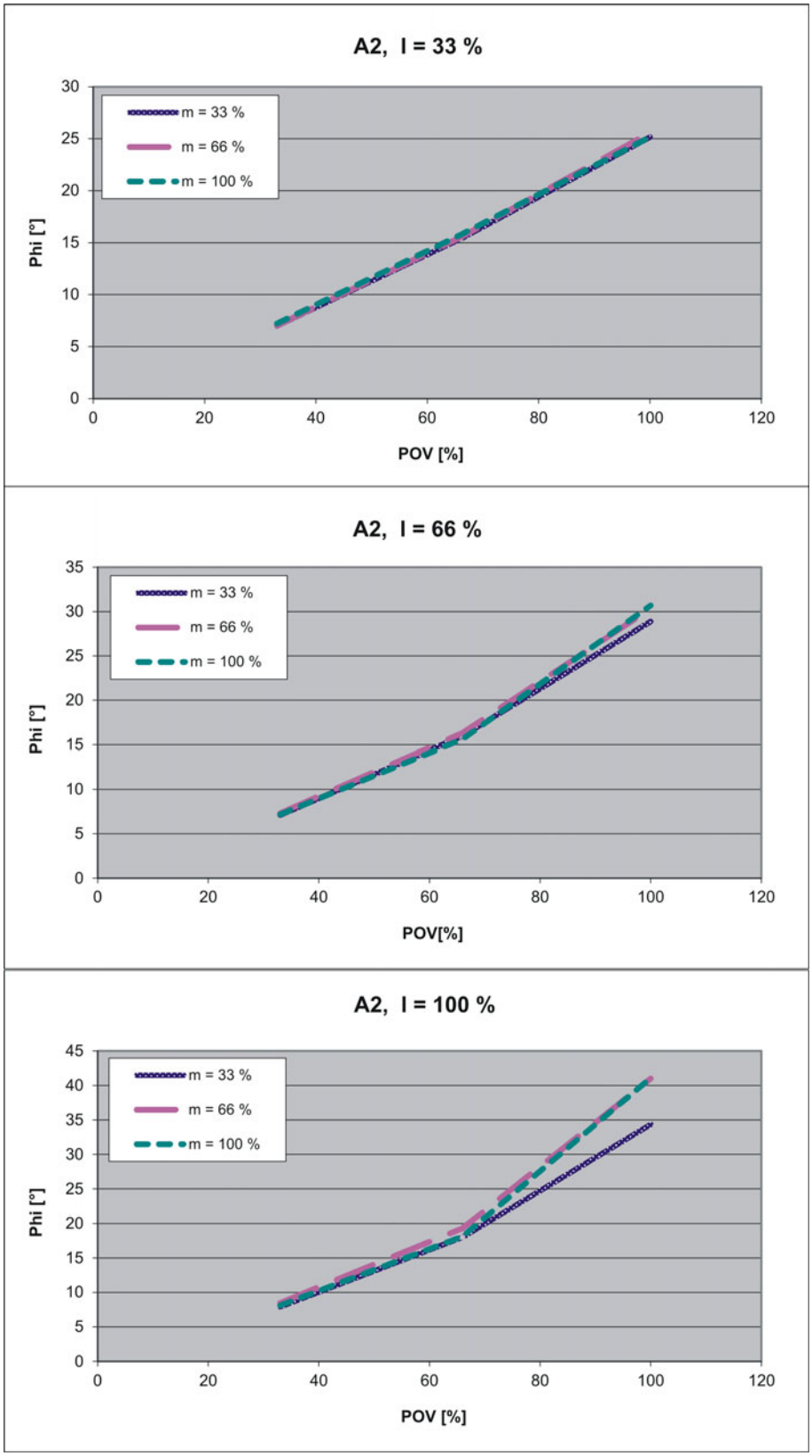


Fig. 4-21: Stopping distances for STOP 1, axis 2

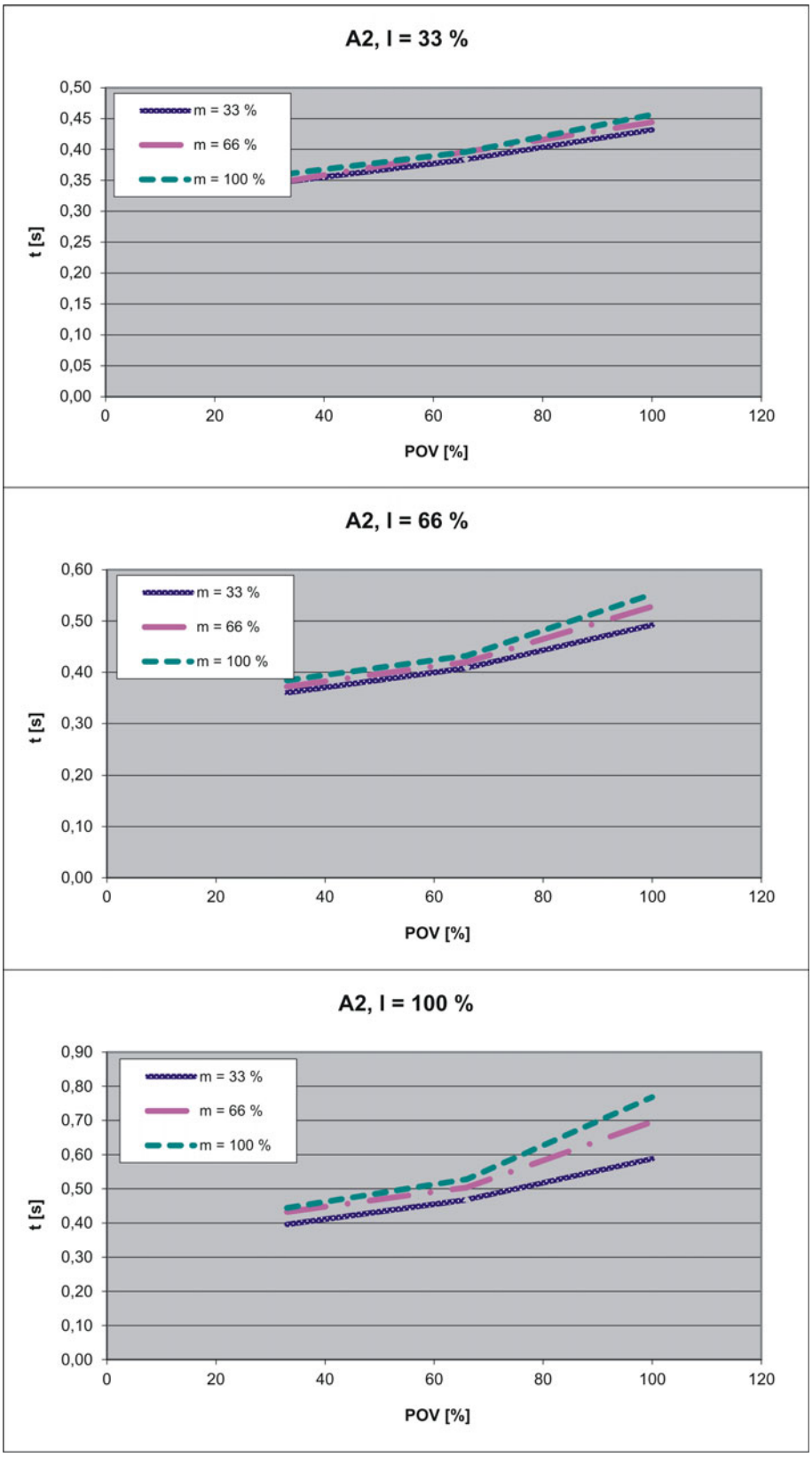


Fig. 4-22: Stopping times for STOP 1, axis 2

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

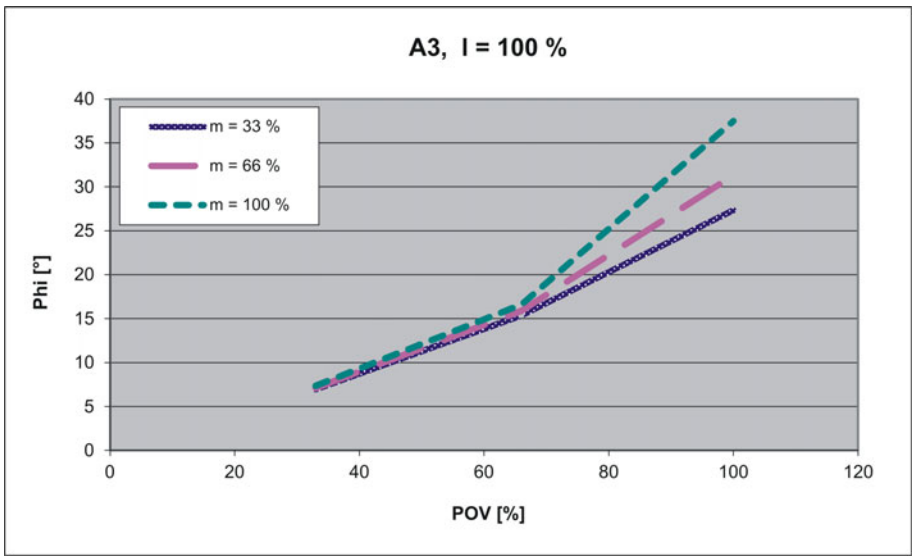


Fig. 4-23: Stopping distances for STOP 1, axis 3

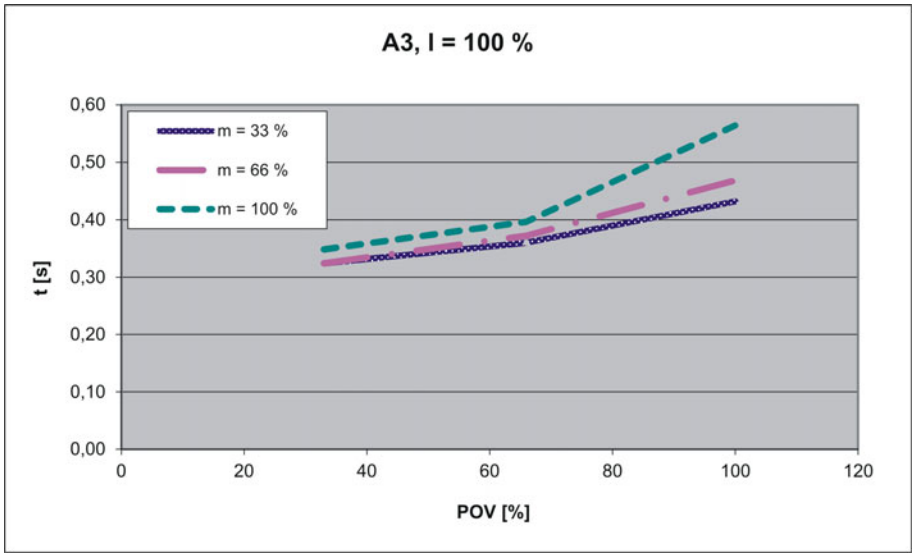


Fig. 4-24: Stopping times for STOP 1, axis 3

4.7.3 Stopping distances and times, KR 180 R3100 K prime

4.7.3.1 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	63.01	1.092
Axis 2	50.19	0.823
Axis 3	37.74	0.505

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

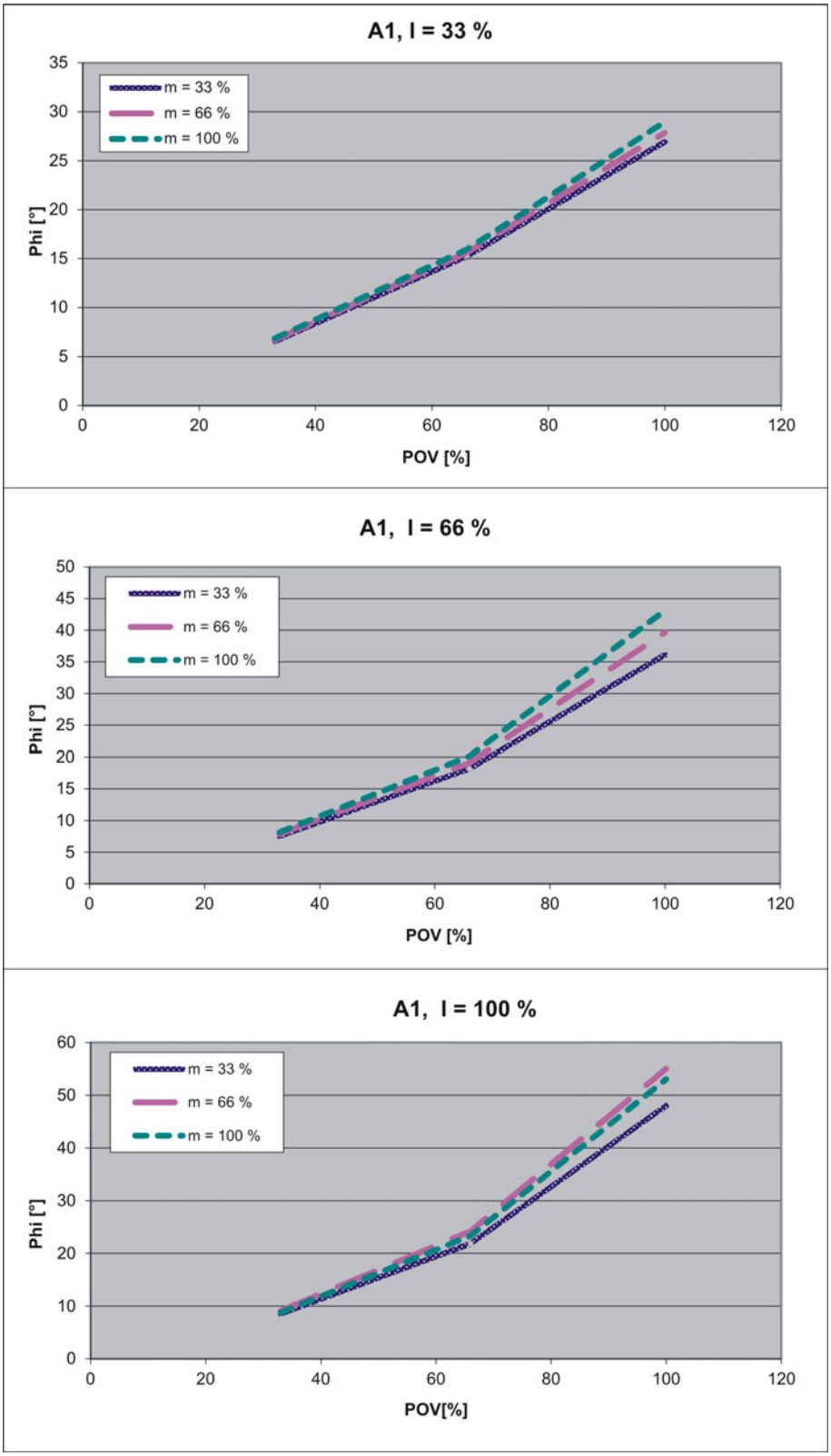


Fig. 4-25: Stopping distances for STOP 1, axis 1

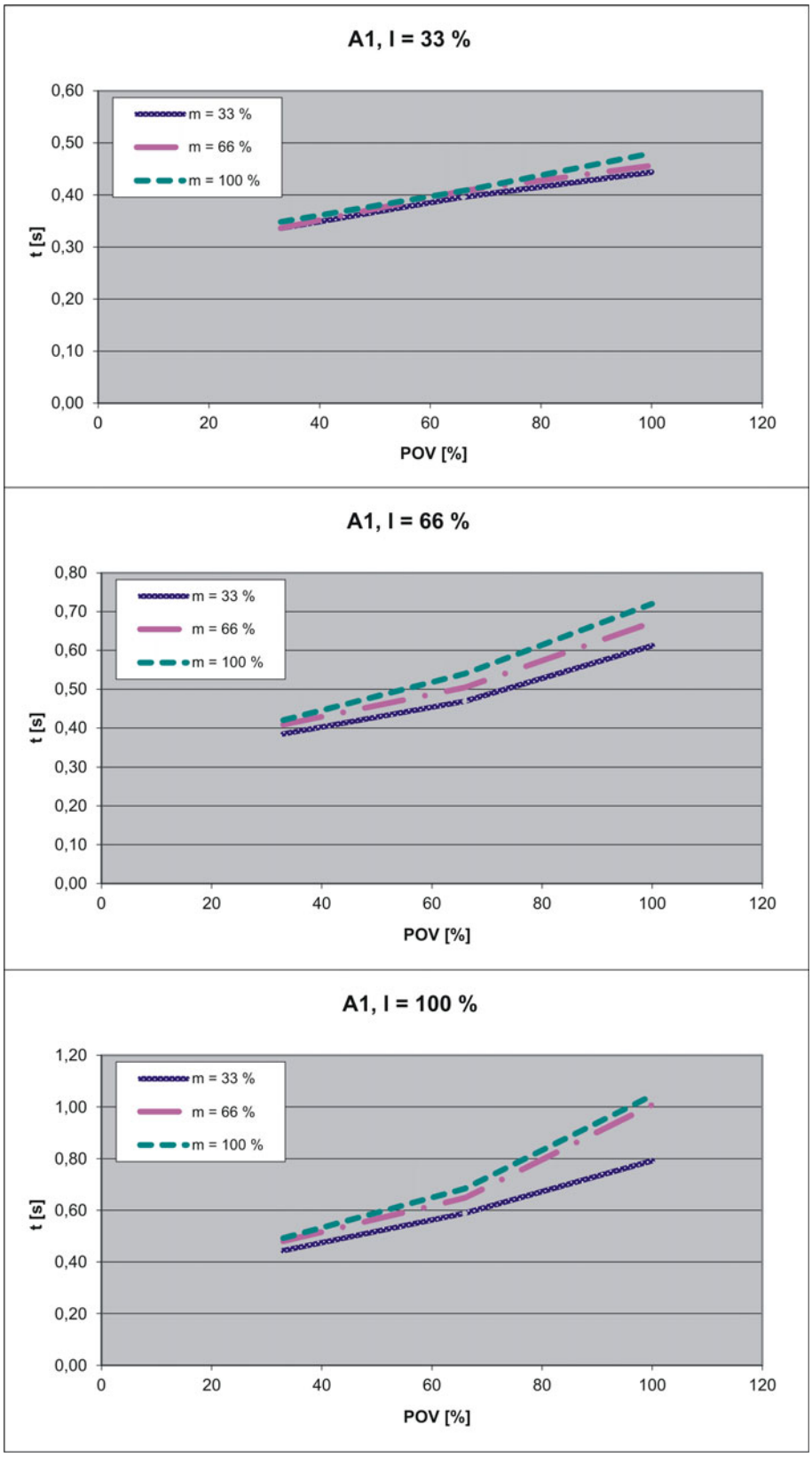


Fig. 4-26: Stopping times for STOP 1, axis 1

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

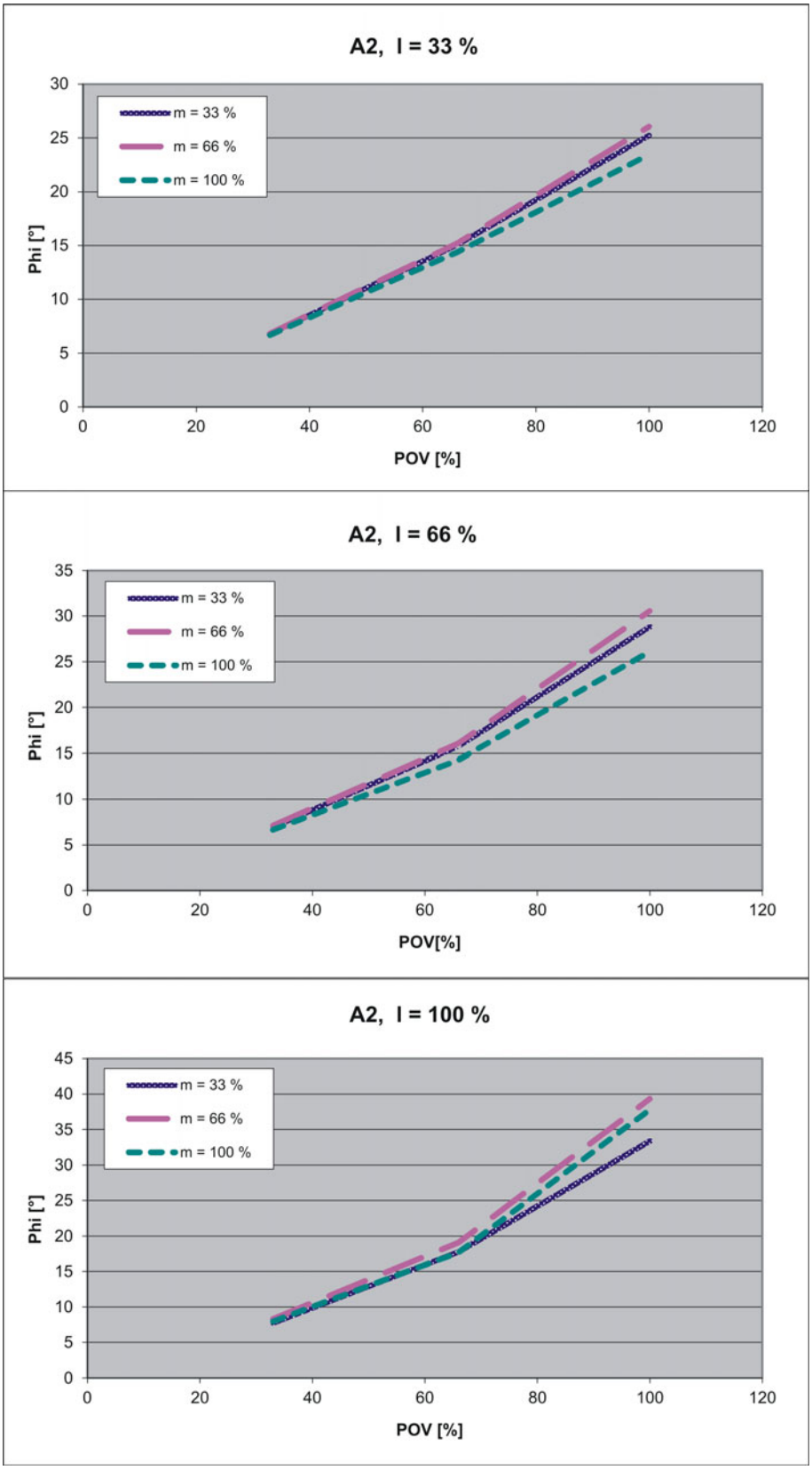


Fig. 4-27: Stopping distances for STOP 1, axis 2

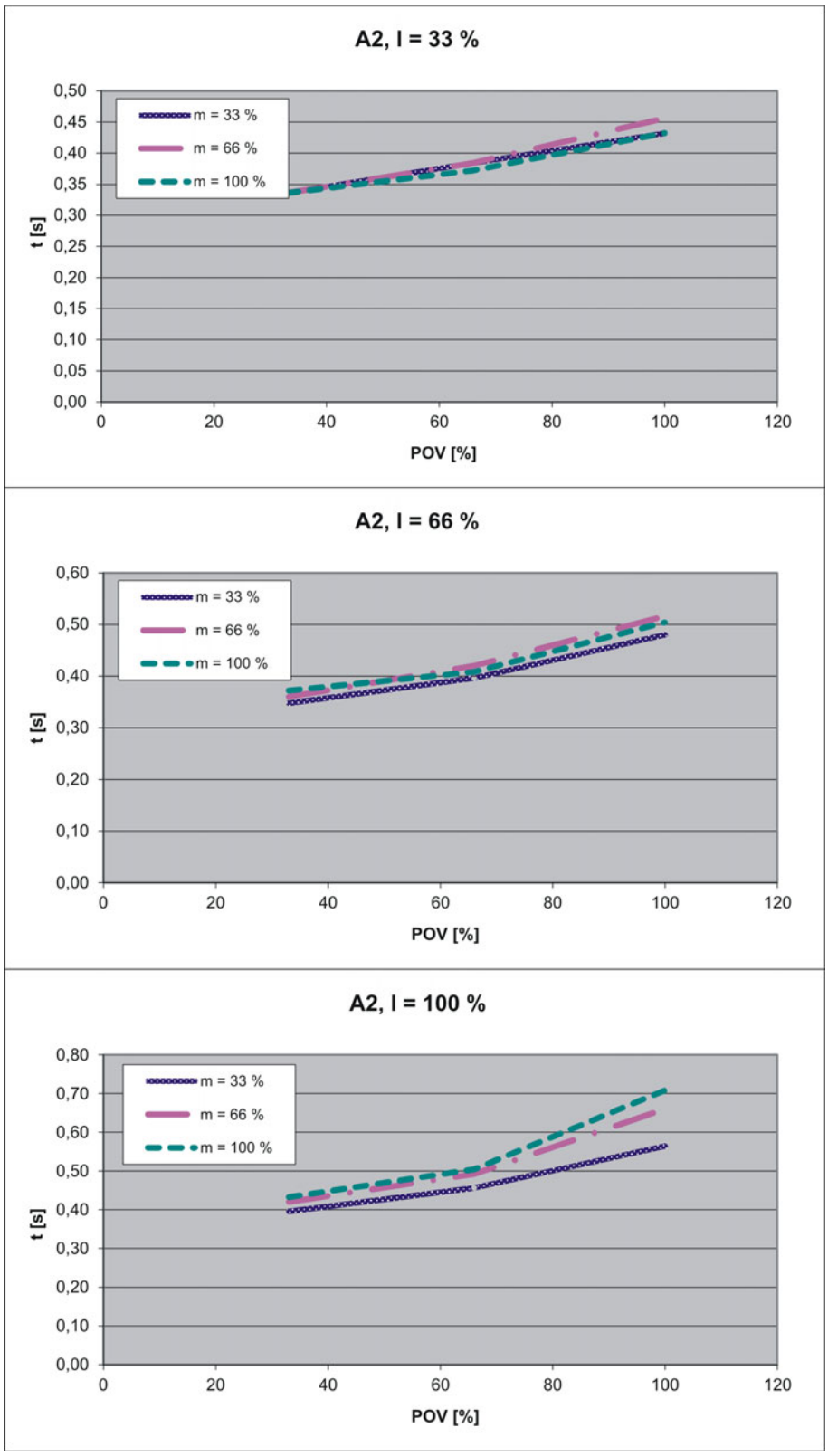


Fig. 4-28: Stopping times for STOP 1, axis 2

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

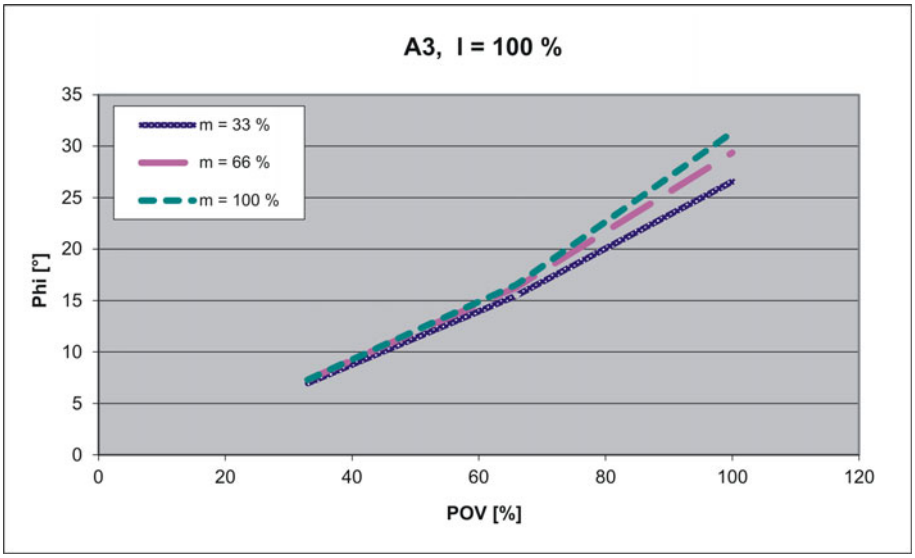


Fig. 4-29: Stopping distances for STOP 1, axis 3

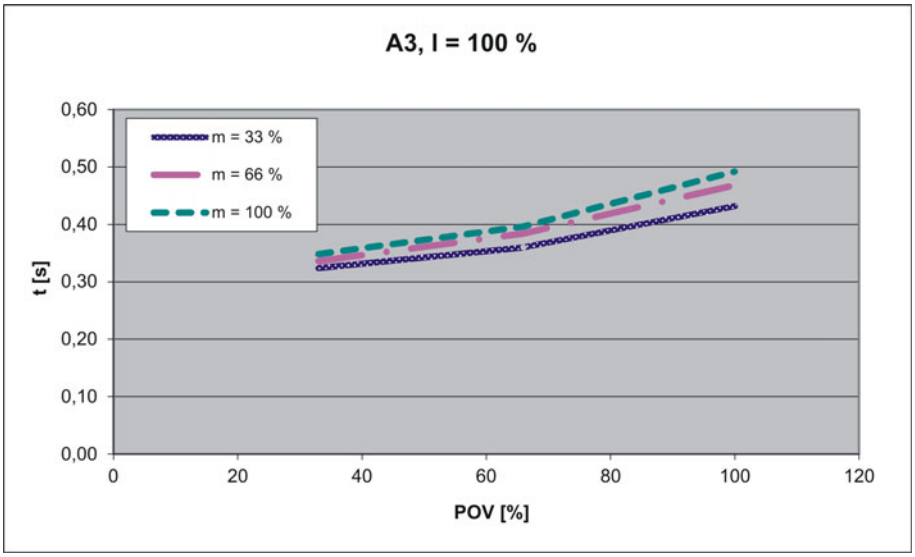


Fig. 4-30: Stopping times for STOP 1, axis 3

4.7.4 Stopping distances and times, KR 150 R3300 K prime

4.7.4.1 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	63.56	1.107
Axis 2	68.07	1.15
Axis 3	47.42	0.606

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

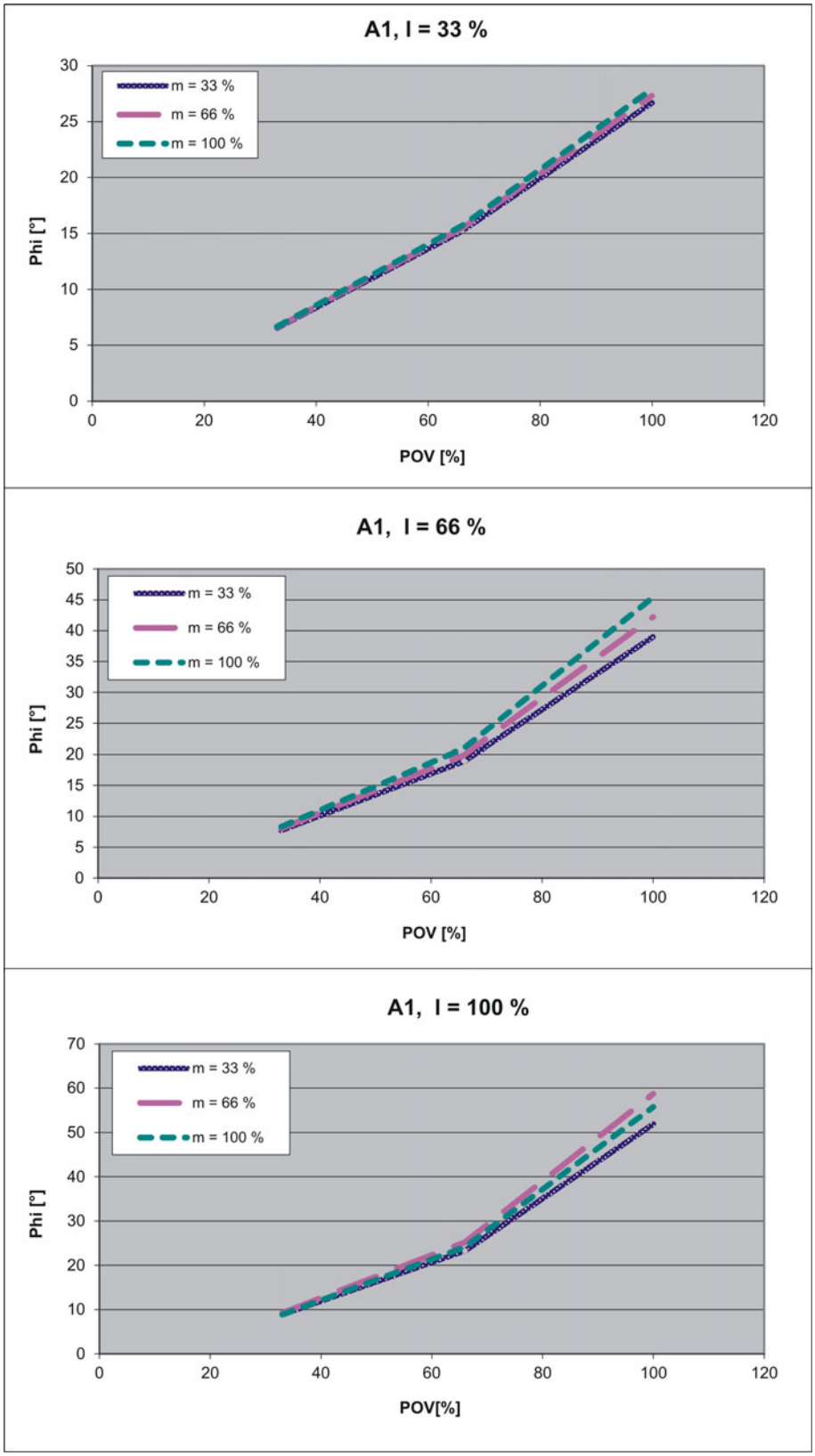


Fig. 4-31: Stopping distances for STOP 1, axis 1

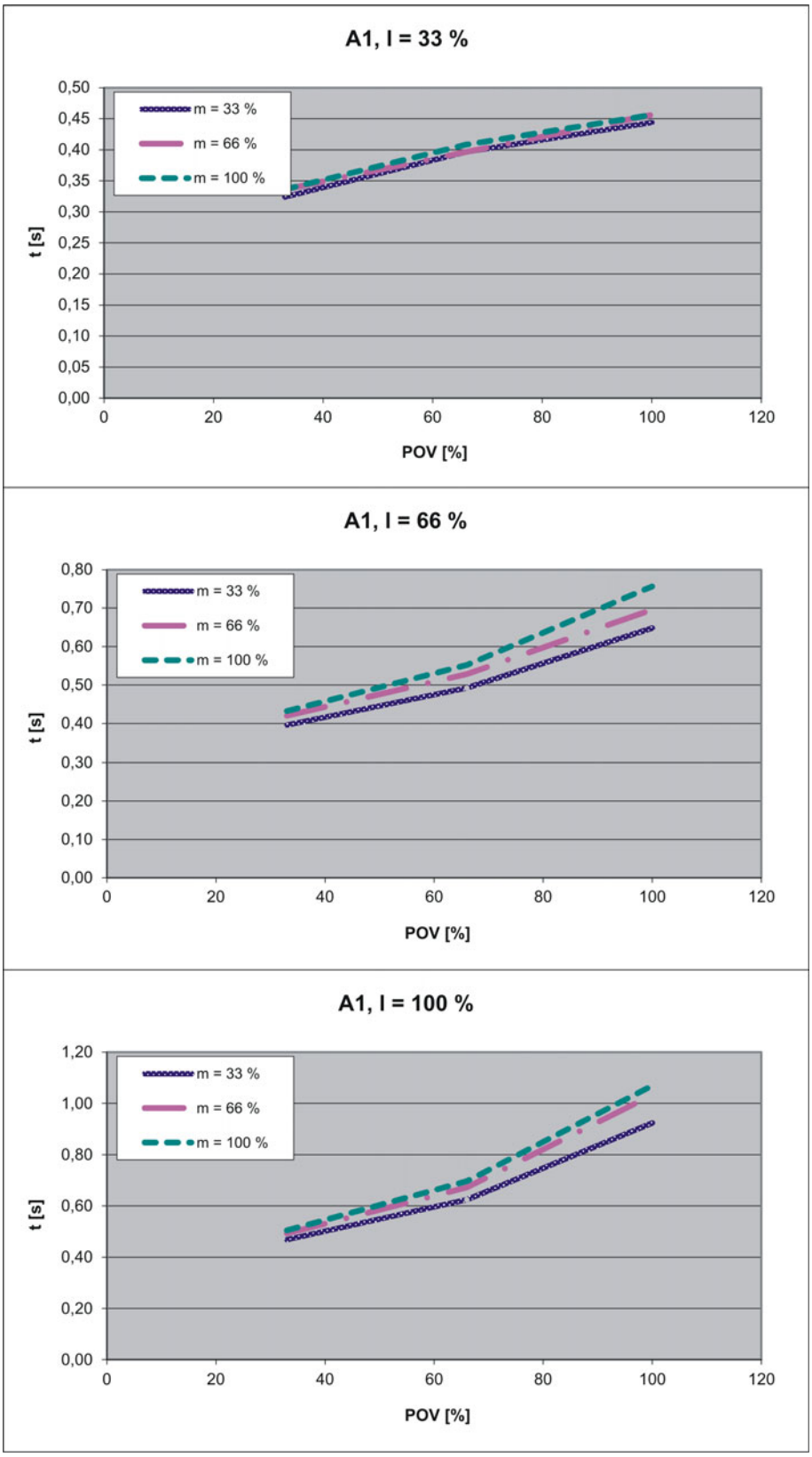


Fig. 4-32: Stopping times for STOP 1, axis 1

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

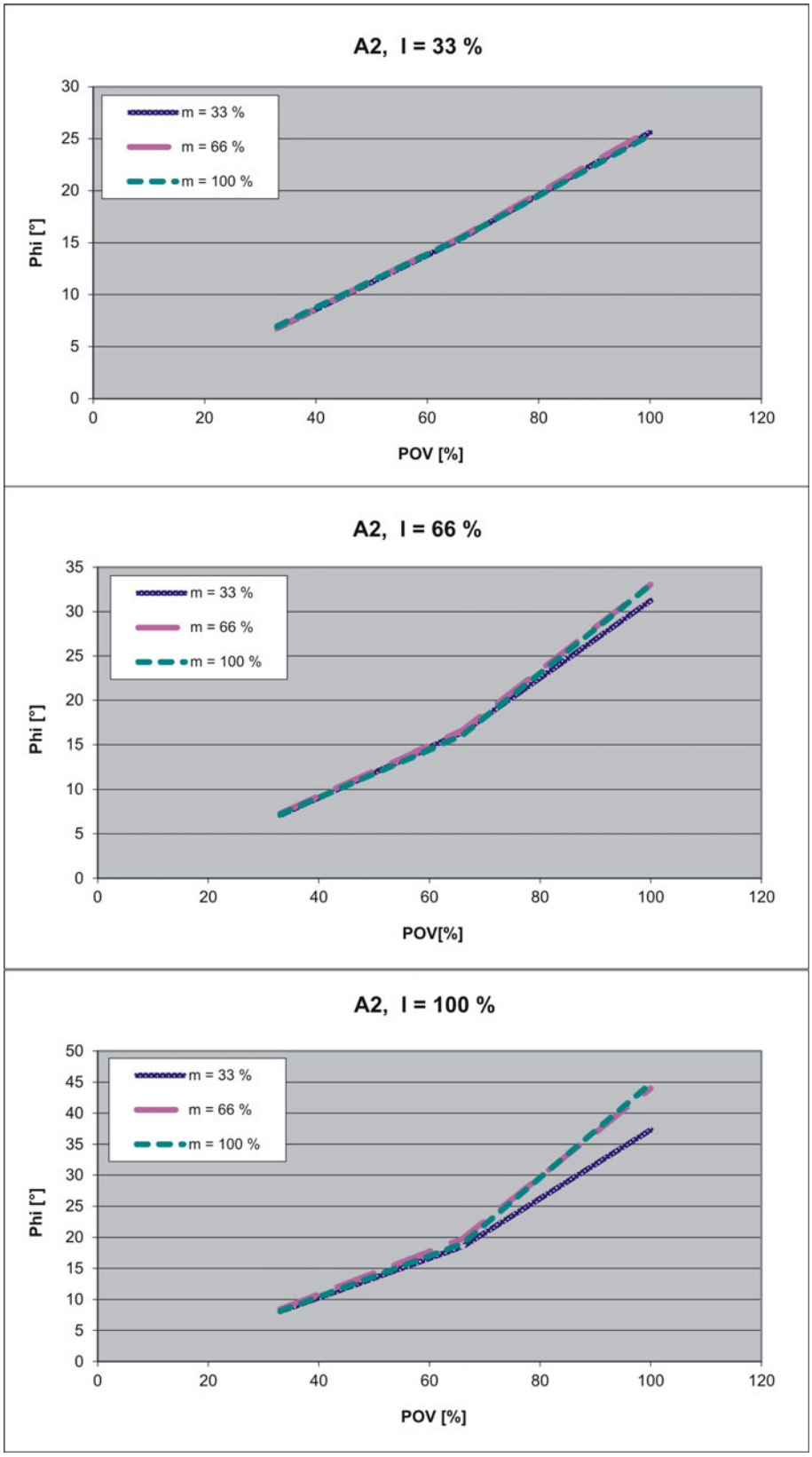


Fig. 4-33: Stopping distances for STOP 1, axis 2

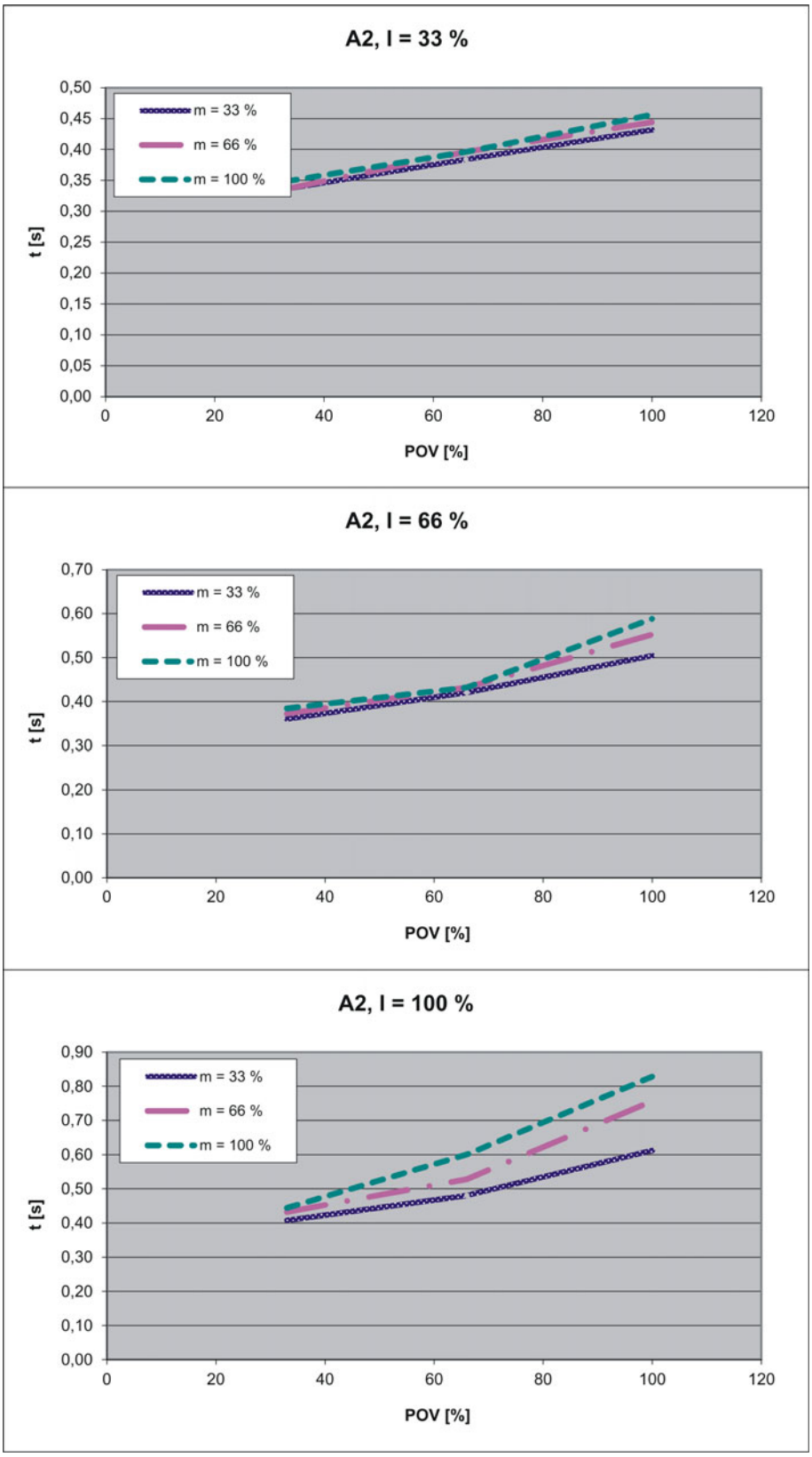


Fig. 4-34: Stopping times for STOP 1, axis 2

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

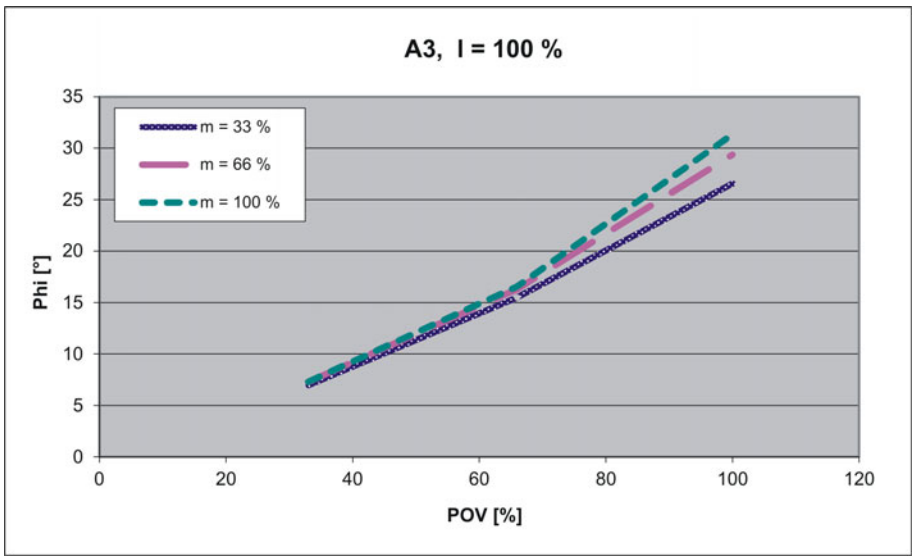


Fig. 4-35: Stopping distances for STOP 1, axis 3

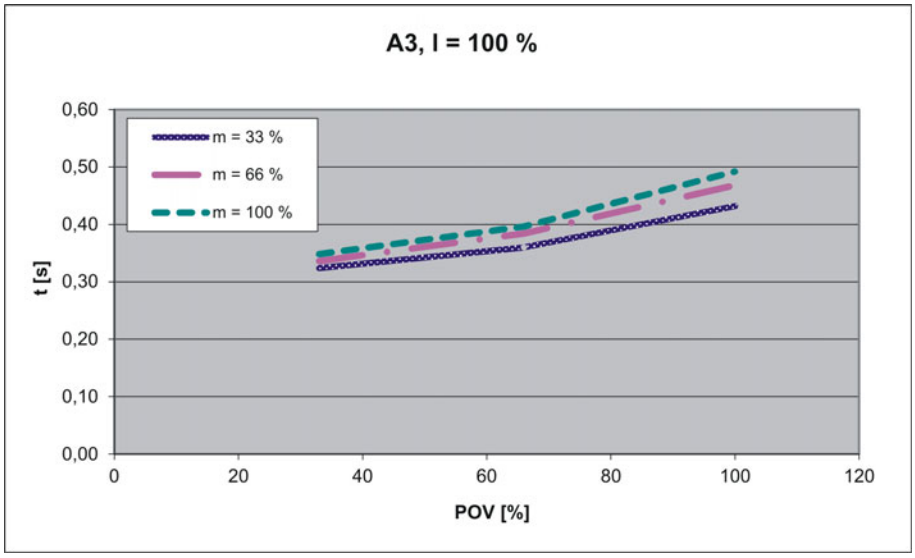


Fig. 4-36: Stopping times for STOP 1, axis 3

4.7.5 Stopping distances and times, KR 120 R3500 K prime

4.7.5.1 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	64.08	1.116
Axis 2	60.69	1.034
Axis 3	46.01	0.599

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

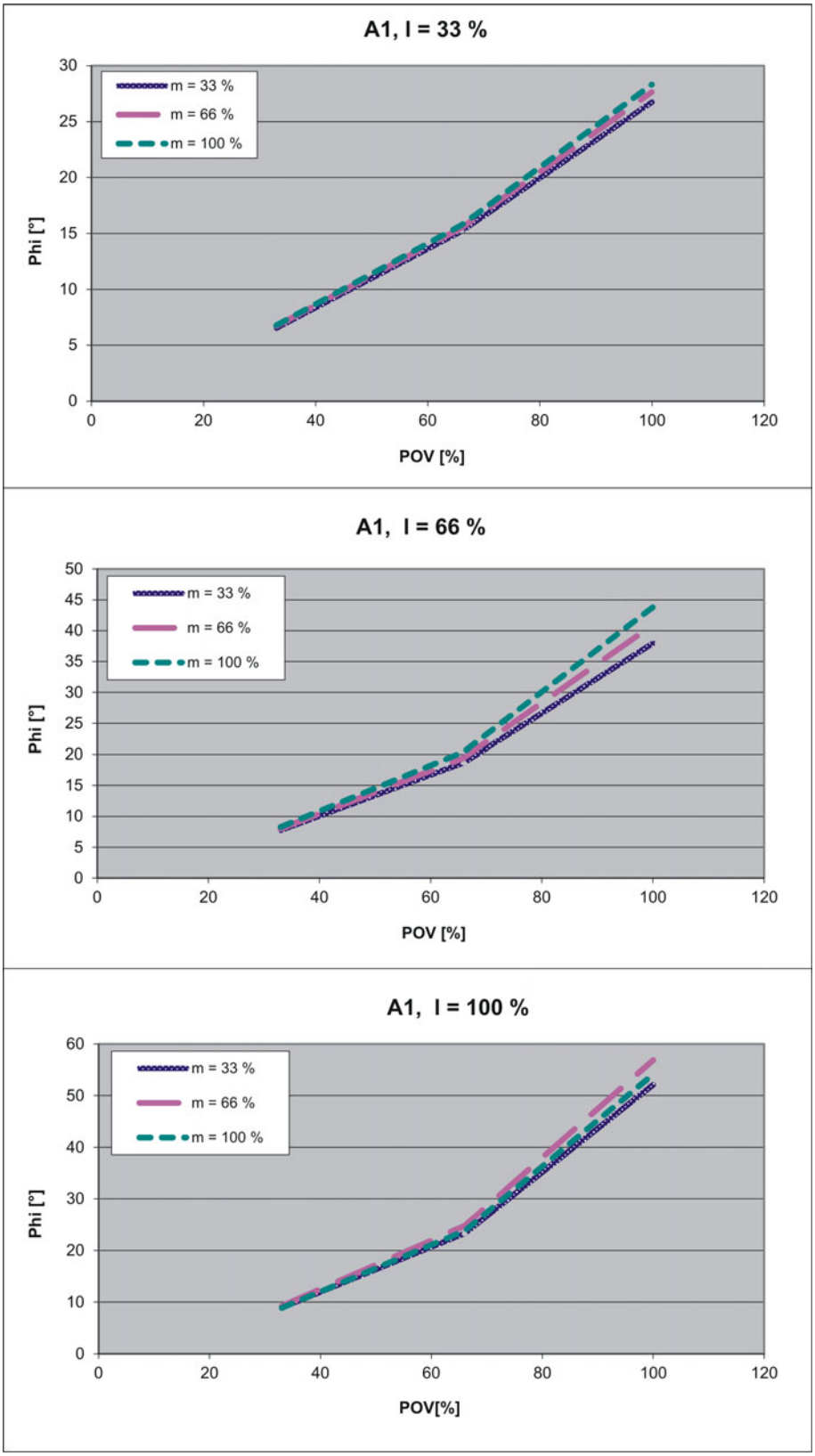


Fig. 4-37: Stopping distances for STOP 1, axis 1

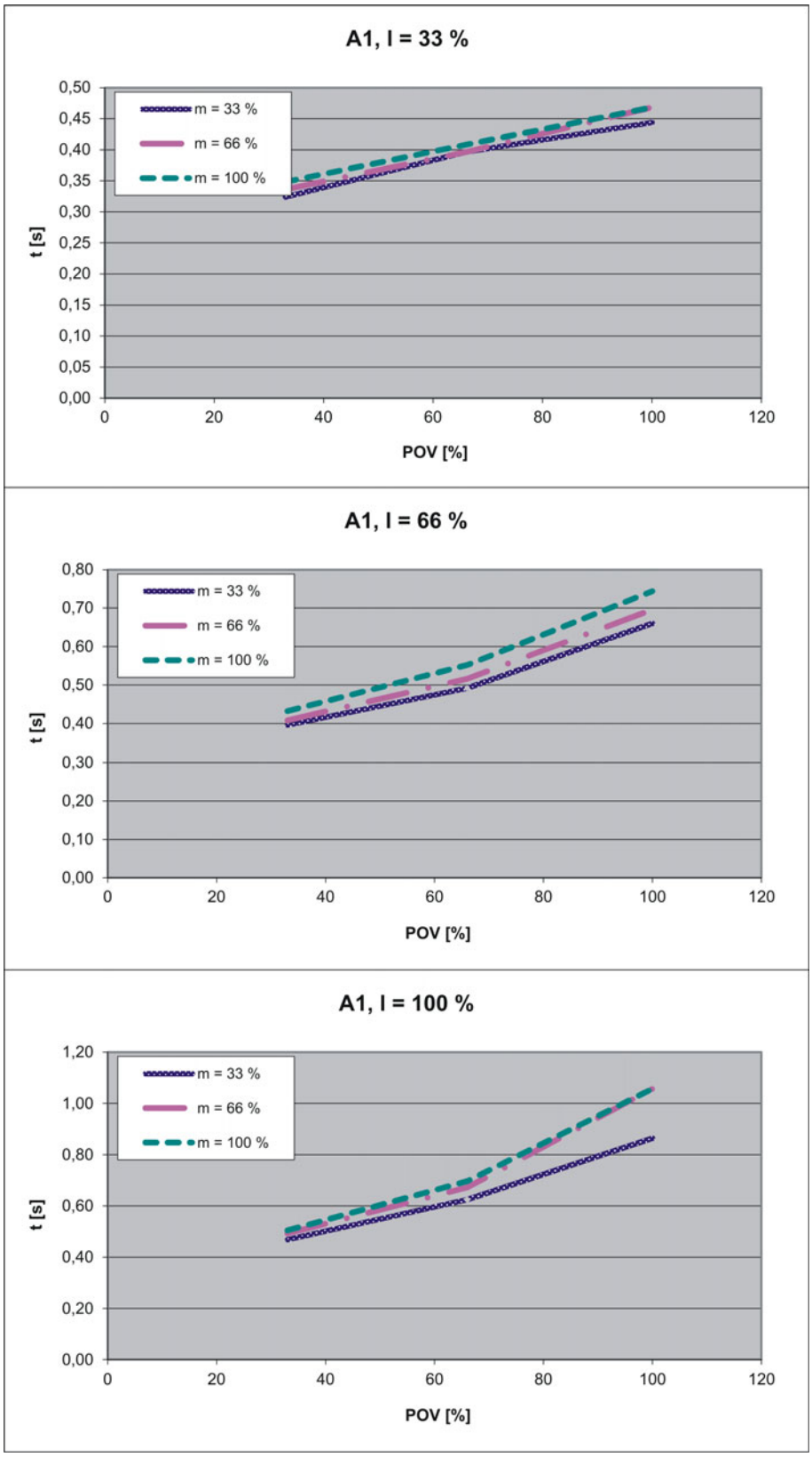


Fig. 4-38: Stopping times for STOP 1, axis 1

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

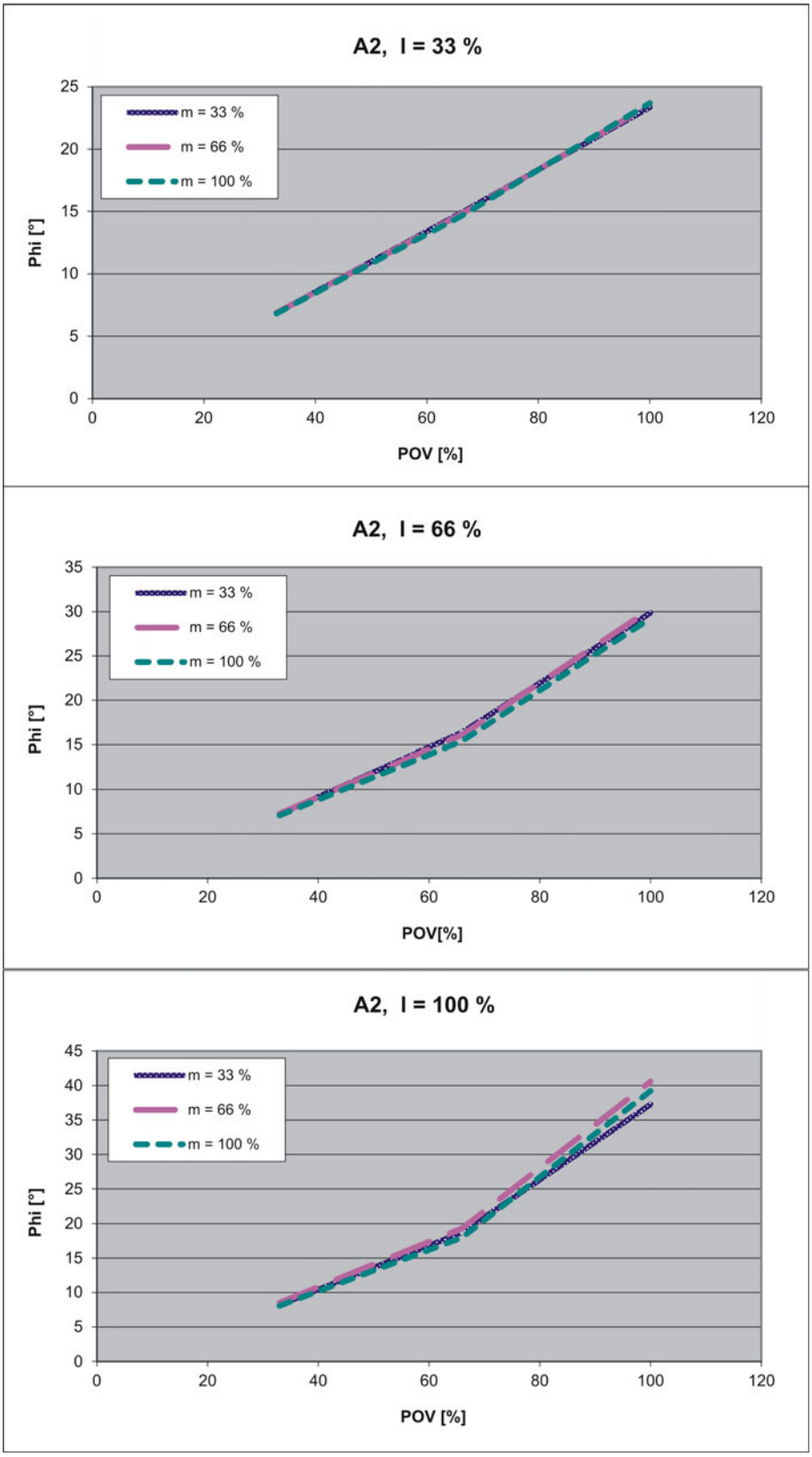


Fig. 4-39: Stopping distances for STOP 1, axis 2

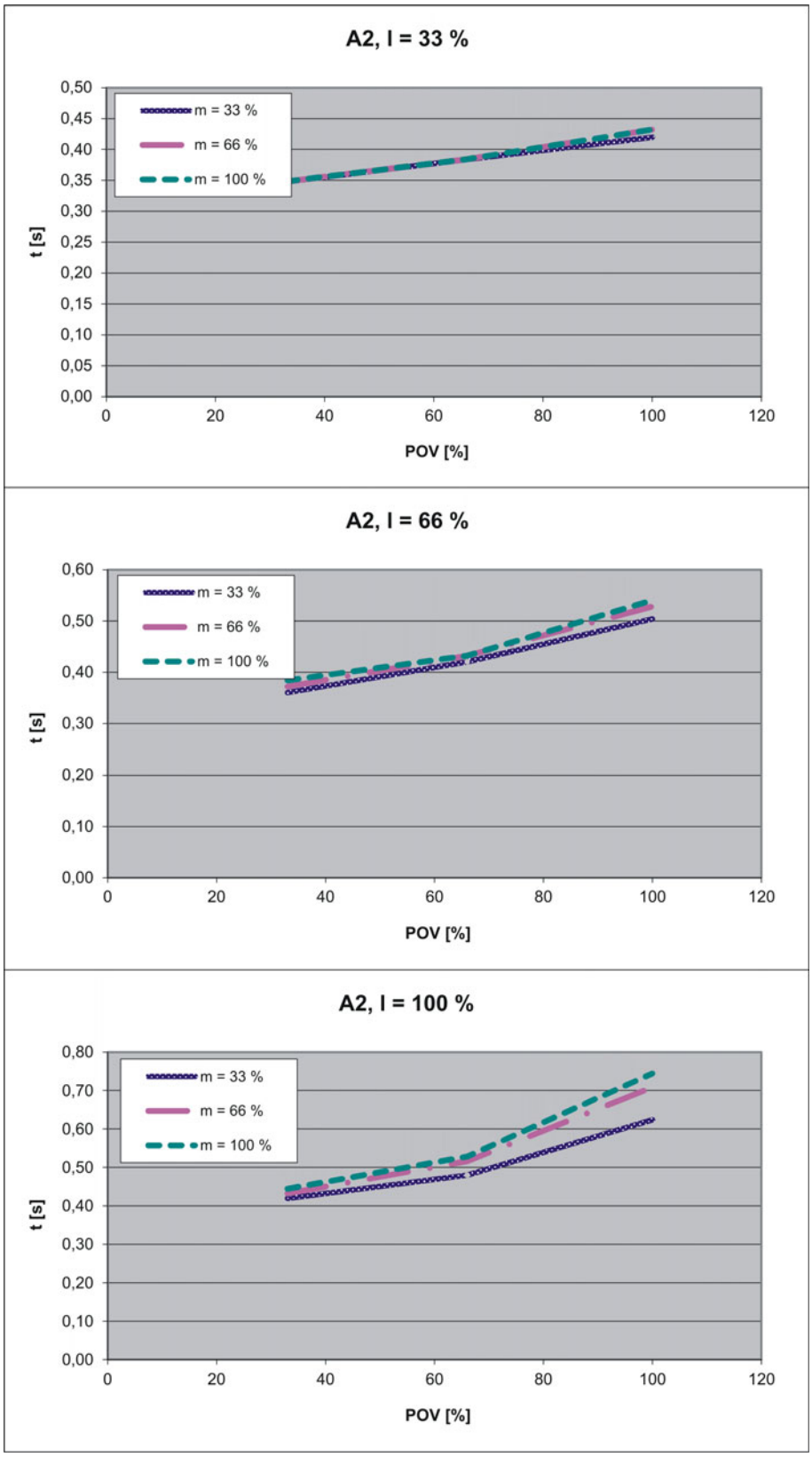


Fig. 4-40: Stopping times for STOP 1, axis 2

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

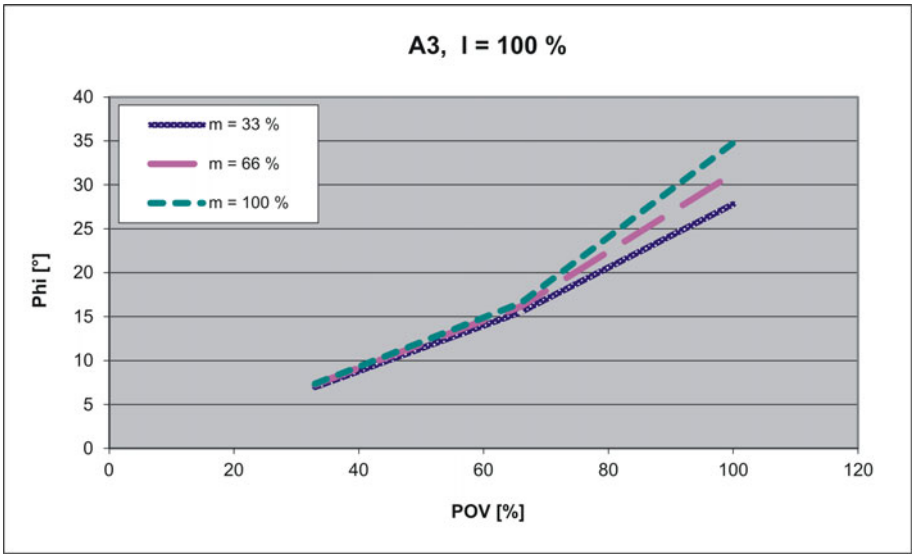


Fig. 4-41: Stopping distances for STOP 1, axis 3

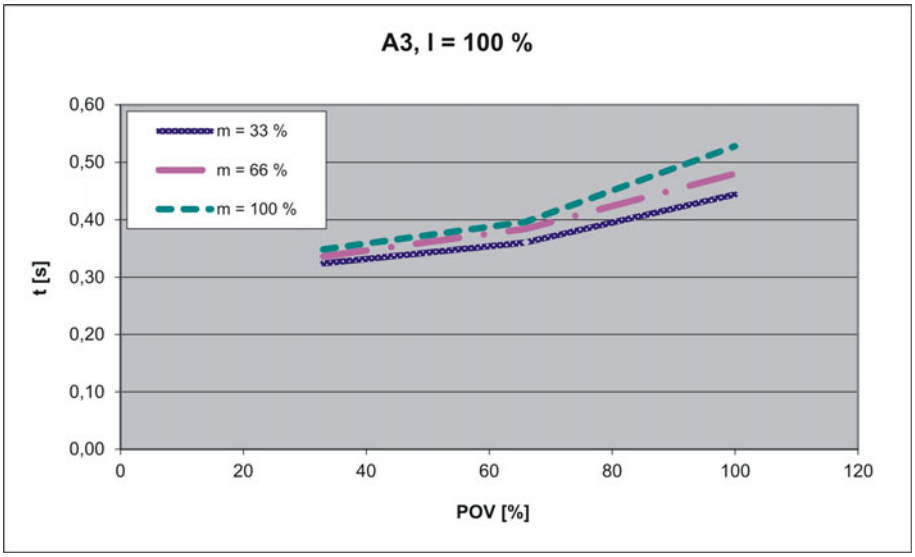


Fig. 4-42: Stopping times for STOP 1, axis 3

4.7.6 Stopping distances and times, KR 90 R3700 K prime

4.7.6.1 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	62.37	1.07
Axis 2	63.23	1.033
Axis 3	46.46	0.597

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

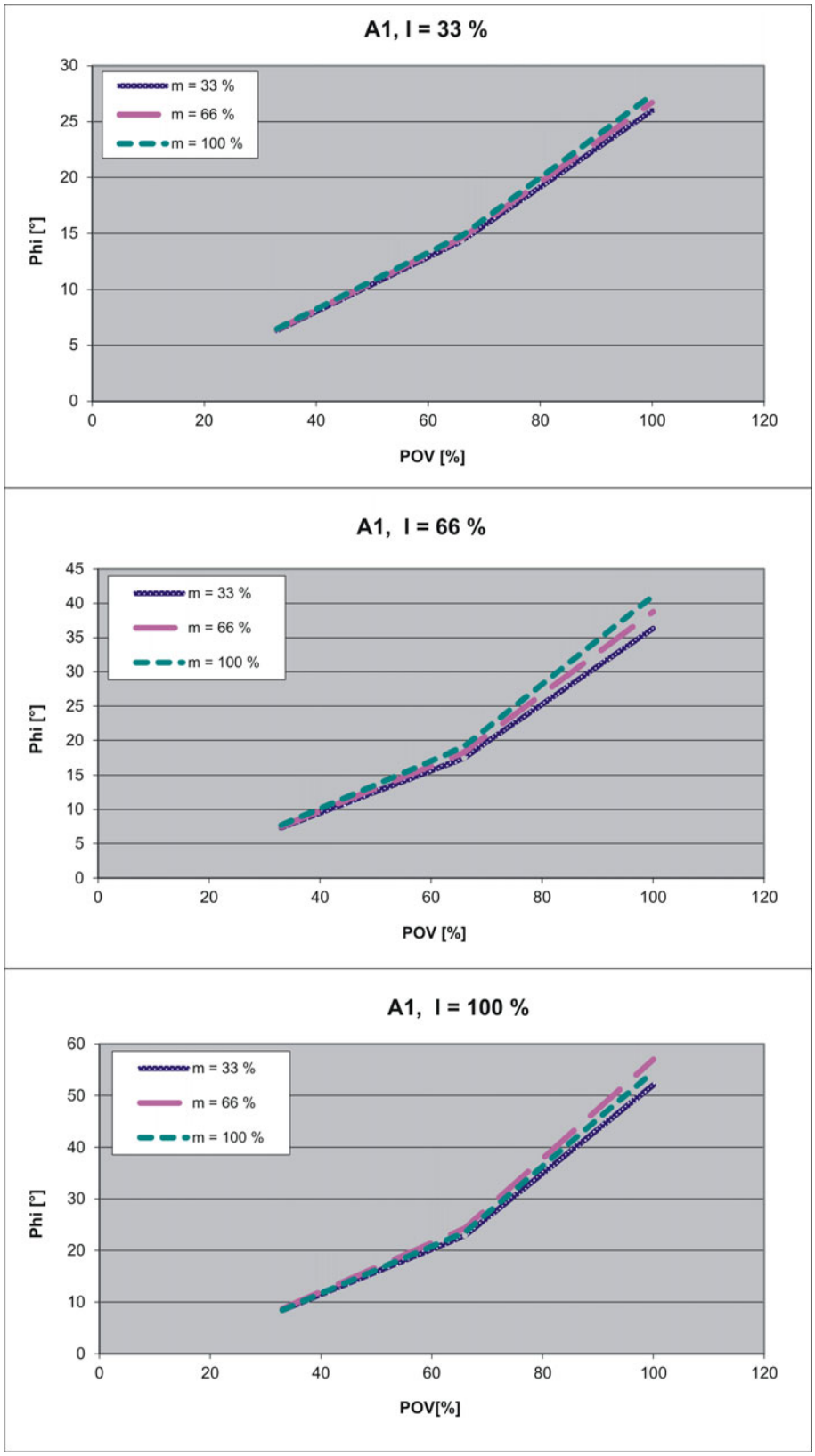


Fig. 4-43: Stopping distances for STOP 1, axis 1

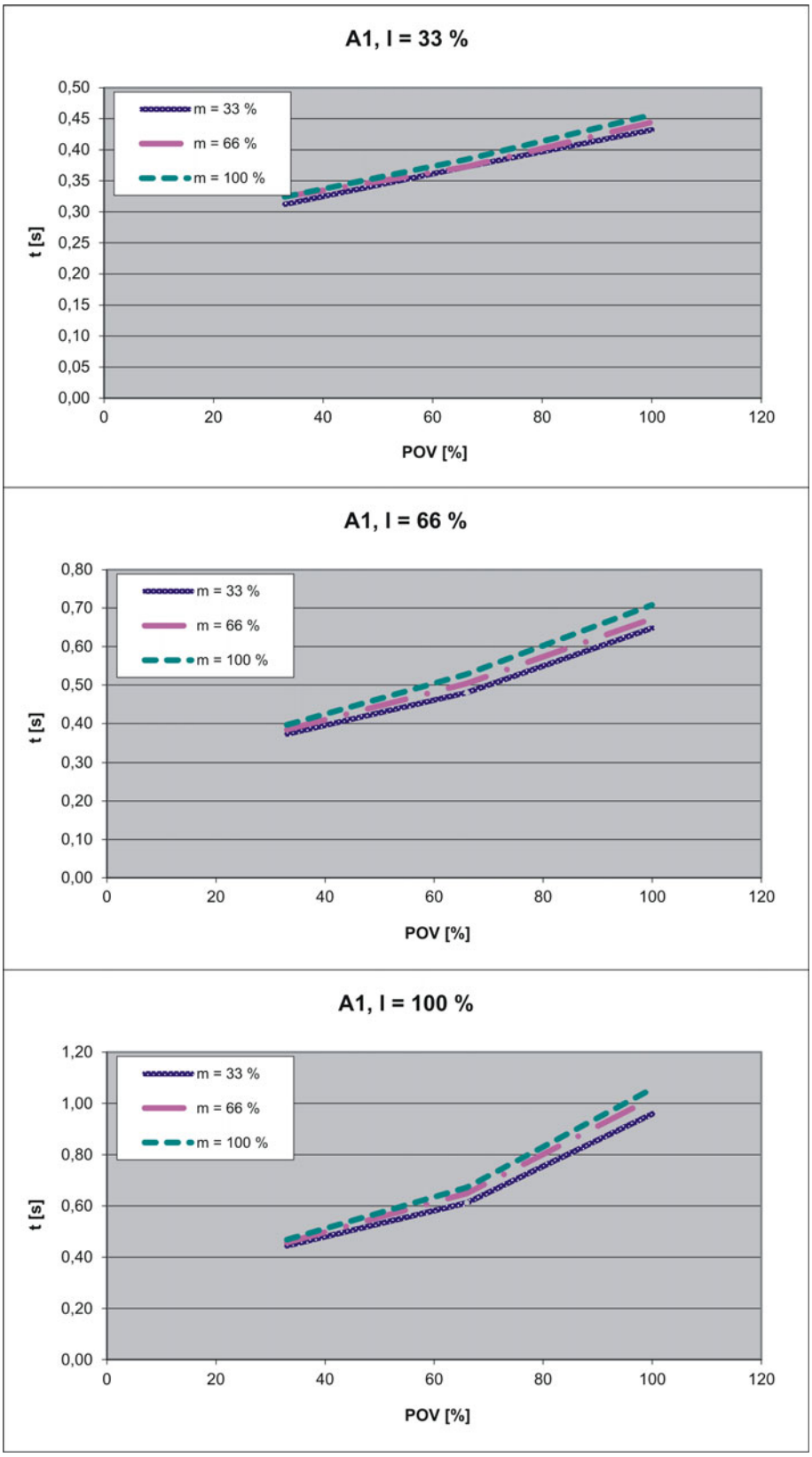


Fig. 4-44: Stopping times for STOP 1, axis 1

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

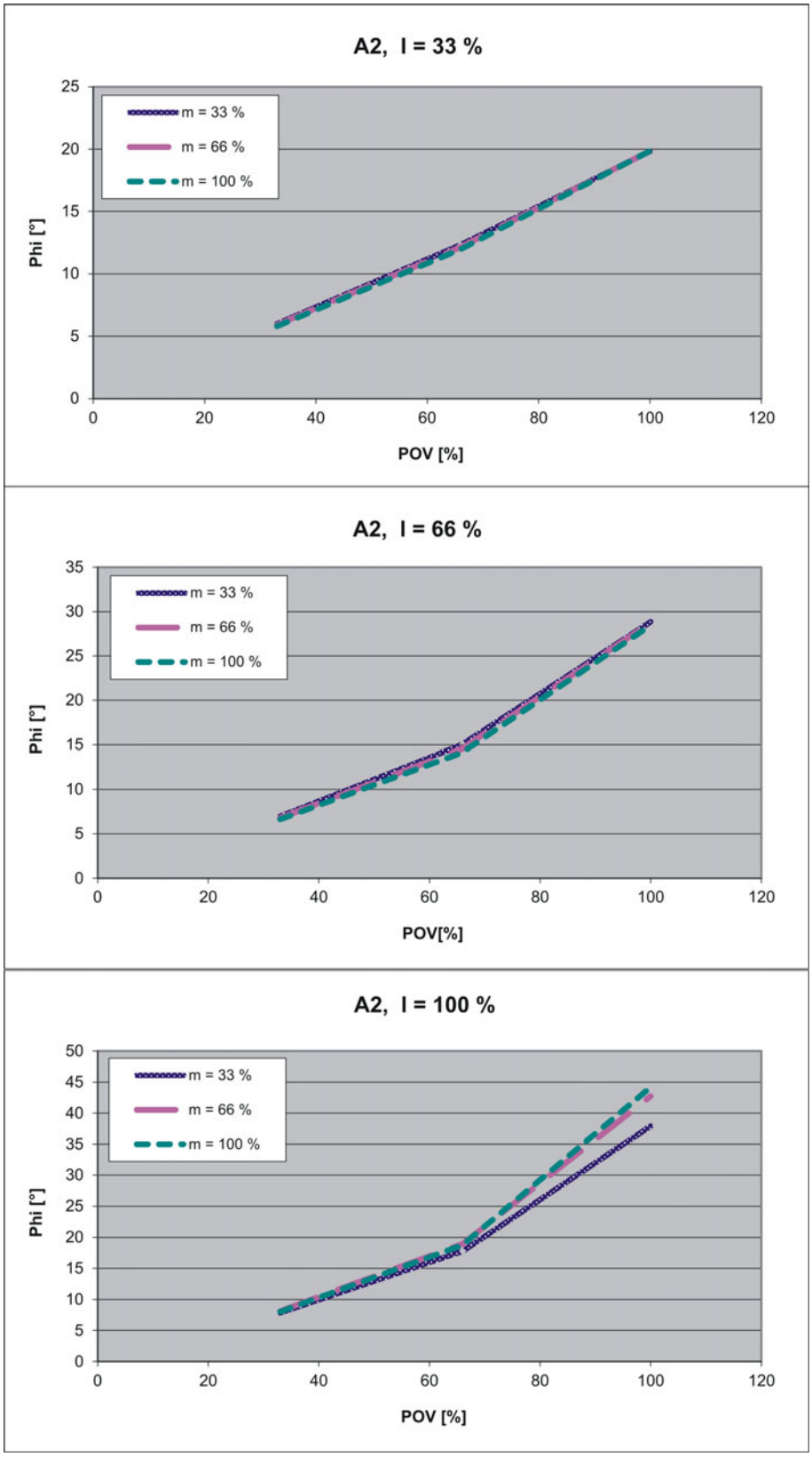


Fig. 4-45: Stopping distances for STOP 1, axis 2

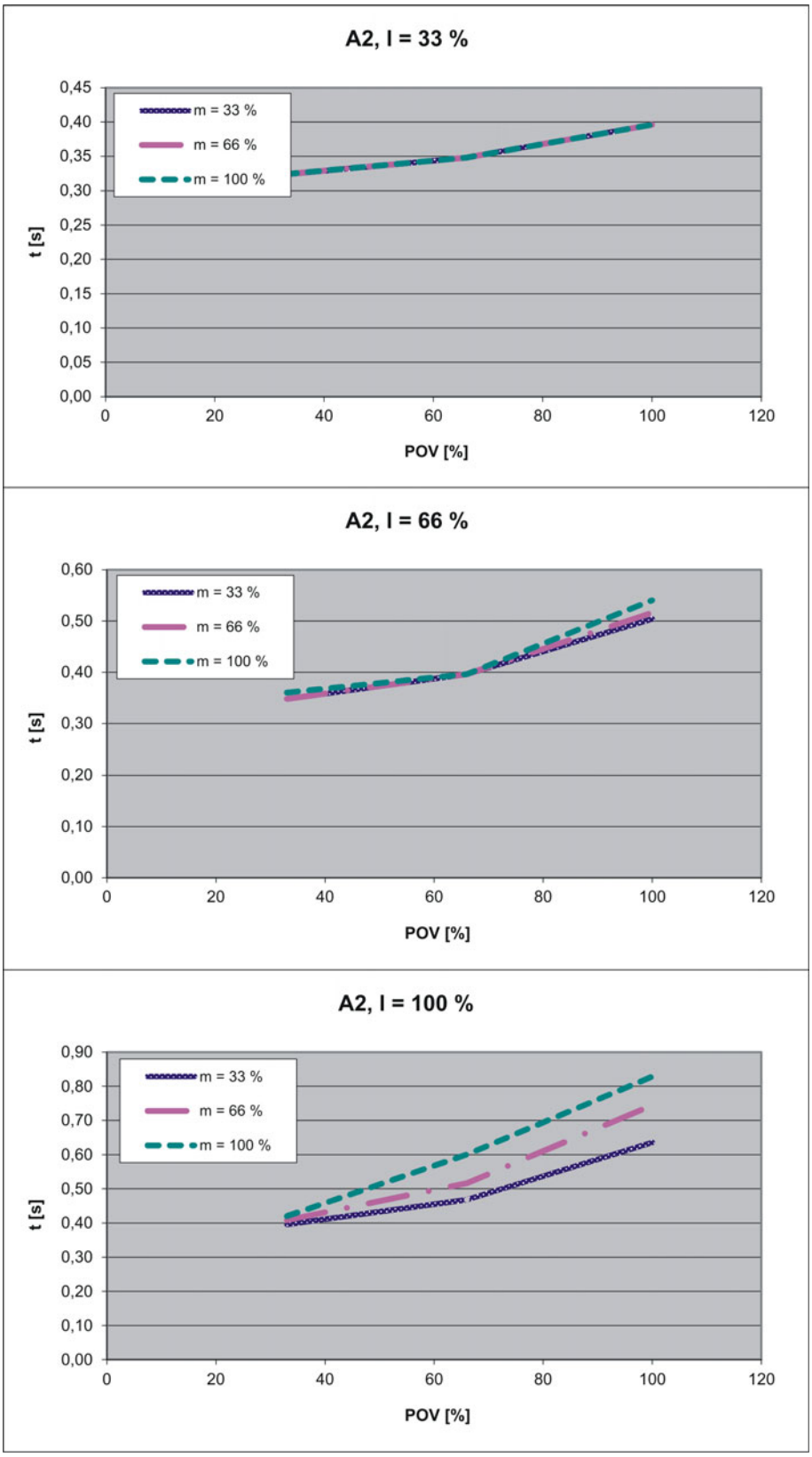


Fig. 4-46: Stopping times for STOP 1, axis 2

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

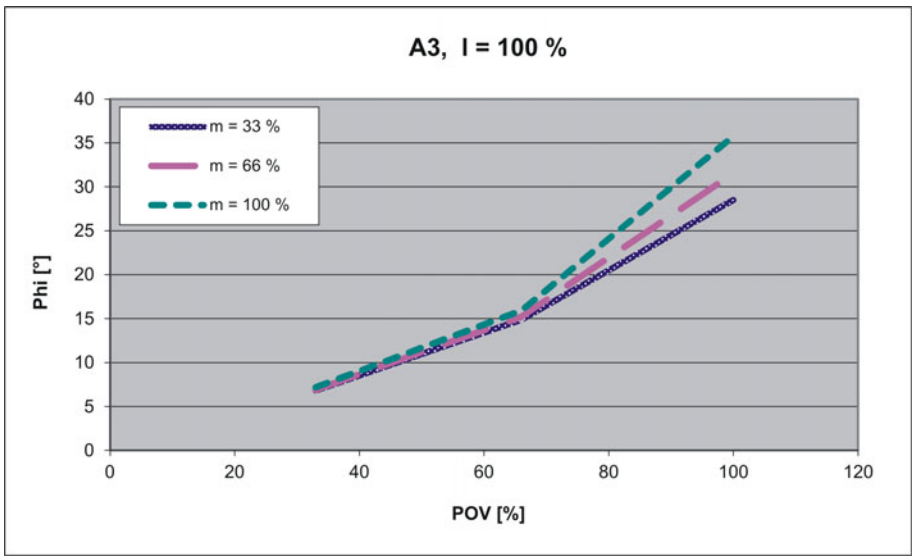


Fig. 4-47: Stopping distances for STOP 1, axis 3

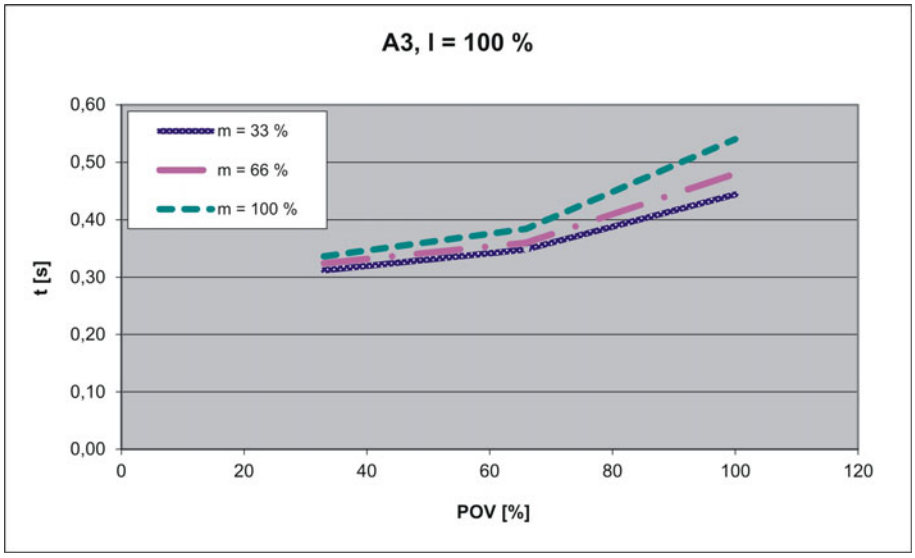


Fig. 4-48: Stopping times for STOP 1, axis 3

5 Safety

5.1 General

- This “Safety” chapter refers to a mechanical component of an industrial robot.
- If the mechanical component is used together with a KUKA robot controller, the “Safety” chapter of the operating instructions or assembly instructions of the robot controller must be used!

  This contains all the information provided in this “Safety” chapter. It also contains additional safety information relating to the robot controller which must be observed.
- Where this “Safety” chapter uses the term “industrial robot”, this also refers to the individual mechanical component if applicable.

5.1.1 Liability

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

Components of the industrial robot:

- Manipulator
- Robot controller
- Teach pendant
- Connecting cables
- External axes (optional)

  e.g. linear unit, turn-tilt table, positioner
- Software
- Options, accessories

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

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

Safety information

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

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

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

5.1.2 Intended use of the industrial robot

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

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

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

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

Misuse

Any use or application deviating from the intended use is deemed to be impermissible misuse. This includes e.g.:

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

5.1.3 EC declaration of conformity and declaration of incorporation

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

- The industrial robot is integrated into a complete system.

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

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

Declaration of conformity

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

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

Declaration of incorporation

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

The declaration of incorporation declares that the start-up of the partly completed machinery remains impermissible until the partly completed machinery

has been incorporated into machinery, or has been assembled with other parts to form machinery, and this machinery complies with the terms of the EC Machinery Directive, and the EC declaration of conformity is present in accordance with Annex II A.

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

5.1.4 Terms used

Term	Description
Axis range	Range of each axis, in degrees or millimeters, within which it may move. The axis range must be defined for each axis.
Stopping distance	Stopping distance = reaction distance + braking distance The stopping distance is part of the danger zone.
Workspace	The manipulator is allowed to move within its workspace. The workspace is derived from the individual axis ranges.
Operator (User)	The user of the industrial robot can be the management, employer or delegated person responsible for use of the industrial robot.
Danger zone	The danger zone consists of the workspace and the stopping distances.
Service life	The service life of a safety-relevant component begins at the time of delivery of the component to the customer. The service life is not affected by whether the component is used in a robot controller or elsewhere or not, as safety-relevant components are also subject to ageing during storage.
KCP	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)

Term	Description
T2	Test mode, Manual High Velocity (> 250 mm/s permissible)
External axis	Motion axis which is not part of the manipulator but which is controlled using the robot controller, e.g. KUKA linear unit, turn-tilt table, Posiflex.

5.2 Personnel

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

- User
- Personnel

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

User

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

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

Personnel

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

Personnel includes:

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

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

System integrator

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

The system integrator is responsible for the following tasks:

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

Operator

The operator must meet the following preconditions:

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

Example The tasks can be distributed as shown in the following table.

Tasks	Operator	Programmer	System integrator
Switch robot controller on/off	x	x	x
Start program	x	x	x
Select program	x	x	x
Select operating mode	x	x	x
Calibration (tool, base)		x	x
Master the manipulator		x	x
Configuration		x	x
Programming		x	x
Start-up			x
Maintenance			x
Repair			x
Shutting down			x
Transportation			x

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

5.3 Workspace, safety zone and danger zone

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

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

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

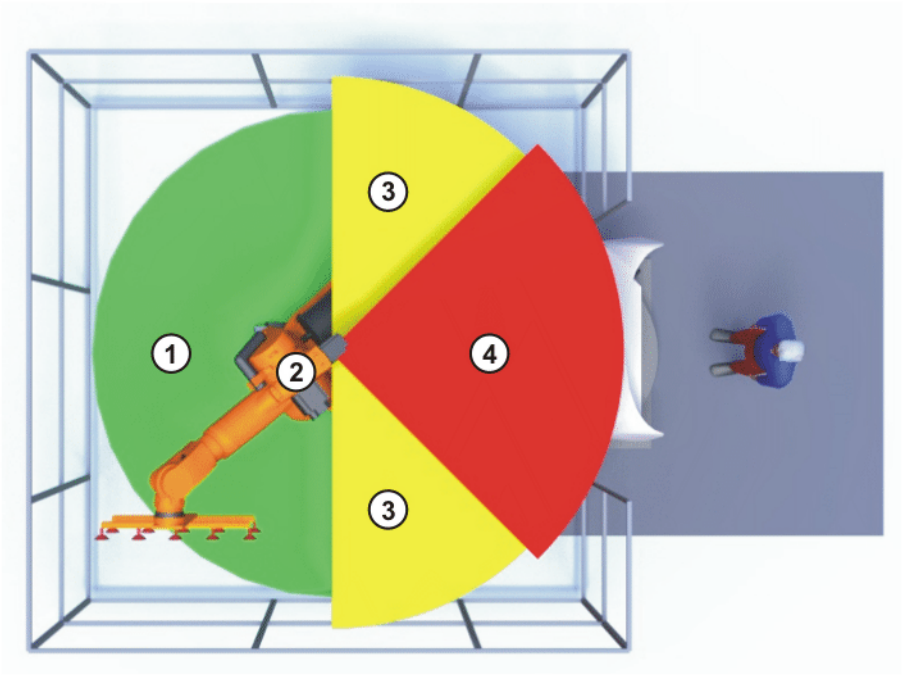


Fig. 5-1: Example of axis range A1

1	Workspace	3	Stopping distance
2	Manipulator	4	Safety zone

5.4 Overview of protective equipment

The protective equipment of the mechanical component may include:

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

Not all equipment is relevant for every mechanical component.

5.4.1 Mechanical end stops

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

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

⚠ WARNING If the manipulator or an external axis hits an obstruction or a mechanical end stop or axis range limitation, this can result in material damage to the industrial robot. The manipulator must be taken out of operation and KUKA Roboter GmbH must be consulted before it is put back into operation (>>> 15 "KUKA Service" Page 191).

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 or exceptional situations, 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 labels
- Safety symbols
- Designation labels
- Cable markings
- Rating plates

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

5.5 Safety measures

5.5.1 General safety measures

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

It is important to be prepared for possible movements of the industrial robot even after the robot controller has been switched off and locked 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.

Robot controller

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

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

External axis (optional)

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

5.5.3 Start-up and recommissioning

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

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

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

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

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

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

Function test

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

It must be ensured that:

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

Machine data

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

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

5.5.4 Manual mode

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

- Jog mode
- Teach
- Programming
- Program verification

The following must be taken into consideration in manual mode:

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

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

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

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

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

  If it is necessary for there to be several persons inside the safeguarded area, the following must be observed:
  - Each person must have an enabling device.
  - All persons must have an unimpeded view of the industrial robot.
  - Eye-contact between all persons must be possible at all times.
- The operator must be so positioned that he can see into the danger area and get out of harm's way.

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

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

5.5.5 Automatic mode

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

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

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

5.5.6 Maintenance and repair

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

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

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

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

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

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

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

Robot controller

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

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

Voltages in excess of 50 V (up to 600 V) can be present in various components for several minutes after the robot controller has been switched off! To prevent

life-threatening injuries, no work may be carried out on the industrial robot in this time.

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

Counterbalancing system

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

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

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

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

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

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

Hazardous substances

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

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

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

5.5.7 Decommissioning, storage and disposal

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

5.6 Applied norms and regulations

Name	Definition	Edition
2006/42/EC	**Machinery Directive:** Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)	2006
2004/108/EC	**EMC Directive:** Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC	2004

97/23/EC	**Pressure Equipment Directive**: Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment (Only applicable for robots with hydropneumatic counterbalancing system.)	1997
EN ISO 13850	**Safety of machinery:** Emergency stop - Principles for design	2008
EN ISO 13849-1	**Safety of machinery:** Safety-related parts of control systems - Part 1: General principles of design	2008
EN ISO 13849-2	**Safety of machinery:** Safety-related parts of control systems - Part 2: Validation	2012
EN ISO 12100	**Safety of machinery:** General principles of design, risk assessment and risk reduction	2010
EN ISO 10218-1	**Industrial robot:** Safety	2011
EN 614-1	**Safety of machinery:** Ergonomic design principles - Part 1: Terms and general principles	2006
EN 61000-6-2	**Electromagnetic compatibility (EMC):** Part 6-2: Generic standards; Immunity for industrial environments	2005
EN 61000-6-4	**Electromagnetic compatibility (EMC):** Part 6-4: Generic standards; Emission standard for industrial environments	2007
EN 60204-1	**Safety of machinery:** Electrical equipment of machines - Part 1: General requirements	2006

6 Planning

6.1 Mounting base with centering

Description

The mounting base with centering is used when the robot is fastened to the floor, i.e. directly on a concrete foundation.

The mounting base with centering consists of:

- Bedplates
- Resin-bonded anchors (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.

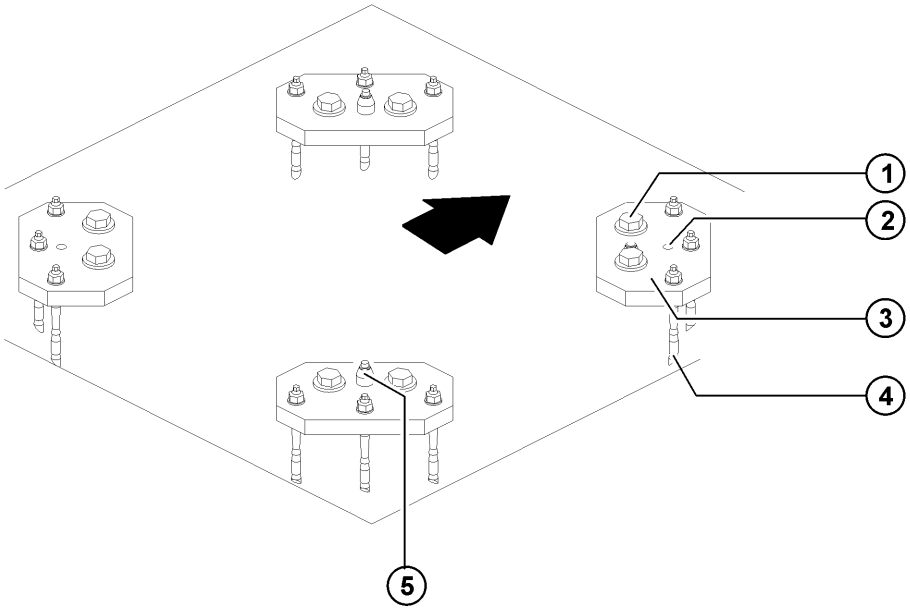


Fig. 6-1: Mounting base

1	Hexagon bolt	4	Resin-bonded anchors with Dynamic Set
2	M20 thread for mastering screw	5	Pin with Allen screw
3	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 illustrations provide all the necessary information on the mounting base, together with the required foundation data.

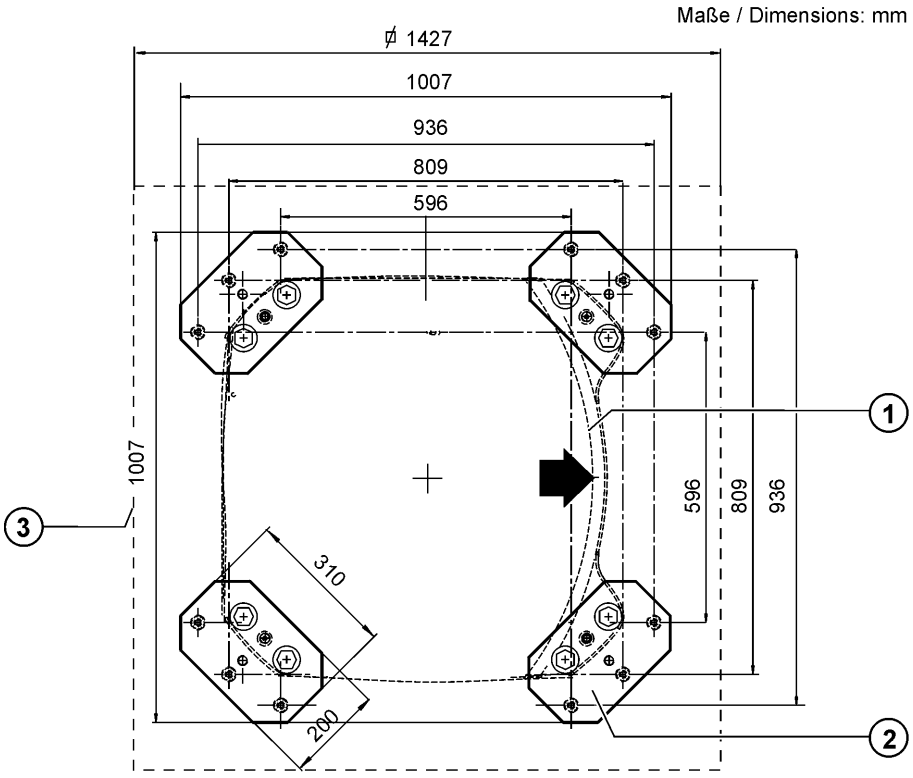


Fig. 6-2: Mounting base, dimensioned drawing

1 Robot
2 Bedplate
3 Concrete foundation

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

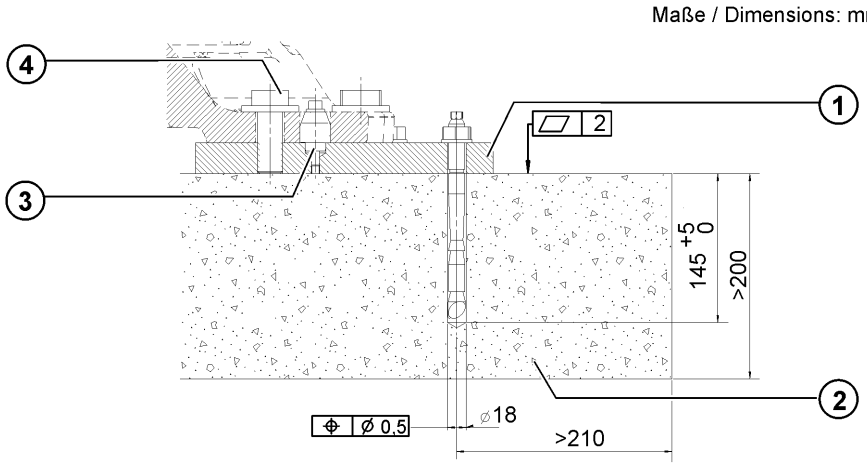


Fig. 6-3: Cross-section of foundations

1 Bedplate
2 Concrete foundation
3 Pin
4 Hexagon bolt

6.2 Machine frame mounting

Description

The “machine frame mounting” assembly with centering 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. 6-4).

The machine frame mounting assembly consists of:

- Pins with fasteners
- Hexagon bolts with conical spring washers

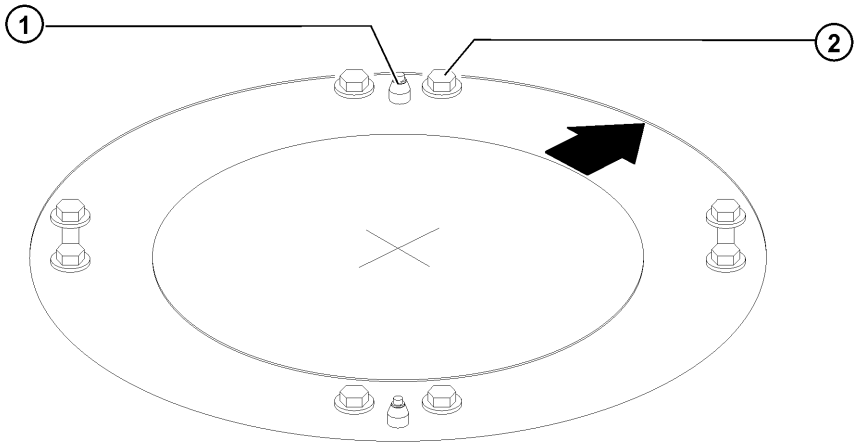


Fig. 6-4: Machine frame mounting

1 Pin
2 Hexagon bolt

Dimensioned drawing

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

Maße / Dimensions: mm

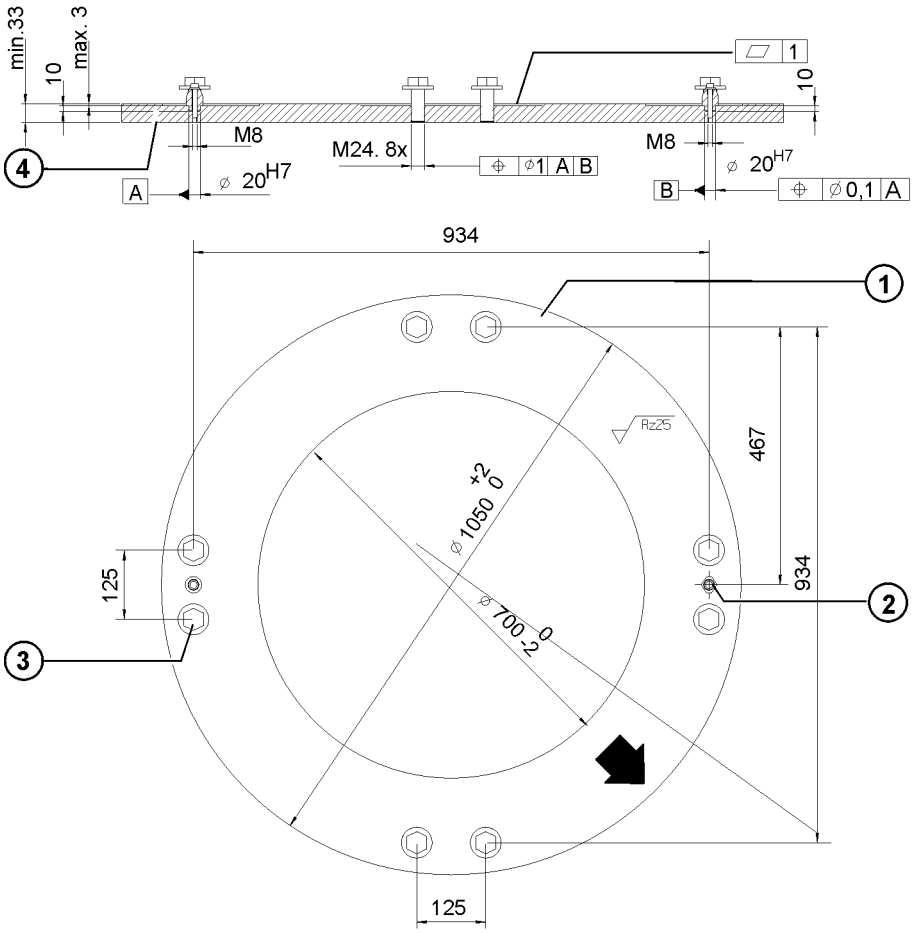


Fig. 6-5: Machine frame mounting, dimensioned drawing

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

6.3 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 - X30
- Data cable X21 - X31
- Ground conductor (order as an option)

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.

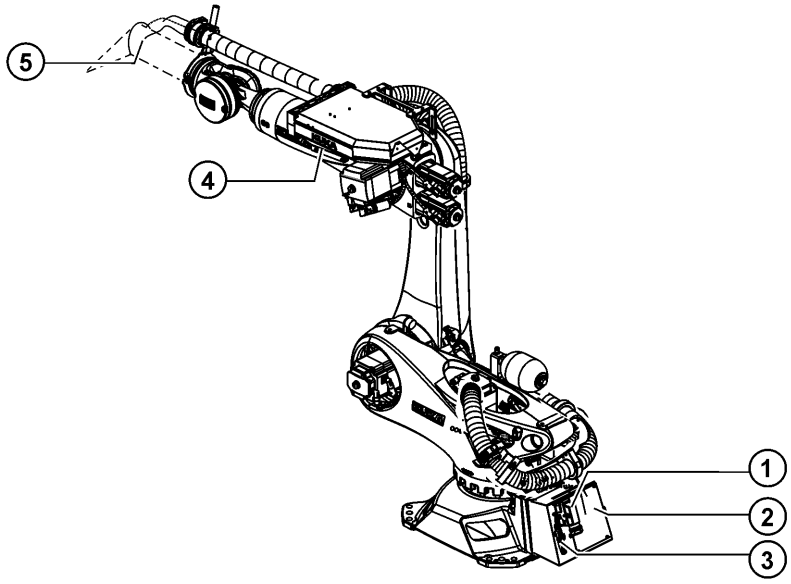


Fig. 6-6: Interfaces on the robot

1	Connection, motor cable X30	4	Interface, axis 3, arm
2	Interface, axis 1, base frame	5	Interface, axis 6, tool
3	Connection, data cable, X31		

7 Transportation

7.1 Transporting the robot

Before transporting the robot, always move the robot into its transport position. It must be ensured that the robot is stable while it is being transported. The robot must remain in its transport position until it has been fastened in position. Before the robot is lifted, it must be ensured that it is free from obstructions. Remove all transport safeguards, such as nails and screws, in advance. First remove any rust or glue on contact surfaces.

Transport position

The 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
Transport position	0°	-120°	-115°	0°	+120°	0°

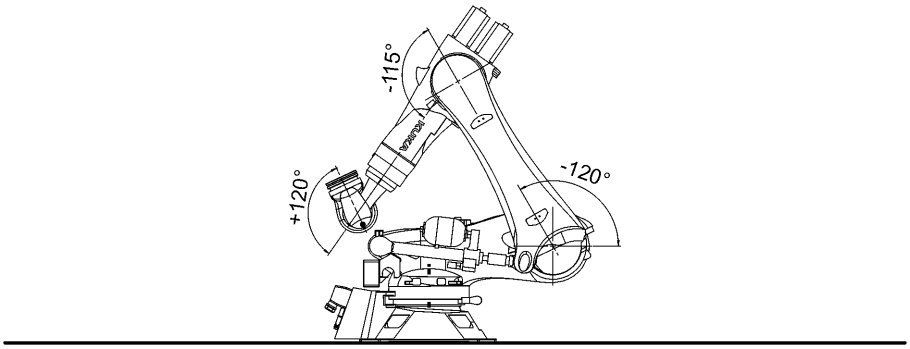


Fig. 7-1: Transport position

Transport dimensions

The transport dimensions (>>> Fig. 7-2) for the robot can be noted from the following diagram. The position of the center of gravity and the weight vary according to the specific configuration and the position of axes 2 and 3. The specified dimensions refer to the robot without equipment.

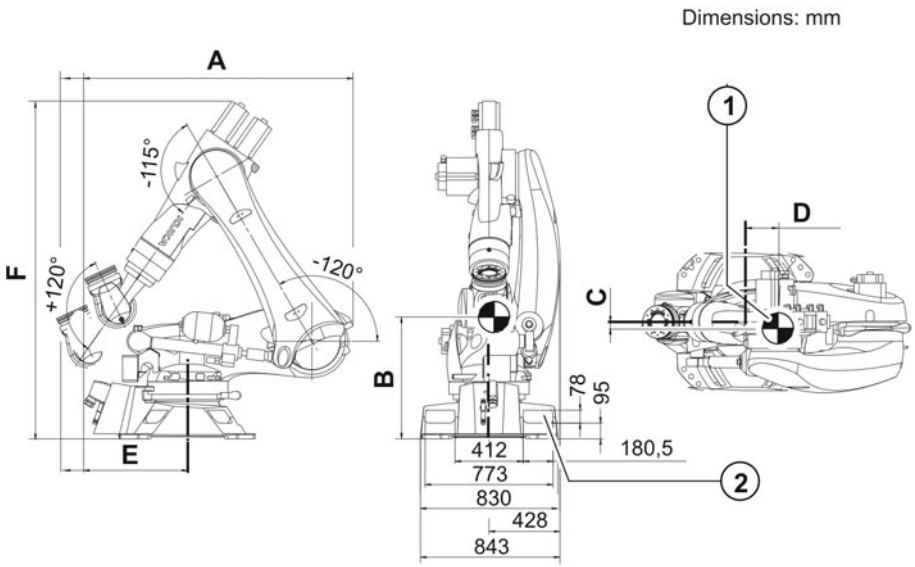


Fig. 7-2: Transport dimensions

1 Center of gravity
2 Fork slots

Transport dimensions and centers of gravity

Robot with reach	A	B	C	D	E	F
R2900	1628	737	41	190	630	2042
R3100	1701	722	43	187	703	2042
R3300	1801	778	46	165	803	2215
R3500	1916	766	46	151	918	2215
R3700	2031	766	45	140	1032	2215

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 2.0 t and an adequate fork length.

For installation situations in which the fork slots are not accessible, the “Recovery aid” accessory is available. With this device, the robot can also be transported using the 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.

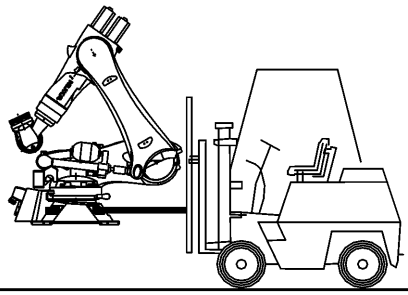


Fig. 7-3: Transportation by fork lift truck

Transportation with lifting tackle

The robot can also be transported using lifting tackle (>>> Fig. 7-4). The robot must be in the transport position. The lifting tackle is attached at 3 points to M16 DIN 580 eyebolts. All the legs must be routed as shown in the following illustration so that the robot is not damaged. Installed tools and items of equipment can cause undesirable shifts in the center of gravity. Items of equipment, especially energy supply systems, must be removed to the extent necessary to avoid them being damaged by the legs of the lifting tackle during transportation.

All the legs are labeled.

⚠ 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!

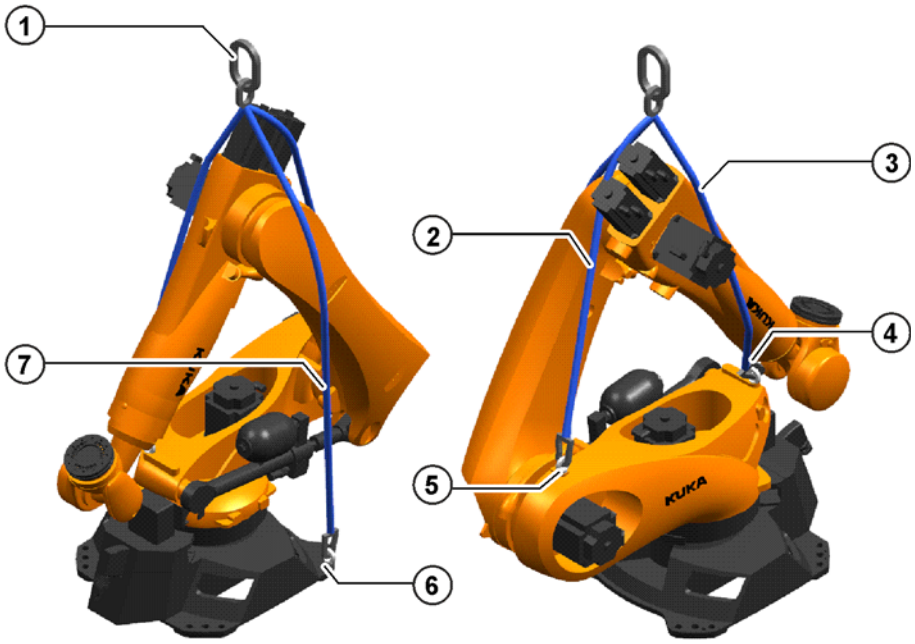


Fig. 7-4: Transportation using lifting tackle

1 Lifting tackle assembly
2 Leg G2
3 Leg G1
4 M16 eyebolt, rotating column, rear
5 M16 eyebolt, rotating column, front
6 M16 eyebolt, base frame, front, right
7 Leg G3

8 Start-up and recommissioning

8.1 Installation of the mounting base

Description

These instructions apply to the “mounting base with centering” variant. 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 a Dynamic Set and resin-bonded anchors, use only components and resin capsules from the same manufacturer. No diamond tools or core drills may be used for drilling the anchor holes; for preference, drilling tools supplied by the anchor manufacturer are to be used. Observe also the manufacturer’s instructions for the use of resin-bonded anchors.

Preconditions

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

Special tools

The following special tools are required:

- Drill with a ø 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 two M24x65-8.8-A2K hexagon bolts and lock 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 mounting base in relation to the working envelope.
4. Set the robot down on the mounting base in its installation position.
5. Align the robot horizontally. For this, an M20 thread is provided in each bedplate.

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. Only if leveling compound is used.

   Allow the leveling compound to cure for about 3 hours. The curing time is longer at temperatures below 293 K (+20 °C).
7. Drill 12 anchor holes (>>> Fig. 8-1) (5) through the holes of the bedplates into the foundation.
8. Clean the anchor holes.
9. Insert 12 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 cor-

rectly if the resin is completely mixed and the anchor hole in the concrete is completely filled to the upper edge.

Maße / Dimensions: mm

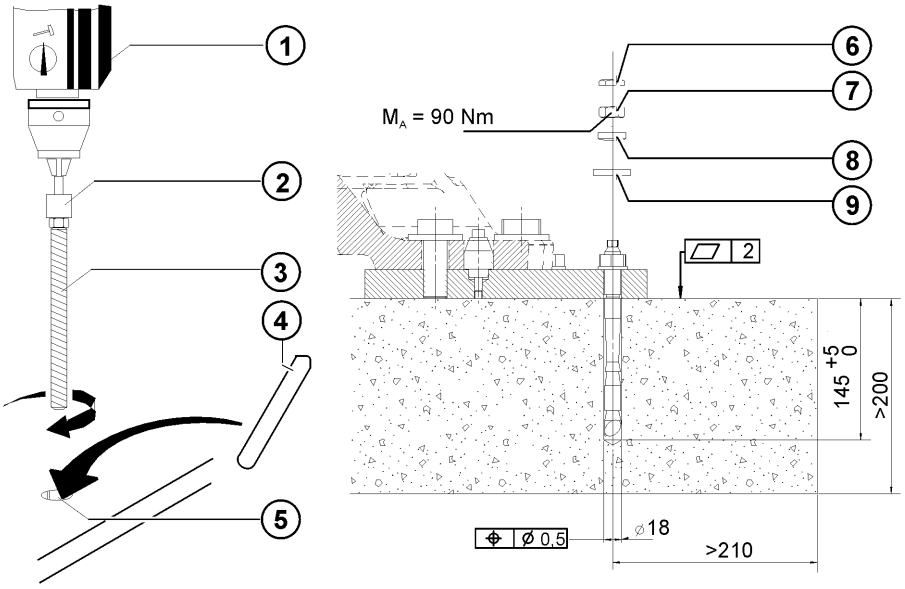


Fig. 8-1: Installation of resin-bonded anchors

1	Drill	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. Carry out the following steps 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 and robot are now ready for connection of the robot.

8.2 Installation of the machine frame mounting assembly

Description

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

Preconditions

- The mounting surface is prepared as shown in the diagram (>>> Fig. 6-5).
- The substructure is checked for sufficient safety.
- The machine frame mounting assembly is complete.

Procedure

1. Clean the mounting surface (>>> Fig. 8-2) of the robot.
2. Check the hole pattern.
3. Insert 2 pins and 2 M8x55-8.8 Allen screws with conical spring washers and tighten with a torque wrench; M_A = 23.9 Nm.
4. Prepare 8 M24x65-8.8-A2K hexagon bolts and conical spring washers.

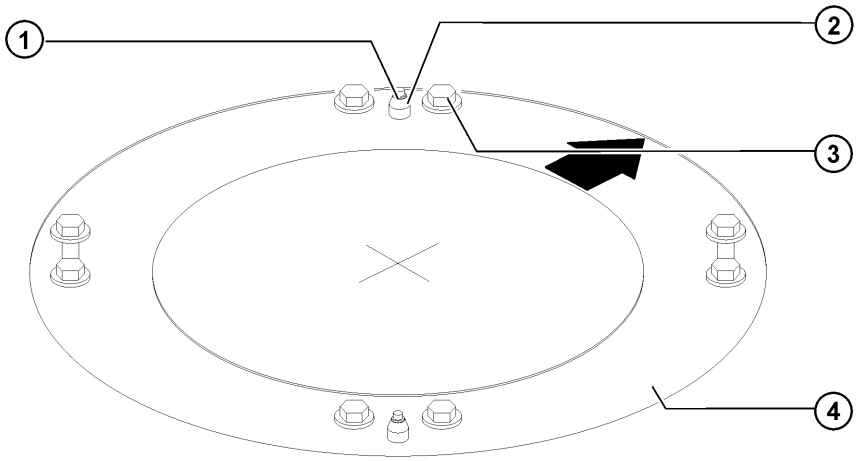


Fig. 8-2: Installing the machine frame mounting assembly

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

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

8.3 Installing the robot

Description

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

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 both pins (>>> Fig. 8-3) are undamaged and fitted securely.
2. Bring the robot to the installation site by crane or fork lift truck.
   The lifting tackle must not damage the robot.
3. Clean the mounting surface on the robot.
4. Lower the robot vertically onto the mounting base. Ensure that an entirely vertical position is maintained in order to prevent damage to the pins.
5. Insert 8 M24x65-8.8 hexagon bolts with conical spring washers.

6. Tighten the hexagon bolts with torque wrench. Gradually increase the tightening torque to 640 Nm.
7. Remove the lifting tackle and eyebolts or the fork slots.
8. Connect motor cable X30 and data 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. Connect compressed air supply to the pressure regulator and set the pressure regulator to zero; F variant only.
13. Open compressed air supply and set pressure regulator to 0.01 MPa (0.1 bar); F variant only.
14. Mount tooling, if required.
15. Retighten the hexagon bolts with a torque wrench after 100 hours of operation.

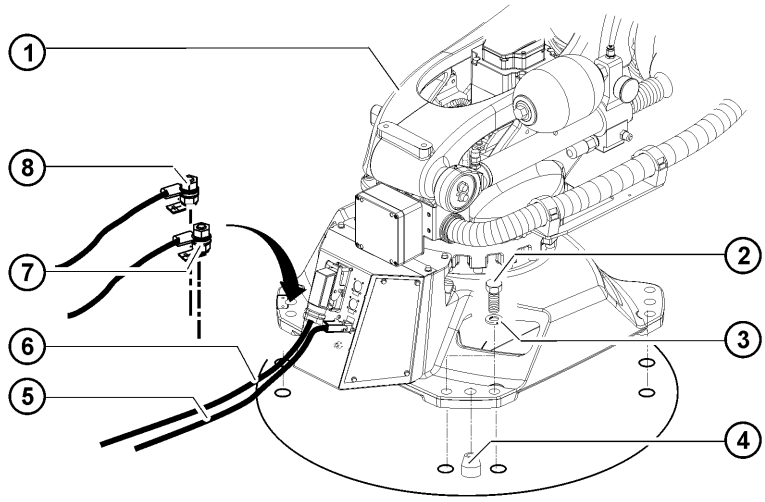


Fig. 8-3: Installing the robot

1	Rotating column	5	Data cable
2	Hexagon bolts	6	Motor cable
3	Conical spring washers	7	Ground conductor connection, system
4	Pin	8	Ground conductor connection, controller

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.

8.4 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
- Data cable
- Ground conductor (order as an option)

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 - X30	HAN size 24
Data cable	X21 - X31	Rectangular connector
Ground conductor / equi-potential bonding 16 mm^2 can be ordered as an option		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

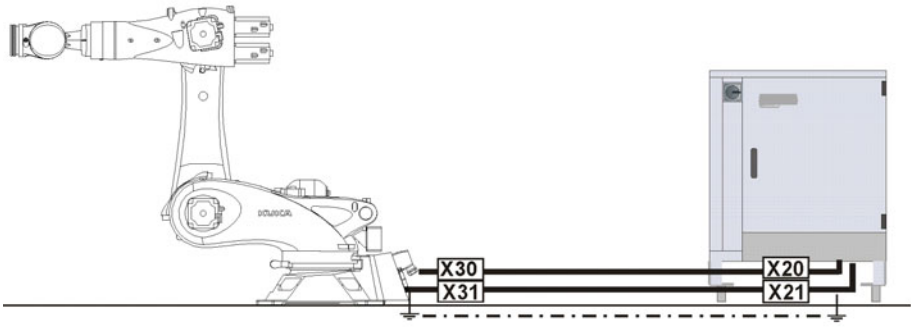


Fig. 8-4: Connecting cables, overview

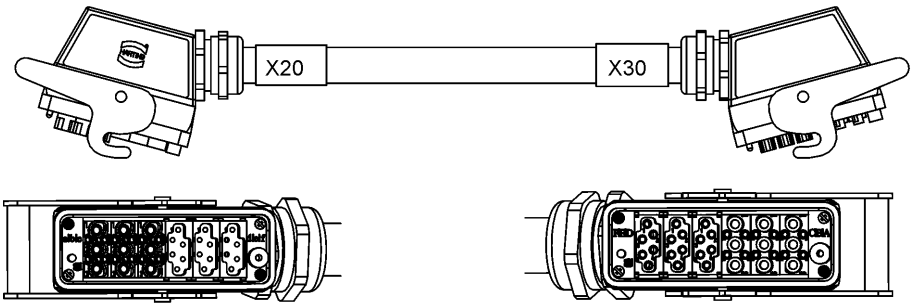


Fig. 8-5: Connecting cable, motor cable, X20 - X30

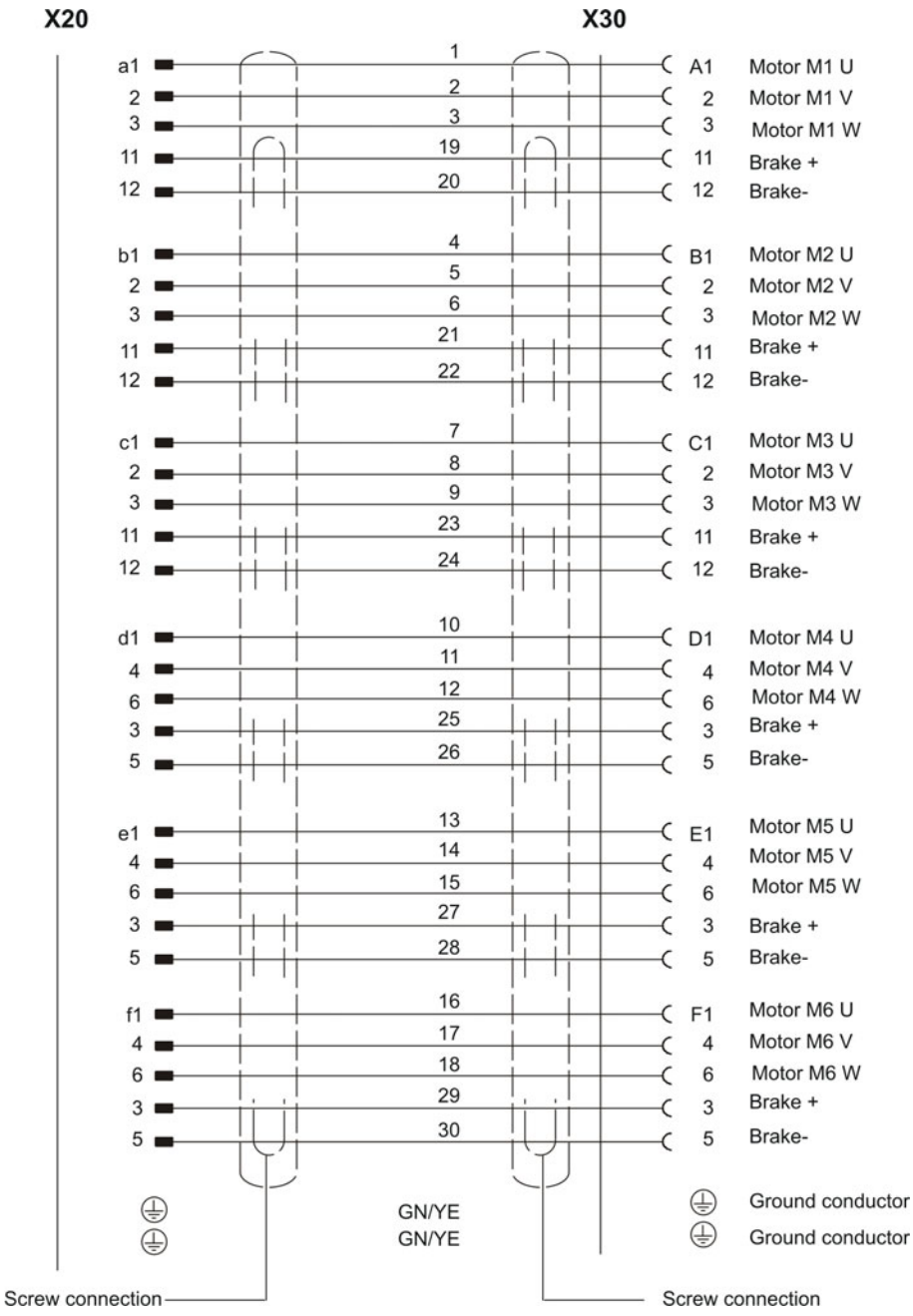


Fig. 8-6: Connecting cable, wiring diagram, motor cable

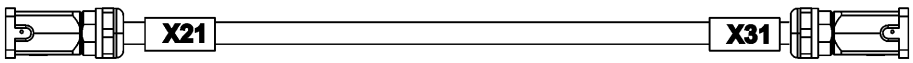


Fig. 8-7: Connecting cable, data cable X21 - X31

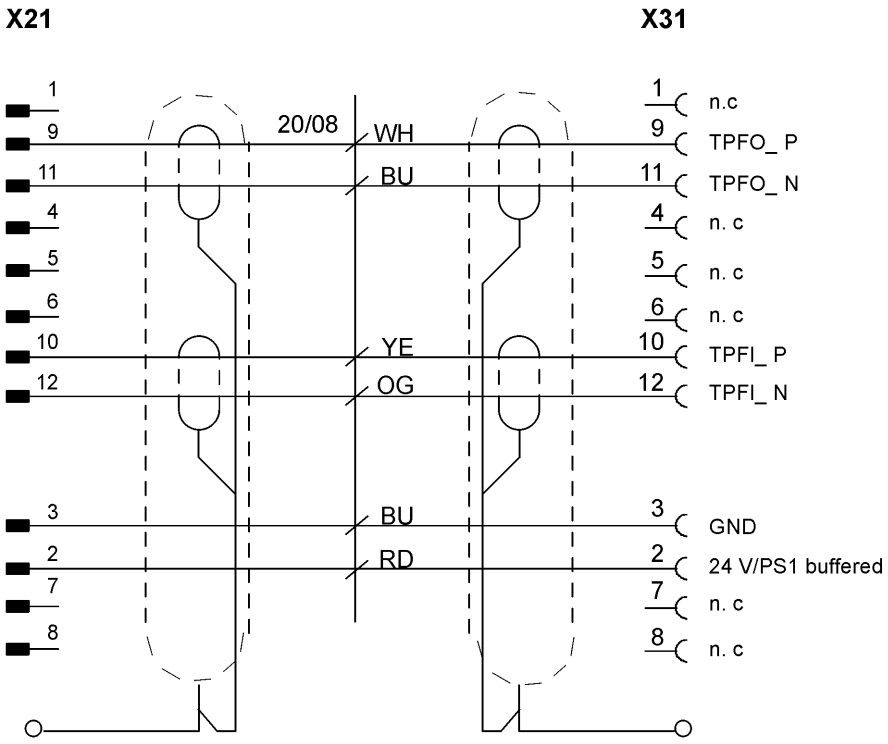


Fig. 8-8: Connecting cable, wiring diagram, data cable X21 - X31

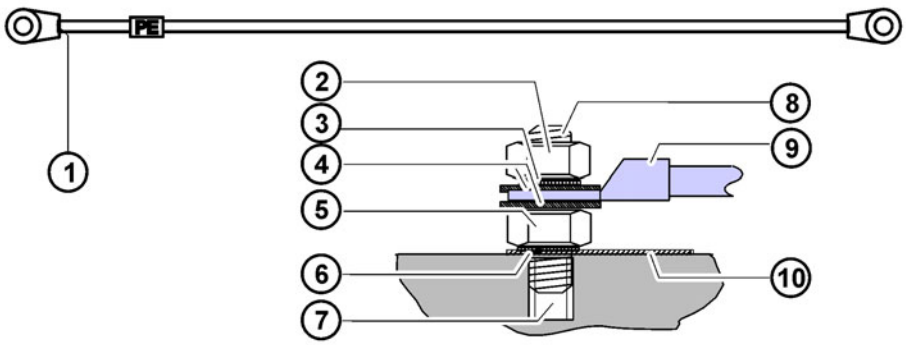


Fig. 8-9: Connecting cable, ground conductor

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

8.5 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. 8-10).
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.

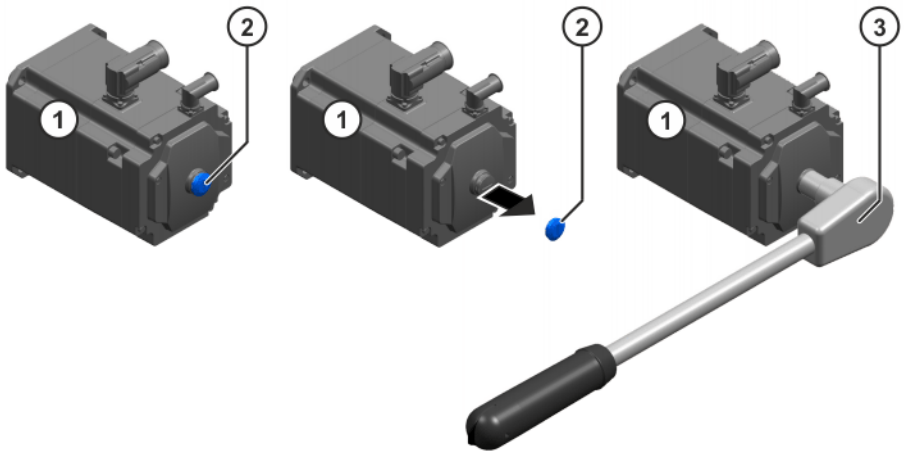


Fig. 8-10: Fitting the release device onto the motor

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 table

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.

Description

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

The maintenance intervals given in the tables are valid for the operating conditions specified in the technical data (>>> 4 "Technical data" Page 17). In case of variations from normal conditions (e.g. increased dust or water content in the environment of the robot, abnormal temperatures), KUKA Roboter GmbH must be consulted. Special maintenance intervals apply for F variant robots.

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.

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.

Maintenance symbols

 Oil change

 Lubricate with grease gun

Lubricate with brush

Tighten screw/nut

Check component, visual inspection

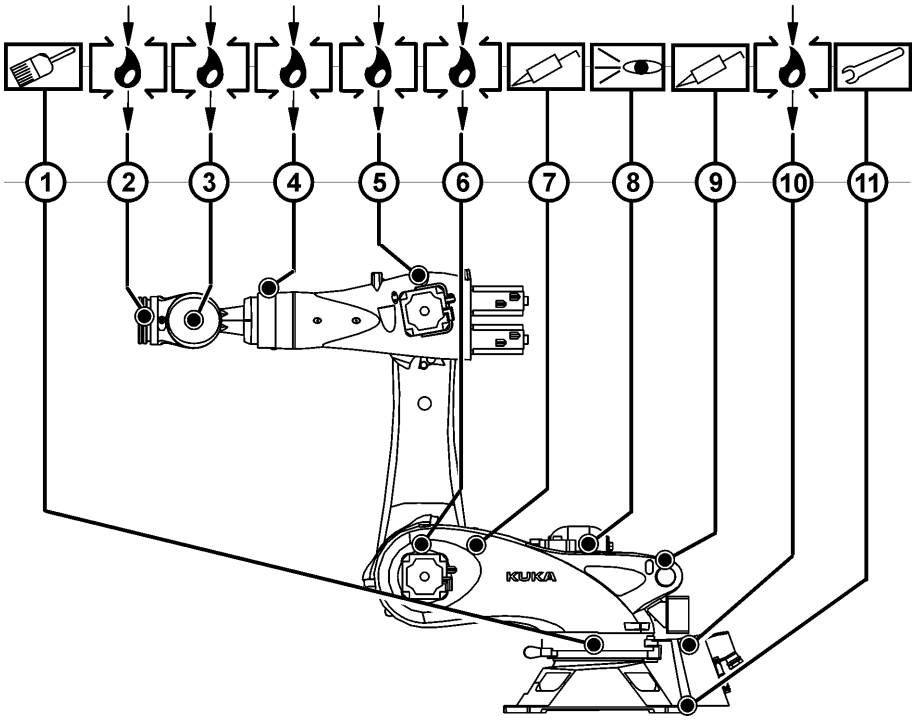


Fig. 9-1: Maintenance work

Maintenance table, payload range 90 kg to 180 kg

Interval	Item	Activity	Lubricant
Once only, after 100 h	11	Check bolts M_A 640 Nm	
5,000 h or 1 year at the latest 1)	7	Counterbalancing system bearing, link arm, lubricate. Grease nipples in the middle position and at the plus and minus end positions of axis 2.	SKF LGEP 2 Art. no. 00-119-990 10 cm³
5,000 h or 1 year at the latest 1)	9	Counterbalancing system bearing, rotating column, lubricate. Grease nipples in the middle position and at the plus and minus end positions of axis 2.	SKF LGEP 2 Art. no. 00-119-990 10 cm³
5,000 h	8	Counterbalancing system, check pressure Setpoint, tolerance -5 bar	Hyspin ZZ 46 Art. no. 83-236-202

Interval	Item	Activity	Lubricant
10,000 h	1	Grease cables of cable set and energy supply system. (>>> 9.8 "Greasing the cable set" Page 108)	Cable grease RB1 00-101-456 200 cm³
20,000 h or 5 years at the latest	2	Oil change, gear unit A6. (>>> 9.7 "Changing the gear oil on axis 6" Page 107)	Optigear Synthetic RO 150 Art. no. 00-144-898 1.000 l
20,000 h or 5 years at the latest	3	Oil change, gear unit A5. (>>> 9.6 "Changing the gear oil on axis 5" Page 106)	Optigear Synthetic RO 150 Art. no. 00-144-898 0.900 l
20,000 h or 5 years at the latest	4	Oil change, gear unit A4. (>>> 9.5 "Changing the gear oil on axis 4" Page 105)	Optigear Synthetic RO 150 Art. no. 00-144-898 2.100 l
20,000 h or 5 years at the latest	5	Oil change, gear unit A3.	Optigear Synthetic RO 150 Art. no. 00-144-898 1.800 l
20,000 h or 5 years at the latest	6	Oil change, gear unit A2. (>>> 9.3 "Changing the gear oil on axis 2" Page 102)	Optigear Synthetic RO 150 Art. no. 00-144-898 2.900 l
20,000 h or 5 years at the latest	10	Oil change, gear unit A1. (>>> 9.2 "Changing the gear oil on axis 1" Page 100)	Optigear Synthetic RO 150 Art. no. 00-144-898 6.500 l

1) In the case of frequently recurring, short-distance movements, the maintenance interval is 3000 hours.

Maintenance table, payload range 210 kg

Interval	Item	Activity	Lubricant
Once only, after 100 h	11	Check bolts M_A 640 Nm	
5,000 h or 1 year at the latest 1)	7	Counterbalancing system bearing, link arm, lubricate. Grease nipples in the middle position and at the plus and minus end positions of axis 2.	SKF LGEP 2 Art. no. 00-119-990 10 cm³
5,000 h or 1 year at the latest 1)	9	Counterbalancing system bearing, rotating column, lubricate. Grease nipples in the middle position and at the plus and minus end positions of axis 2.	SKF LGEP 2 Art. no. 00-119-990 10 cm³

Interval	Item	Activity	Lubricant
5,000 h	8	Counterbalancing system, check pressure Setpoint, tolerance -5 bar	Hyspin ZZ 46 Art. no. 83-236-202
10,000 h	1	Grease cables of cable set and energy supply system. (>>> 9.8 "Greasing the cable set" Page 108)	Cable grease RB1 00-101-456 200 cm³
20,000 h or 5 years at the latest	2	Oil change, gear unit A6. (>>> 9.7 "Changing the gear oil on axis 6" Page 107)	Optigear Synthetic RO 150 Art. no. 00-144-898 1.200 l
20,000 h or 5 years at the latest	3	Oil change, gear unit A5. (>>> 9.6 "Changing the gear oil on axis 5" Page 106)	Optigear Synthetic RO 150 Art. no. 00-144-898 1.100 l
20,000 h or 5 years at the latest	4	Oil change, gear unit A4. (>>> 9.5 "Changing the gear oil on axis 4" Page 105)	Optigear Synthetic RO 150 Art. no. 00-144-898 2.100 l
20,000 h or 5 years at the latest	5	Oil change, gear unit A3. (>>> 9.4 "Changing the gear oil on axis 3" Page 103)	Optigear Synthetic RO 150 Art. no. 00-144-898 1.800 l
20,000 h or 5 years at the latest	6	Oil change, gear unit A2. (>>> 9.3 "Changing the gear oil on axis 2" Page 102)	Optigear Synthetic RO 150 Art. no. 00-144-898 2.900 l
20,000 h or 5 years at the latest	10	Oil change, gear unit A1. (>>> 9.2 "Changing the gear oil on axis 1" Page 100)	Optigear Synthetic RO 150 Art. no. 00-144-898 6.500 l

1) In the case of frequently recurring, short-distance movements, the maintenance interval is 3000 hours.

The description of the following oil change work applies to all robot variants, irrespective of the variant shown.

9.2 Changing the gear oil on axis 1

Preconditions

- 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.

Procedure, draining oil

1. Remove 4 Allen screws with conical spring washers, and take off interface A1 or cover (>>> Fig. 9-2).
2. Pull out the oil drain hose.
3. Place a suitable receptacle under the oil drain hose.
4. Unscrew the union nut of the oil drain hose.
5. Remove the magnetic screw plug.
6. Drain the oil.
7. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
8. Check the magnetic screw plug for deposits; take appropriate measures if necessary.

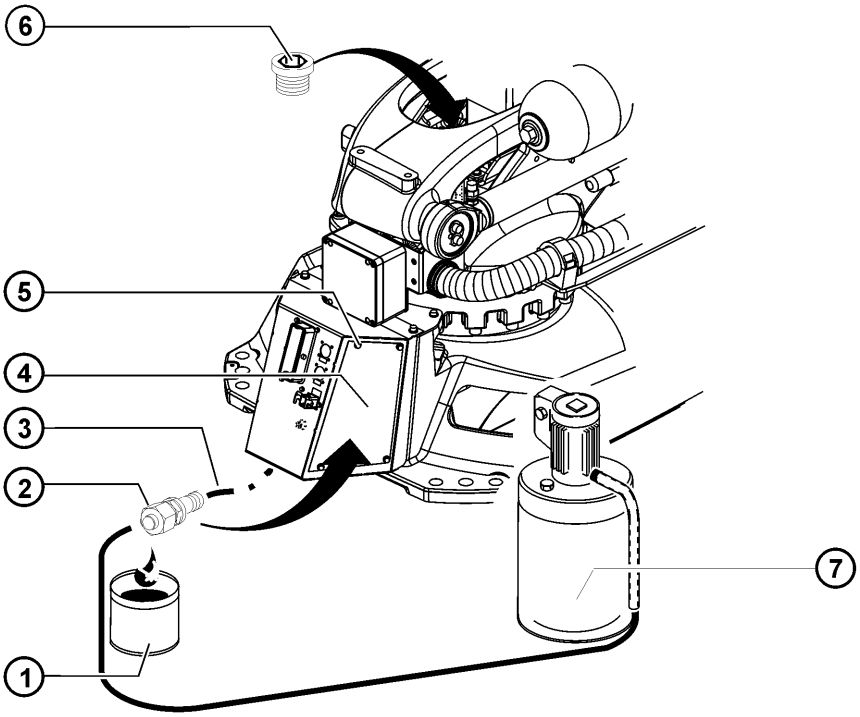


Fig. 9-2: Oil change, A1

1	Receptacle	5	Allen screws
2	Sealing cap	6	Magnetic screw plug
3	Oil drain hose	7	Oil pump
4	Cover		

Procedure, filling with oil

1. Fill the specified amount of oil from below via the oil drain hose using the oil pump.
2. Screw the sealing cap onto the oil drain hose.
3. Clean the magnetic screw plug and check the sealing element; exchange the magnetic screw plug if damaged.
4. Insert and tighten the magnetic screw plug; M_A = 25 Nm.

5. Check the sealing cap for leaks.
6. Stow the oil drain hose in the base frame.
7. Mount interface A1 or cover and fasten it with 4x M6x16 Allen screws and conical spring washers.

9.3 Changing the gear oil on axis 2

Preconditions

- The robot is in a position in which the oil filler and drain holes on the axis 2 gear unit are 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.

Procedure, draining oil

1. Pull the oil drain hose (>>> Fig. 9-3) out of the rotating column.
2. Release and unscrew the sealing cap.
3. Place a suitable receptacle under the oil drain hose and remove the magnetic screw plug.
4. Catch the oil in the receptacle as it drains out.
5. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
6. Check the magnetic screw plug for deposits; take appropriate measures if necessary.

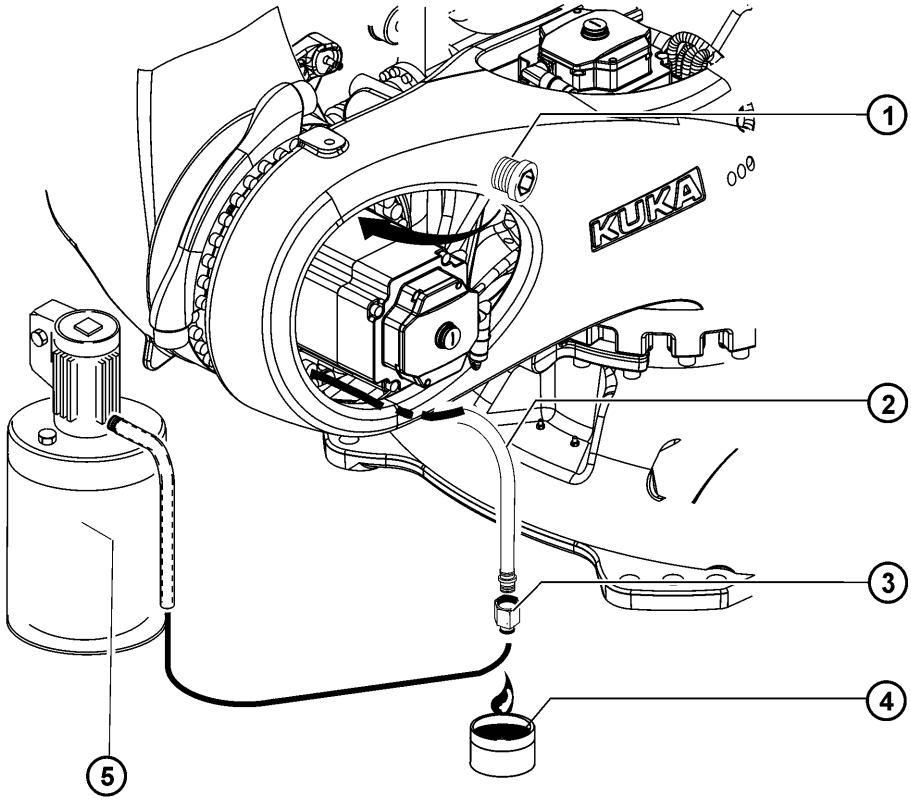


Fig. 9-3: Oil change, A2

1	Magnetic screw plug	4	Receptacle
2	Oil drain hose	5	Oil pump
3	Sealing cap		

Procedure, filling with oil

1. Fill the same amount of oil as was drained, from below via the oil drain hose, using the oil pump.
2. Screw on the the sealing cap and tighten it.
3. Clean the M18x1.5 magnetic screw plug and check the sealing element; exchange the magnetic screw plug if damaged.
4. Insert and tighten the M18x1.5 magnetic screw plug; M_A = 20 Nm.
5. Check the magnetic screw plug and sealing cap for leaks.

9.4 Changing the gear oil on axis 3

Preconditions

- The robot is in a position in which the oil filler and drain holes on the axis 3 gear unit are 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.

Procedure, draining oil

1. Place a suitable receptacle (>>> Fig. 9-4) under the (lower) magnetic screw plug and remove the magnetic screw plug.
   It is easier to drain the oil if an M16x1.5 oil drain hose is screwed into the tapped hole of the magnetic screw plug.
2. Remove the (upper) magnetic screw plug.
3. Catch the oil in the receptacle as it drains out.
4. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
5. Check the magnetic screw plugs for deposits; take appropriate measures if necessary.

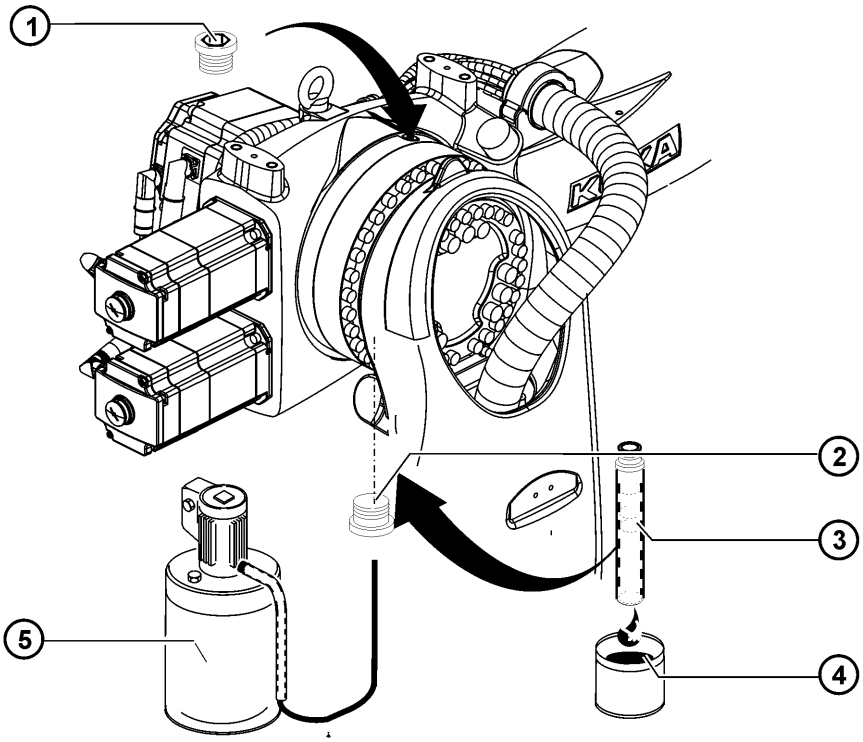


Fig. 9-4: Oil change, A3

1	Magnetic screw plug	4	Receptacle
2	Magnetic screw plug	5	Oil pump
3	Oil drain hose		

Procedure, filling with oil

1. Fill the same amount of oil as was drained, from below via the oil drain hose, using the oil pump.
2. Clean the M16x1.5 magnetic screw plug (top) and check the sealing element; exchange the magnetic screw plug if damaged.
3. Insert and tighten the (upper) M16x1.5 magnetic screw plug; M_A = 20 Nm.
4. Remove the oil drain hose.
5. Clean the M16x1.5 magnetic screw plug (bottom) and check the sealing element; exchange the magnetic screw plug if damaged.
6. Insert and tighten the (lower) M16x1.5 magnetic screw plug; M_A = 20 Nm.

7. Check both magnetic screw plugs for leaks.

9.5 Changing the gear oil on axis 4

Preconditions

- 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.

Procedure, draining oil

1. Place a suitable receptacle (>>> 9.5 "Changing the gear oil on axis 4" Page 105) under the (lower) magnetic screw plug and remove the magnetic screw plug.
   It is easier to drain the oil if an M18x1.5 oil drain hose is screwed into the tapped hole of the magnetic screw plug.
2. Remove the (upper) magnetic screw plug.
3. Catch the oil in the receptacle as it drains out.
4. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
5. Check the magnetic screw plug for deposits; take appropriate measures if necessary.
6. Remove the oil drain hose if necessary.

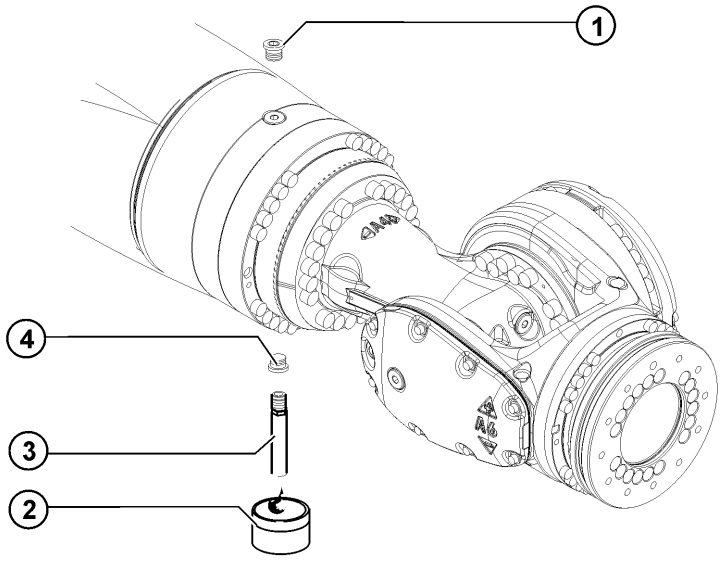


Fig. 9-5: Oil change, A4

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

Procedure, filling with oil

1. Clean both M18x1.5 magnetic screw plugs and check the sealing element; exchange magnetic screw plugs if damaged.

2. Insert and tighten the (lower) M18x1.5 magnetic screw plug; M_A = 20 Nm.
3. Pour in, from above, the same amount of oil as was drained.
4. Insert and tighten the (upper) M18x1.5 magnetic screw plug; M_A = 20 Nm.
5. Check both magnetic screw plugs for leaks.

9.6 Changing the gear oil on axis 5

Preconditions

- 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 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, draining oil

1. Put the robot into operation, move axis 4 to the +90° position and axis 5 to the +45° position, and then secure the robot.
2. Place a suitable receptacle (>>> Fig. 9-6) under the (lower) magnetic screw plug and remove the magnetic screw plug.
   It is easier to drain the oil if an M18x1.5 oil drain hose is screwed into the tapped hole of the magnetic screw plug.
3. Remove the magnetic screw plug (on the side).
4. Catch the oil in the receptacle as it drains out.
5. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
6. Remove the oil drain hose if necessary.
7. Check the magnetic screw plugs for deposits; take appropriate measures if necessary.
8. Clean both M18x1.5 magnetic screw plugs and check the sealing element; exchange magnetic screw plugs if damaged.
9. Insert and tighten the M18x1.5 magnetic screw plug (on the side); M_A = 20 Nm.
10. Put the robot into operation, move axis 4 to the -90° position and axis 5 to the 0° position, and then secure the robot by activating the EMERGENCY STOP device.

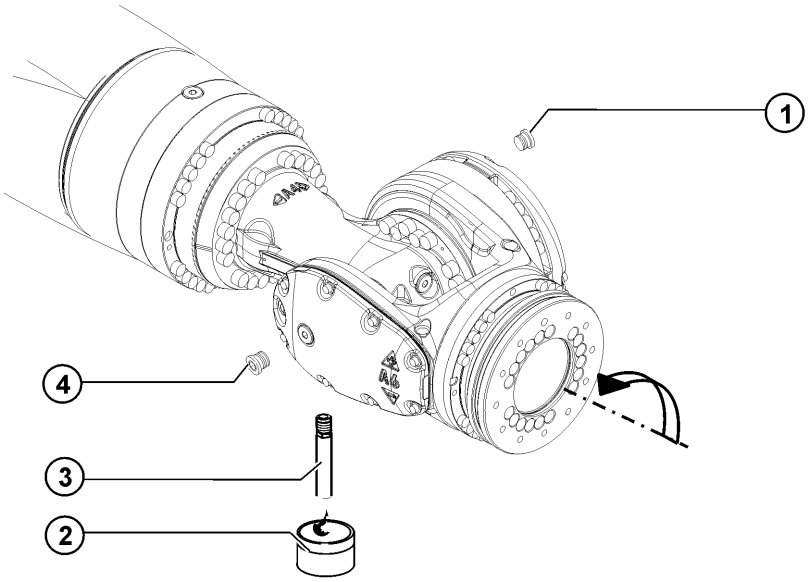


Fig. 9-6: Oil change, A5

1	Magnetic screw plug	3	Oil drain hose
2	Receptacle	4	Magnetic screw plug, side

Procedure, filling with oil

1. Pour in, from above, the same amount of oil as was drained.
2. Insert and tighten the (upper) M18x1.5 magnetic screw plug; M_A = 20 Nm.
3. Check both magnetic screw plugs for leaks.

9.7 Changing the gear oil on axis 6

Preconditions

- 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 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, draining oil

1. Put the robot into operation, move axis 4 to the -90° position, and then secure the robot.
2. Place a suitable receptacle (>>> Fig. 9-7) under the (lower) magnetic screw plug and remove the magnetic screw plug.
   It is easier to drain the oil if an M18x1.5 oil drain hose is screwed into the tapped hole of the magnetic screw plug.
3. Remove the (upper) magnetic screw plug.
4. Catch the oil in the receptacle as it drains out.

5. Measure the amount of oil drained and store or dispose of the used oil in accordance with the pertinent regulations.
6. Remove the oil drain hose if necessary.
7. Check the magnetic screw plug for deposits; take appropriate measures if necessary.
8. Clean both M18x1.5 magnetic screw plugs and check the sealing element; exchange magnetic screw plugs if damaged.
9. Insert and tighten the M18x1.5 magnetic screw plug (on the side); M_A = 20 Nm.
10. Put the robot into operation, move axis 4 to the +90° position, and then secure the robot.

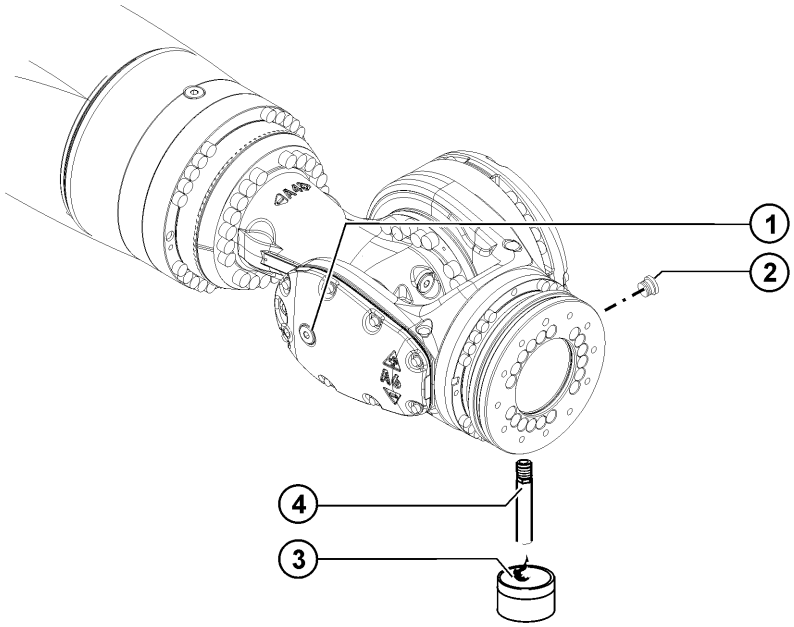


Fig. 9-7: Oil change, A6

1	Magnetic screw plug	3	Receptacle
2	Upper magnetic screw plug	4	Oil drain hose

Procedure, filling with oil

1. Pour in, from above, the same amount of oil as was drained.
2. Insert and tighten the (upper) M18x1.5 magnetic screw plug; M_A = 20 Nm.
3. Check both magnetic screw plugs for leaks.

9.8 Greasing the cable set

Preconditions

- 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.

Greasing the cable set

1. Remove 4 Allen screws with conical spring washers, and take off the cover. If necessary, interface A1 can additionally be carefully pulled back (>>> Fig. 9-8).
2. Clean the cables between the push-in module and the inlet of the hollow shaft of axis 1.
3. Apply cable grease evenly to the cables using a brush and by hand.

Protective gloves must be worn.

4. Store used grease and grease residues in accordance with the regulations or dispose of it with minimum environmental impact.
5. Mount the cover and fasten it with 4 Allen screws with conical spring washers.
6. If applicable, carefully insert interface A1 again and fasten it with 4 Allen screws and conical spring washers.

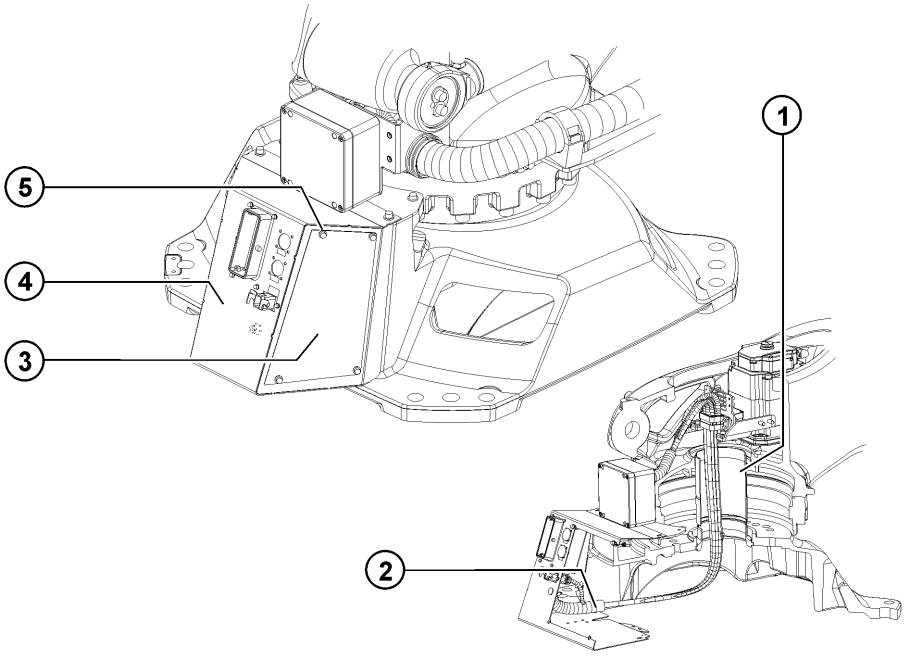


Fig. 9-8: Greasing the cable set

1	Inlet of hollow shaft	4	Interface A1
2	Push-in module, flexible tube	5	Allen screws
3	Cover		

9.9 Inspecting the counterbalancing system

Description

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

Preconditions

- 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.

Inspection procedure

Activity	Required condition	Troubleshooting
Inspect hydraulic system. Move the robot and check the hydraulic oil pressure.	The pressure gauge must show the following value: Link arm in -90° position, hydraulic oil pressure: Floor-mounted robot: 182 bar	Carry out adjustment of the counterbalancing system (>>> 10.3 "Filling and adjusting the counterbalancing system" Page 114).
Check the add-on parts for damage and ensure that they are clean and do not leak.	The add-on parts must not be damaged or leak.	Clean the counterbalancing system, identify and eliminate any leaks. If necessary, exchange the counterbalancing system (>>> 11.7 "Exchanging the counterbalancing system on a floor-mounted robot" Page 135).
Check the condition of the collar.	The collar must not be damaged or fouled.	Clean or exchange the collar (>>> 11.7 "Exchanging the counterbalancing system on a floor-mounted robot" Page 135).

9.10 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 Adjustment

10.1 Counterbalancing system

Description

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

Cause	Activity	Description
The counterbalancing system must be depressurized	Depressurizing the counterbalancing system	(>>> 10.2 "Depressurizing the counterbalancing system" Page 113)
Incorrect pressure	Top up the gas and oil pressure	(>>> 10.3 "Filling and adjusting the counterbalancing system" Page 114)
The counterbalancing system has been drained and must be refilled	Top up the gas and oil pressure	(>>> 10.3 "Filling and adjusting the counterbalancing system" Page 114)

⚠ 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.

10.2 Depressurizing the counterbalancing system

Preconditions

- A measuring tube and collection receptacle must be available.

Procedure

1. Move the link arm into a vertical position and secure it using a crane (>>> Fig. 10-1).
   The link arm must not be able to move after reducing the oil pressure.

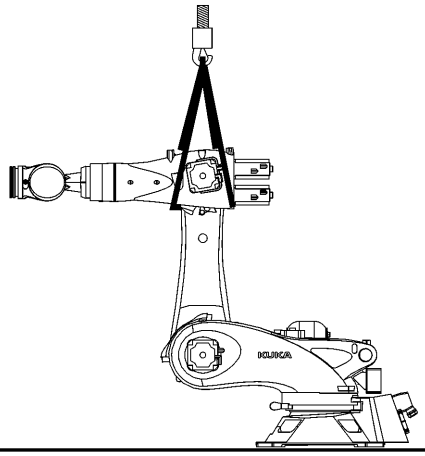


Fig. 10-1: Securing the link arm

2. Remove the screw cap and connect the tube to the vent connection (>>> Fig. 10-2).

3. Drain the hydraulic oil into a suitable receptacle.
   The draining process is complete when the pressure gauge indicating the oil pressure reads zero and no more oil flows into the receptacle.
4. Store used hydraulic oil in accordance with the regulations and dispose of it with minimum environmental impact.

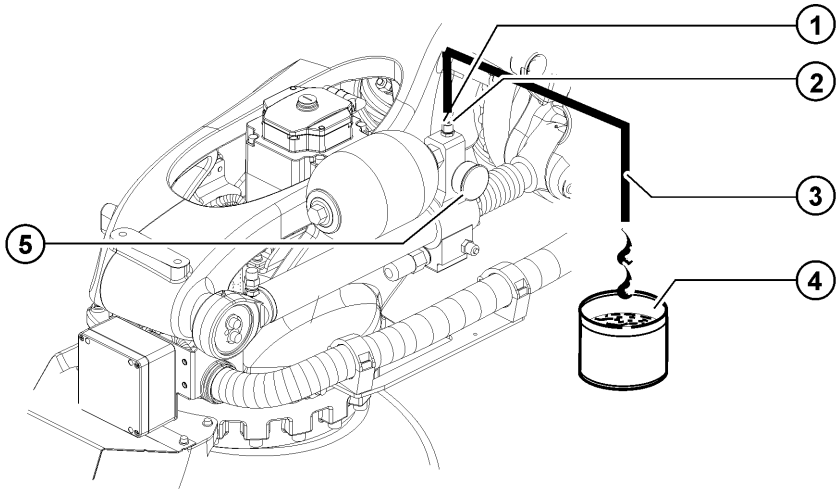


Fig. 10-2: Draining the hydraulic oil

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

10.3 Filling and adjusting the counterbalancing system

Preconditions

- 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.
- The link arm is in the -90° position (vertical).

Procedure

1. Move the link arm into a vertical position and secure it using a crane (>>> Fig. 10-3).
   The link arm must not be able to move after reducing the hydraulic oil pressure.

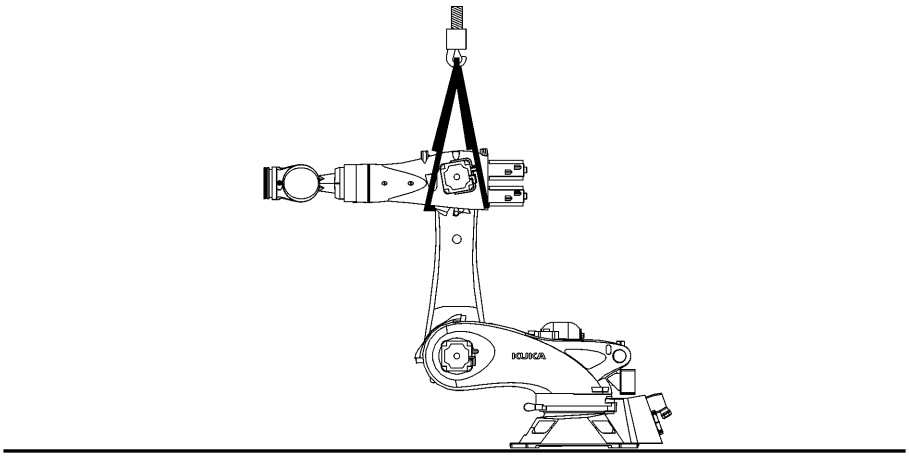


Fig. 10-3: Securing the link arm

2. Remove the screw cap and connect the tube to the vent valve (>>> Fig. 10-5).
3. Place a suitable receptacle under the tube and collect the hydraulic oil.

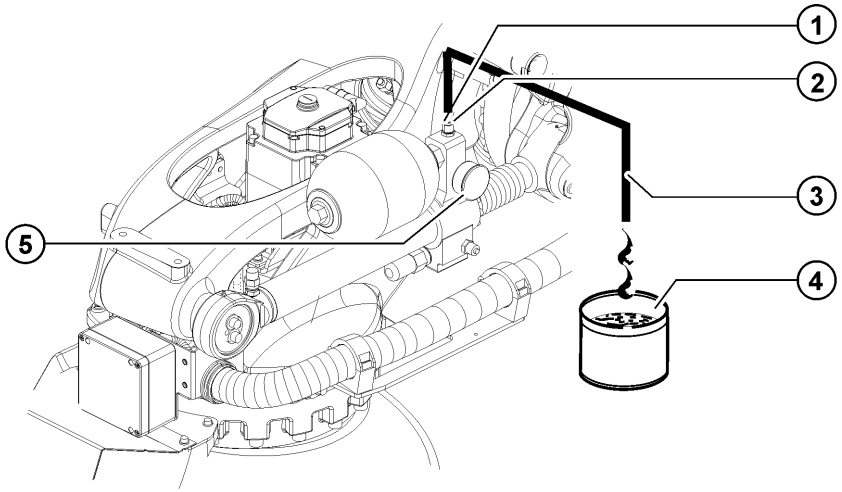


Fig. 10-4: Draining the hydraulic oil

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

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 165 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 (>>> Fig. 10-5) from the diaphragm accumulator and unscrew the Allen screw slightly (without a torque wrench, by a quarter of a turn at the most).

   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 gage on the counterbalancing system indicates the nitrogen pressure in the diaphragm accumulator. If the nitrogen pressure is greater than 162 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 162 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 165 bar.

11. Close the shut-off valve.

12. Open the pressure relief valve and discharge nitrogen until the specified pressure of 162 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.

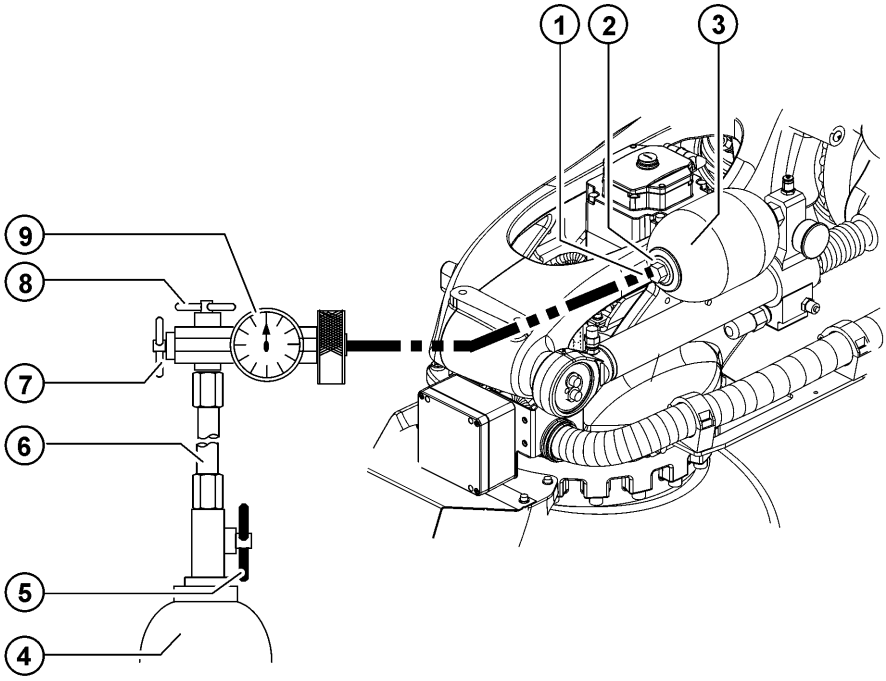


Fig. 10-5: Setting the gas pressure

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

16. Screw on the protective caps.
17. Release and remove the tube on the nitrogen cylinder.
18. Unscrew the screw cap on the filler neck (>>> Fig. 10-6) and connect the hydraulic tube.

    The hydraulic tube must already be free from air.
19. Unscrew the screw cap on the vent connection and connect the measuring tube (unless the tube is still connected from the preceding tasks).
20. Dip the measuring tube into the liquid in the collection receptacle.
21. 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 gage 3 µm).
22. Close the vent valve at the vent connection.
23. Continue to operate the hydraulic pump until the hydraulic oil pressure is approx. 15 bar above the specified value of 182 bar. Then lower the pump pressure to “0”.
24. After approx. 10 minutes, check the hydraulic oil pressure and reduce it to 182 bar by opening the vent valve.
25. Unscrew the hydraulic tube and screw the screw cap back onto the filler neck.
26. Unscrew the measuring tube and screw the screw cap back onto the vent connection.
27. Unscrew the screw plug from the underside of the counterbalancing system and remove any leaked oil; then screw the screw plug back in and tighten with M_A 20 Nm.

28. Check the counterbalancing system for leaks.
29. Remove crane and elements securing the link arm.

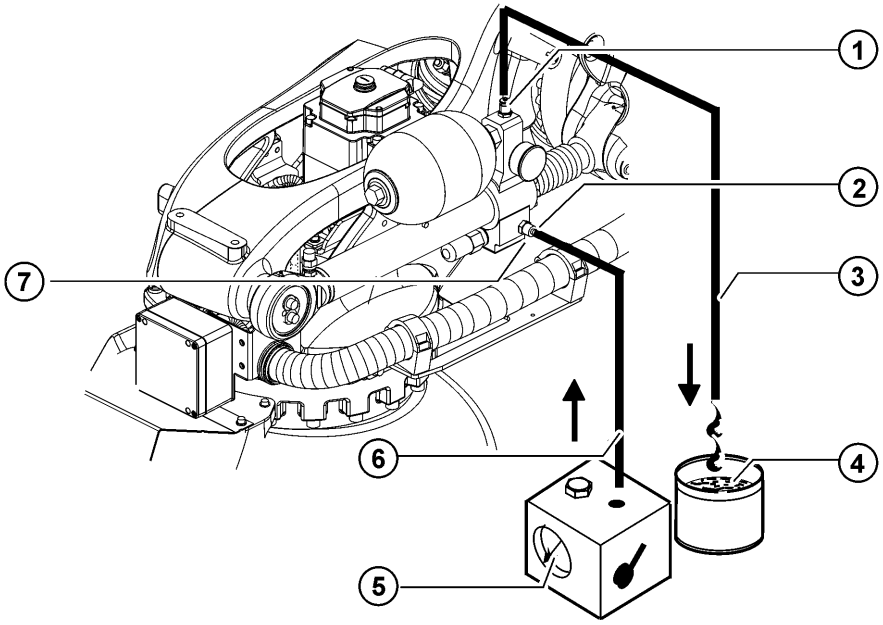


Fig. 10-6: Topping up the hydraulic oil

1	Vent connection	5	Hydraulic pump
2	Filler neck	6	Hydraulic hose
3	Measuring tube	7	Screw plug
4	Receptacle		

11 Repair

NOTICE When installing components and assemblies, the fastening screws (standard, strength class 8.8) must be tightened with the specified KUKA tightening torque. Exceptions to this will be clearly marked.
The specified screw sizes and strength classes are those valid at the copy deadline. The specifications contained in the Parts Catalog are, however, always to be taken as the most up-to-date information.
Screws of strength class 10.9 and higher may only be tightened once with the rated tightening torque. When the screws are next slackened they must be replaced with new ones.

11.1 Exchanging the motor on axis 1

11.1.1 Removing the motor on axis 1

Description

⚠ 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.

Preconditions

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

Procedure for removal

1. Release and unplug connectors XM1 and XP1 at the sockets (>>> Fig. 11-1).
2. Remove 4 Allen screws.
3. Release and lift out motor A1, being careful not to tilt 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 input shaft and protect it against fouling.

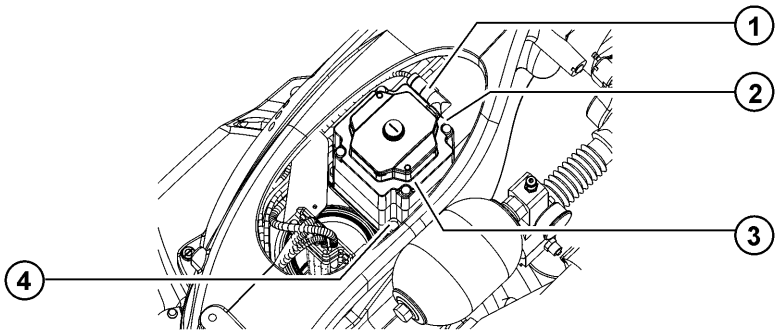


Fig. 11-1: Removing motor A1

1	Connector XP1	3	Motor, axis 1
2	Connector XM1	4	Allen screws

11.1.2 Installing the motor on axis 1

Description

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

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

Procedure for installation

1. Remove all protective coatings and oil from new motor A1, if applicable (>>> Fig. 11-2).
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 motor mount.
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 while it is being installed.

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

8. Insert 4 M12x25-8.8 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.

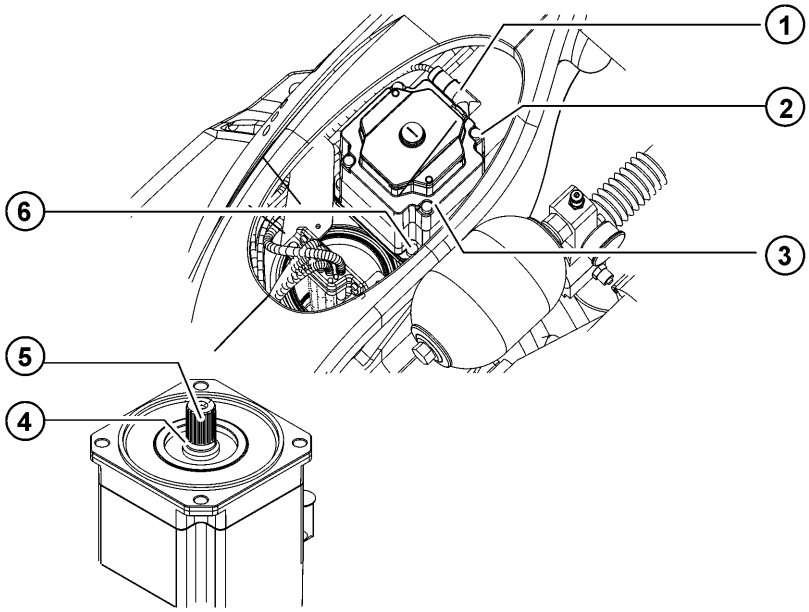


Fig. 11-2: Installing motor A1

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

11.2 Exchanging the motor on axis 2

11.2.1 Removing the motor on axis 2

Description

> **⚠ 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.

Preconditions

- The robot is secured against motion about axis 2.

Procedure for removal

1. Secure the link arm using a rope sling (>>> Fig. 11-3).
2. Raise the rope sling until it is ensured that the link arm cannot move after removal of the motor.

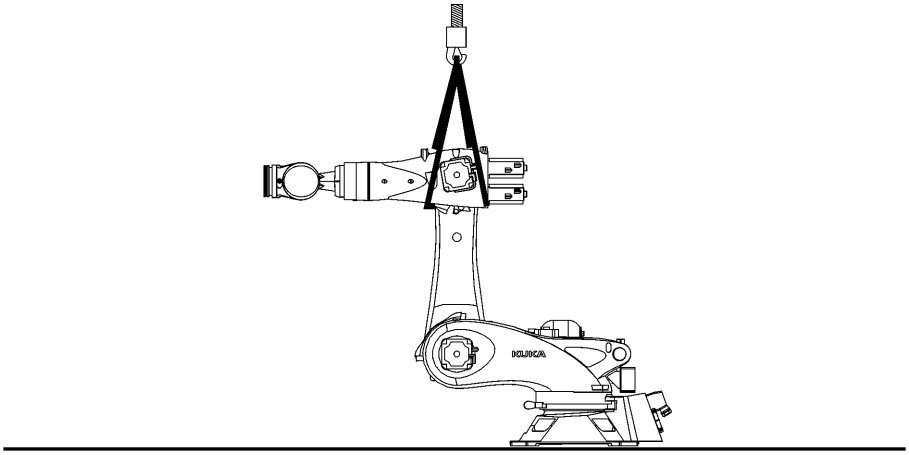


Fig. 11-3: Securing the link arm

3. Release and unplug connectors XM2 and XP2 at the sockets (>>> Fig. 11-4).
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. Release and pull out motor A2, being careful not to tilt it.
7. Remove the seal between the motor and the rotating column; for F variant only.
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.

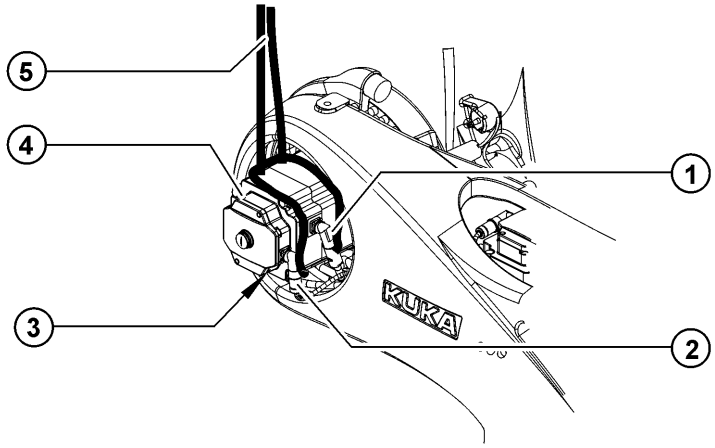


Fig. 11-4: Removing motor A2

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

11.2.2 Installing the motor on axis 2

Description

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

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

Preconditions

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

Procedure for installation

1. Remove all protective coatings and oil from new motor A 2 (>>> Fig. 11-5).
2. Clean the toothing of motor A2 and gear unit before installation and apply a thin but continuous coat of Microlube GL 261 grease.
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. With the rope sling, pick up and insert motor A2, together with the seal (only F variant), being careful not to tilt it.

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

7. Insert 4 M12x25-8.8 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.

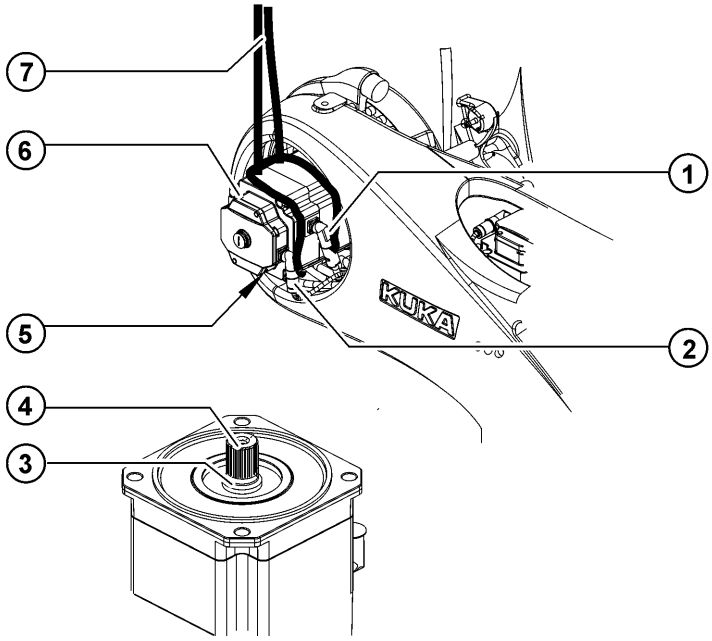


Fig. 11-5: Installing motor A2

1	Connector XM2	5	Allen screws
2	Connector XP2	6	Motor A2

3	O-ring	7	Rope sling
4	Toothing		

11.3 Exchanging the motor on axis 3

11.3.1 Removing the motor on axis 3

Description

⚠ 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.

Preconditions

- The robot is secured against motion about axis 3.

Procedure for removal

1. Secure the arm using a rope sling (>>> Fig. 11-6).
2. Raise the rope sling until it is ensured that the arm cannot move after removal of the motor.

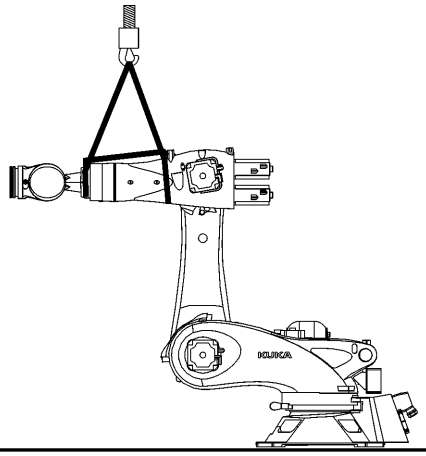


Fig. 11-6: Securing the arm

3. Release and unplug connectors XM3 and XP3 at the sockets (>>> Fig. 11-7).
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, being careful not to tilt 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.

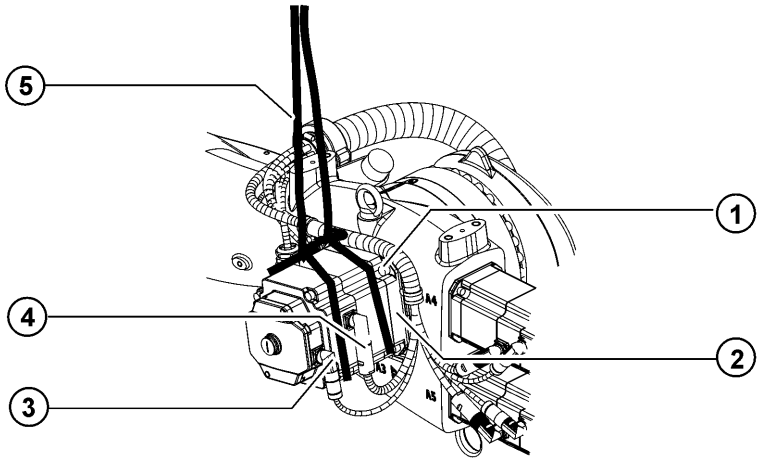


Fig. 11-7: Removing motor A3

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

11.3.2 Installing the motor on axis 3

Description

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

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

Preconditions

- The robot is secured to prevent rotational motions about axis 3 once the motor has been removed.

Procedure for installation

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. 11-8).
3. Clean the mounting surface for the motor A3 on the arm.
4. Check the condition of the O-ring on the motor shaft.
5. Position sockets XM3 and XP3 as shown in the illustration.
6. With the rope sling, pick up and insert motor A3, together with the seal (only F variant), being careful not to tilt it.

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

7. Insert 4 M12x35-8.8 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.

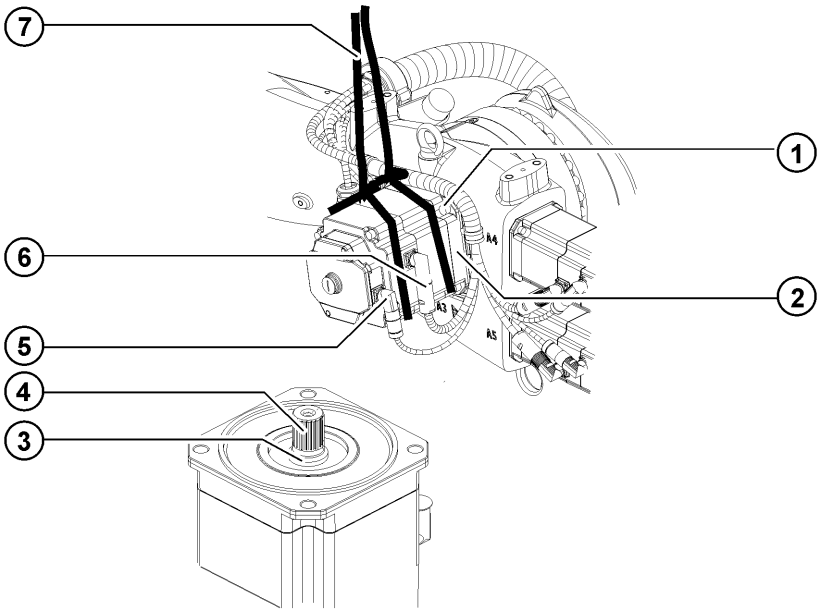


Fig. 11-8: Installing motor A3

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

11.4 Exchanging the motor on axis 4

11.4.1 Removing the motor on axis 4

Description

The following describes the removal of motor A4 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.

⚠ 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.

Preconditions

- Tools are dismounted or secured so that they cannot move once the motor has been removed.
- The arm is positioned horizontally.

Procedure for removal

1. Release and unplug connectors XM4 and XP4 at the sockets (>>> Fig. 11-9).
2. Place the rope sling around motor A4 and raise it using the crane until the weight of motor A4 is supported by the rope sling.
3. Remove 4 Allen screws.
4. Release motor A4 and pull it out together with the connecting shaft, being careful not to tilt it.
5. Remove the seal between the motor and the arm; for F variant only.
6. Set down motor A4.

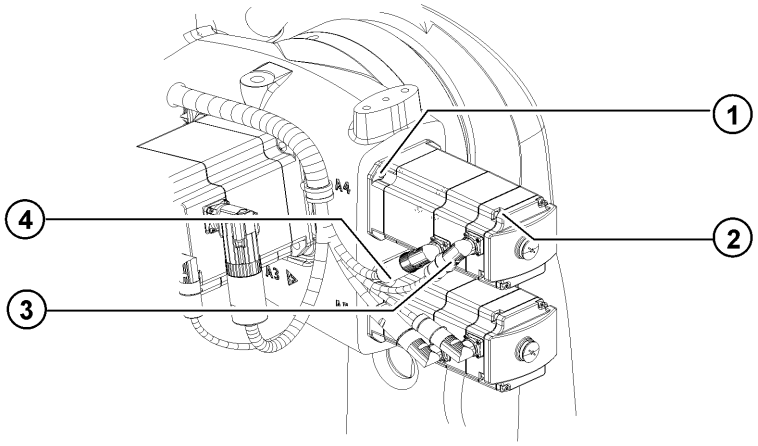


Fig. 11-9: Removing motor A4

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

The following two work steps are only to be carried out if motor A4 is not to be reinstalled.

7. Slacken both setscrews (>>> Fig. 11-10) until the connecting shaft can be pulled off the toothing, and pull off the connecting shaft.
8. Remove the Allen screw from the shaft stub and take off the axial retainer.
9. If the motor on A4 is not to be reinstalled, it must be protected against corrosion before being put into storage.

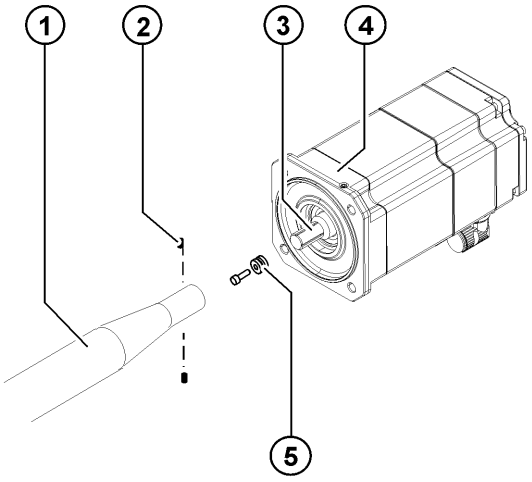


Fig. 11-10: Motor with connecting shaft

1	Connecting shaft	4	Motor A4
2	Setscrew	5	Axial retainer
3	Shaft stub		

11.4.2 Installing the motor on axis 4

Description

The following describes the installation of motor A4 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.

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

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

Preconditions

- The robot is secured to prevent rotational motions about axis 4 once the motor has been removed.

Procedure for installation

1. Remove all protective coatings and oil from the new motor A4 (>>> Fig. 11-11).
2. Mount the axial retainer and fasten it with an M5x20-10.9 Allen screw.
3. Clean the toothing on motor A4 and on the connecting shaft before installation and apply a thin but continuous coat of Microlube GL 261 grease.
4. Fit the connecting shaft onto motor A4.
5. Clean the M4x8 setscrews on both sides, apply Drei Bond 1342 locking agent and insert them.

   The setscrews must engage with the groove in the axial retainer.
6. Evenly tighten the setscrews; M_A = 2.8 Nm.

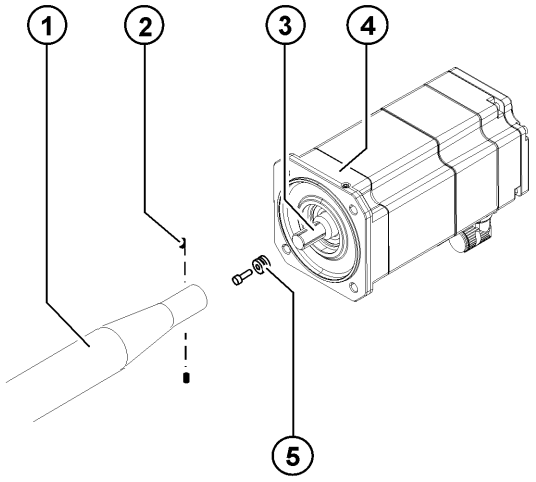


Fig. 11-11: Motor with connecting shaft

1	Connecting shaft	4	Motor A5
2	Setscrew	5	Axial retainer
3	Shaft stub		

7. Clean the mounting surface (>>> Fig. 11-12) for motor A4 on the arm.
8. Position connectors XM4 and XP4 so that they are located on the left-hand side after the motor has been inserted into the arm.
9. Lift motor A4 with a rope sling and insert it into the arm together with the seal (F variant only), being careful not to tilt it and ensuring that the connecting shafts (toothing) are correctly engaged.

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

10. Insert 4 M8x25-8.8 Allen screws.
11. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 23 Nm.
12. Slacken and remove the rope sling.
13. Plug connectors XM4 and XP4 into the sockets.
14. Remove elements securing the tooling.
15. Carry out mastering of axis 4.

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

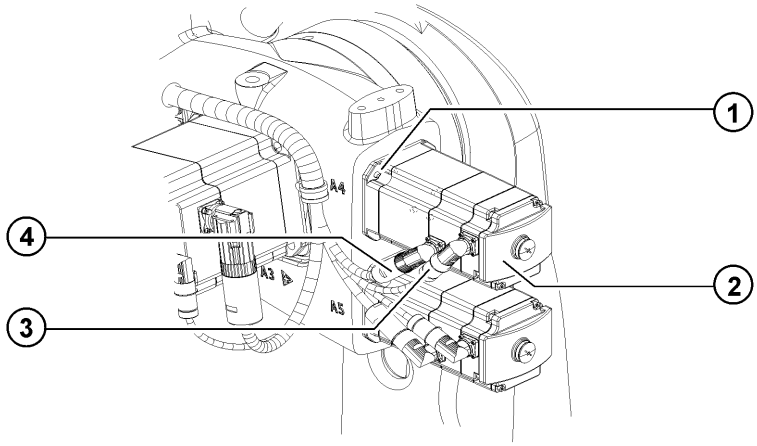


Fig. 11-12: Installing motor A4

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

11.5 Exchanging the motor on axis 5

11.5.1 Removing the motor on axis 5

Description

The following describes the removal of motor A5 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.

⚠ 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.

Preconditions

- Tools are dismounted or secured so that they cannot move once the motor has been removed.
- The arm is positioned horizontally.

Procedure for removal

1. Release and unplug connectors XM5 and XP5 at the sockets (>>> Fig. 11-13).
2. Place the rope sling around motor A5 and raise it using the crane until the weight of motor A5 is supported by the rope sling.
3. Remove 4 Allen screws.

4. Release motor A5 and pull it out together with the connecting shaft, being careful not to tilt it.
5. Remove the seal between the motor and the arm; for F variant only.
6. Set down motor A5.

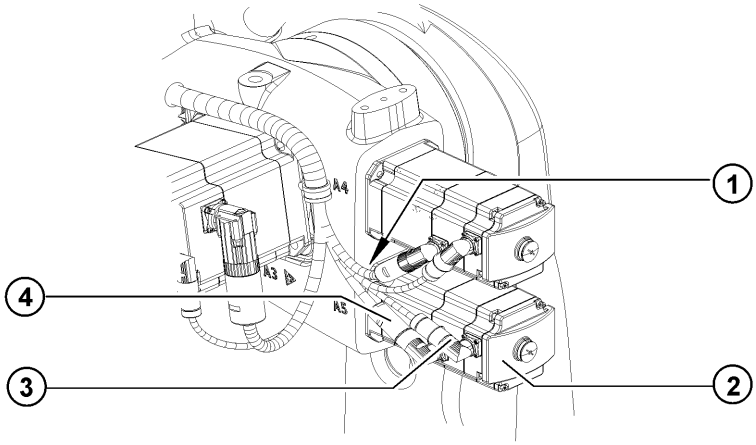


Fig. 11-13: Removal of motor A5

1	Allen screws	3	Connector XP5
2	Motor A5	4	Connector XM5

The following two work steps are only to be carried out if motor A5 is not to be reinstalled.

7. Slacken both setscrews (>>> Fig. 11-14) until the connecting shaft can be pulled off the toothing, and pull off the connecting shaft.
8. Remove the Allen screw from the shaft stub and take off the axial retainer.
9. If motor A5 is not to be reinstalled, it must be protected against corrosion before being put into storage.

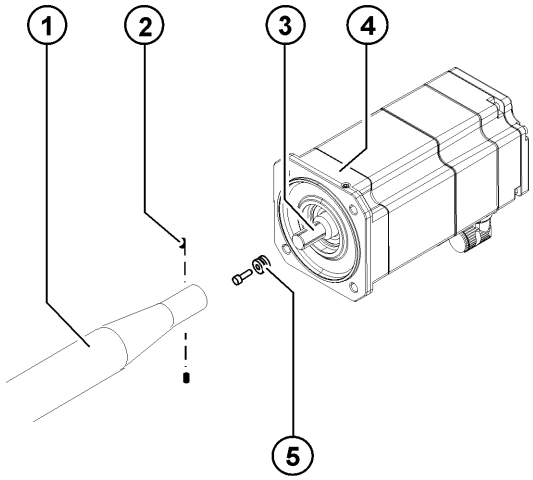


Fig. 11-14: Motor with connecting shaft

1	Connecting shaft	4	Motor A5
2	Setscrew	5	Axial retainer
3	Toothing		

11.5.2 Installing the motor on axis 5

Description

The following describes the installation of motor A5 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.

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

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

Preconditions

- The robot is secured to prevent rotational motions about axis 5 once the motor has been removed.

Procedure for installation

1. Remove all protective coatings and oil from the new motor A5 (>>> Fig. 11-15).
2. Mount the axial retainer and fasten it with an M5x20-10.9 Allen screw.
3. Clean the toothing on motor A5 and on the connecting shaft before installation and apply a thin but continuous coat of Microlube GL 261 grease.
4. Fit the connecting shaft onto motor A5.
5. Clean the M4x8 setscrews on both sides, apply Drei Bond 1342 locking agent and insert them.

   The setscrews must engage with the groove in the axial retainer.
6. Evenly tighten the setscrews; M_A = 2.8 Nm.

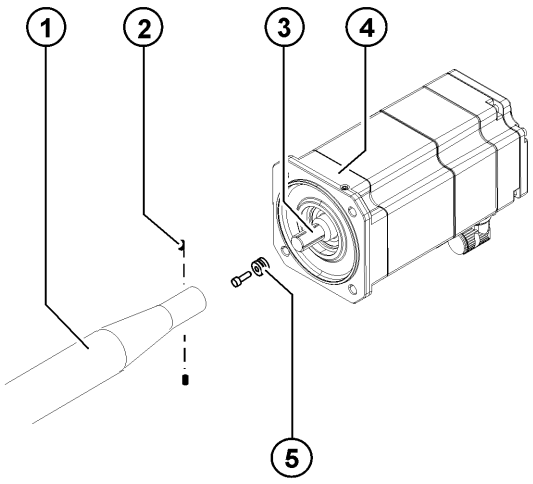


Fig. 11-15: Motor with connecting shaft

1	Connecting shaft	4	Motor A5
2	Setscrew	5	Axial retainer
3	Shaft stub		

7. Clean the mounting surface for motor A5 on the arm (>>> Fig. 11-13).
8. Position connectors XM5 and XP5 so that they are located on the left-hand side after the motor has been inserted into the arm.
9. Lift motor A5 with a rope sling and insert it into the arm together with the seal (F variant only), being careful not to tilt it and ensuring that the connecting shafts (toothing) are correctly engaged in the in-line wrist.

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

The rope sling can only be used if motor A4 is not installed. Otherwise, use suitable handling equipment to bring motor A5 to the site of installation and insert it.

10. Insert 4 M8x25-8.8 Allen screws.
11. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 23 Nm.
12. If applicable, slacken and remove the rope sling.
13. Plug connectors XM5 and XP5 into the sockets.
14. Remove elements securing the tooling.
15. Carry out mastering of axis 5.

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

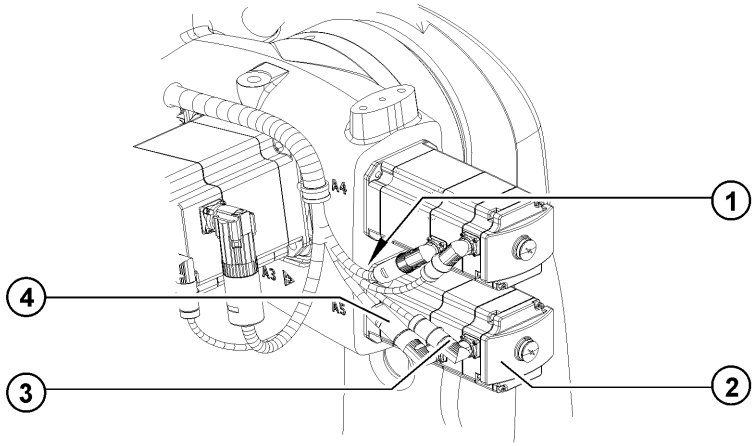


Fig. 11-16: Installation of motor A5

1	Allen screws	3	Connector XP5
2	Motor A5	4	Connector XM5

11.6 Exchanging the motor on axis 6

11.6.1 Removing the motor on axis 6

Description

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.

Preconditions

- The in-line wrist is removed.

Procedure for removal

1. Remove 4 Allen screws (>>> Fig. 11-17).
2. Release motor A6 and pull it out of the in-line wrist, being careful not to tilt it.
3. If the motor on A6 is not to be reinstalled, it must be set down and protected against corrosion before being put into storage.

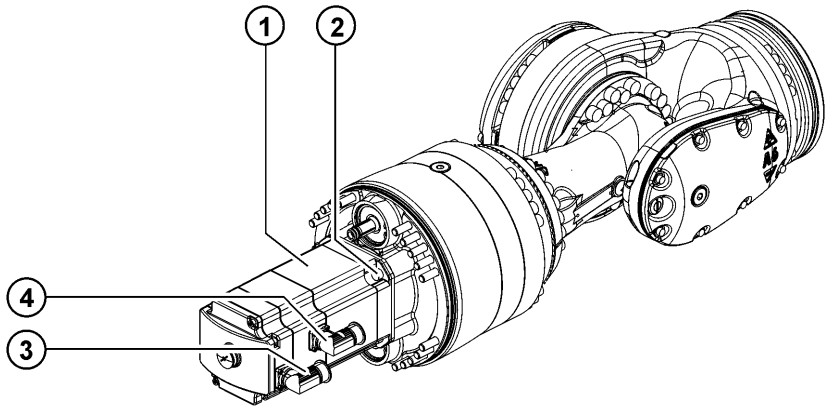


Fig. 11-17: Removing motor A6

1	Motor A6	3	Connector XP6
2	Allen screws	4	Connector XM6

11.6.2 Installing the motor on axis 6

Description

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

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

Procedure for installation

1. Remove all protective coatings and oil from the new motor A6.
2. Clean the toothing on motor A6 and in the gear unit of the in-line wrist before installation and apply a thin but continuous coat of Microlube GL 261 grease (>>> Fig. 11-18).
3. Clean the mounting surface for motor A6 on the in-line wrist.
4. Position connectors XM6 and XP6 so that they are located on the right-hand side after the motor has been inserted into the in-line wrist.
5. Insert motor A6 into the in-line wrist, taking care not to tilt it.

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

6. Insert 4 M8x25-8.8 Allen screws.

7. Tighten 4 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 23 Nm.
8. Install the in-line wrist (>>> 11.8.2 "Installing the in-line wrist" Page 143).

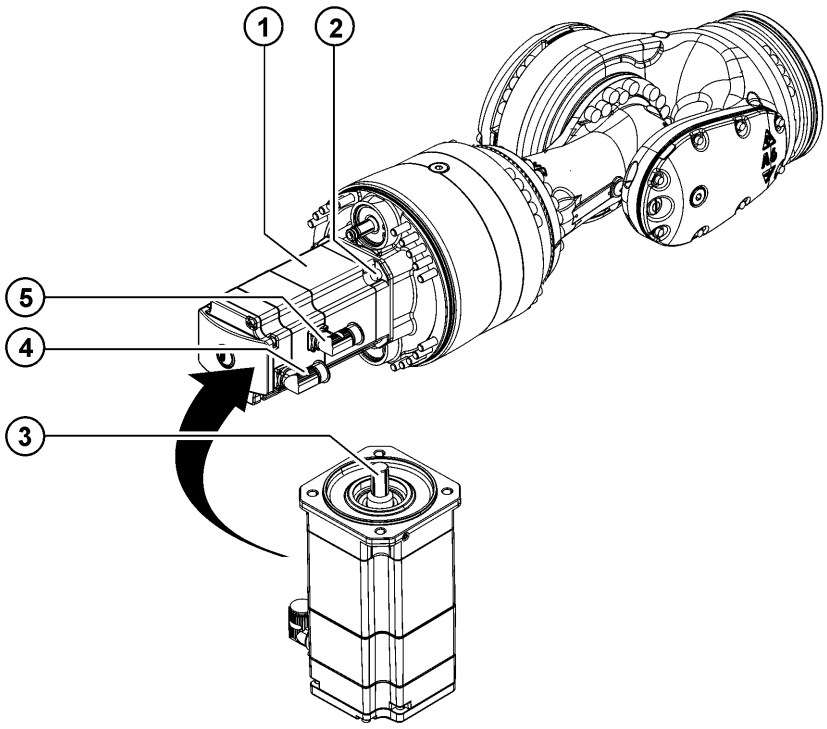


Fig. 11-18: Removing motor A6

1	Motor A6	4	Connector XP6
2	Allen screws	5	Connector XM6
3	Toothing		

11.7 Exchanging the counterbalancing system on a floor-mounted robot

11.7.1 Removing the counterbalancing system

⚠ 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. 40 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.

Preconditions

- It must be possible to move the robot about axis 2.
- The locking pin (00-194-717) for the piston must be available.
- The pin locator (00-190-253) must be available.
- The robot must be correctly bolted to the floor.
- Any items of equipment that are likely to impede the removal work have been removed.

Procedure for removal

1. Remove the screw plugs (>>> Fig. 11-19).
2. Put the robot into operation and move the link arm in the plus direction (approx. +85° position) until the locking pin can be inserted.
3. Remove the screw plug and screw in the locking pin. The wrench flats lie parallel to the counterbalancing system. It must be possible to turn the locking pin by hand.
4. Carefully move the link arm in the minus direction until the piston of the counterbalancing system rests lightly on the locking pin. The locking pin then cannot be turned any further.

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

5. Secure the robot by pressing the E-STOP device.
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 4 Allen screws and conical spring washers, and take off the retaining plate.

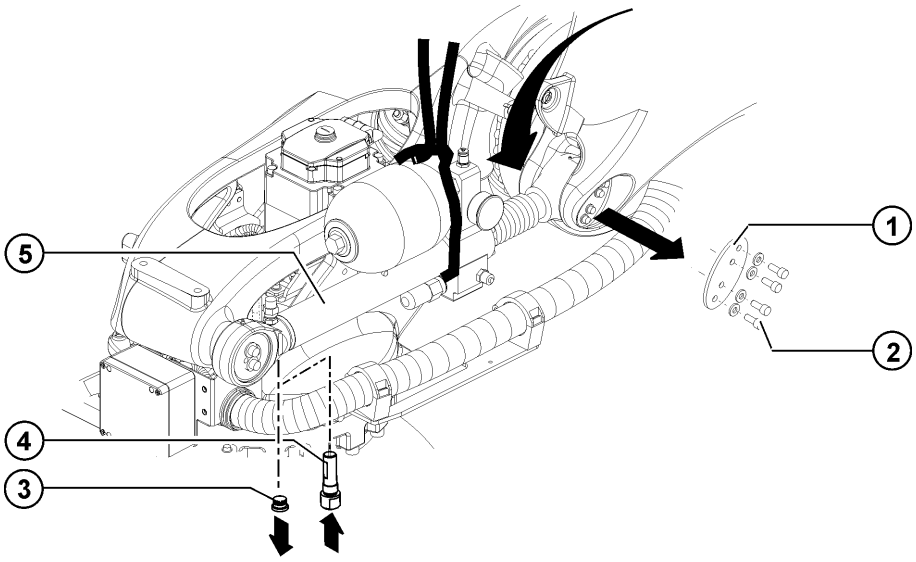


Fig. 11-19: Removing the counterbalancing system: locking pin

1	Retaining plate	4	Locking pin
2	Allen screws	5	Counterbalancing system
3	Screw plug		

8. Secure link arm using a rope sling and crane (>>> Fig. 11-20).

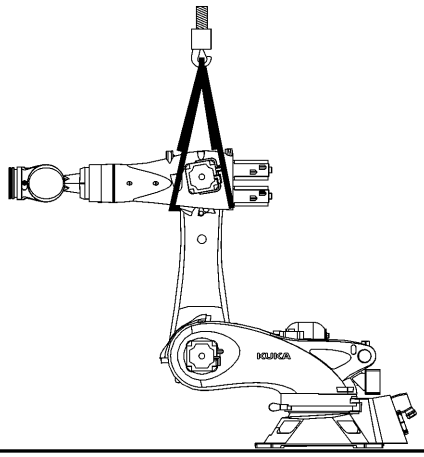


Fig. 11-20: Securing the link arm

9. Remove 2 Allen screws and lock washers, and take the cover off the rotating column (>>> Fig. 11-21).

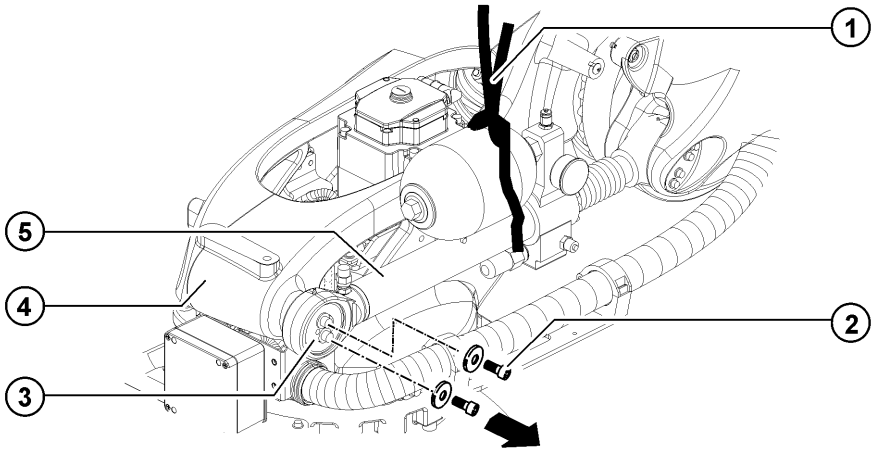


Fig. 11-21: Removing the counterbalancing system: rotating column

1	Rope sling	3	Cover
2	Allen screws	4	Rotating column

10. Insert the pin locator on the right-hand side between the articulated head and the link arm (>>> Fig. 11-22).
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 device.
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. 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.

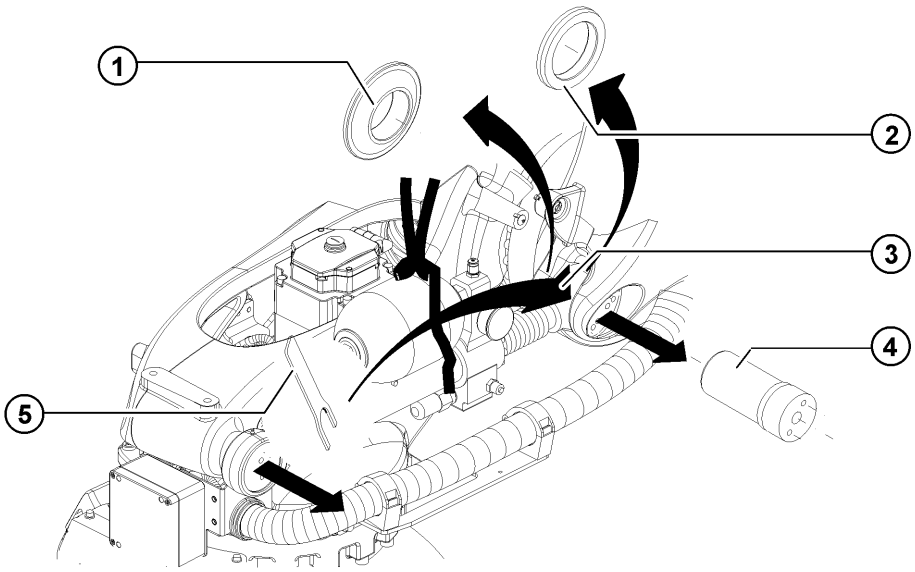


Fig. 11-22: Removing the counterbalancing system: pin

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

11.7.2 Installing the counterbalancing system

Description

⚠ 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. 40 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.

Preconditions

- It must be possible to move the robot about axis 2.
- The robot must be correctly bolted to the floor.
- The counterbalancing system is correctly filled.
- The device (00-190-157) must be available.
- Any items of equipment that are likely to impede the installation work have been removed.

Procedure for installation

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 +85° position.
3. Secure the robot by pressing the E-STOP device.
4. Secure link arm using a rope sling and crane (>>> Fig. 11-23).

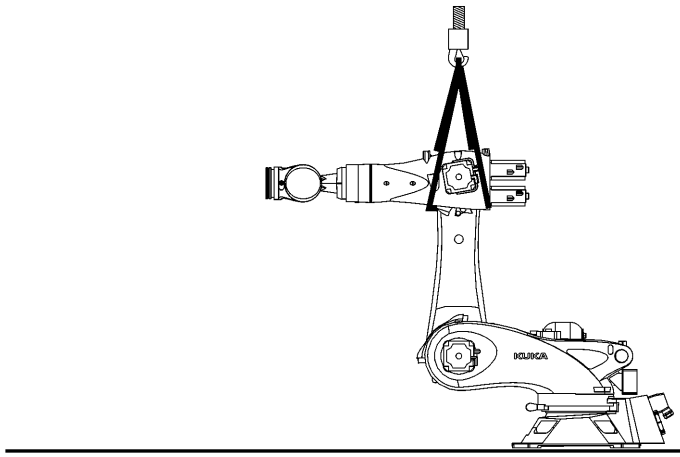


Fig. 11-23: Securing the link arm

5. Lift the counterbalancing system with a rope sling and bring it to the site of installation (>>> Fig. 11-24).
6. Mount the counterbalancing system sideways on the pin in the rotating column, and align.
7. If necessary, adjust the rope tension.
8. Mount the cover and fasten with two M12x30-10.9 Allen screws and conical spring washers.
9. Tighten the Allen screws with a torque wrench; M_A = 104 Nm.

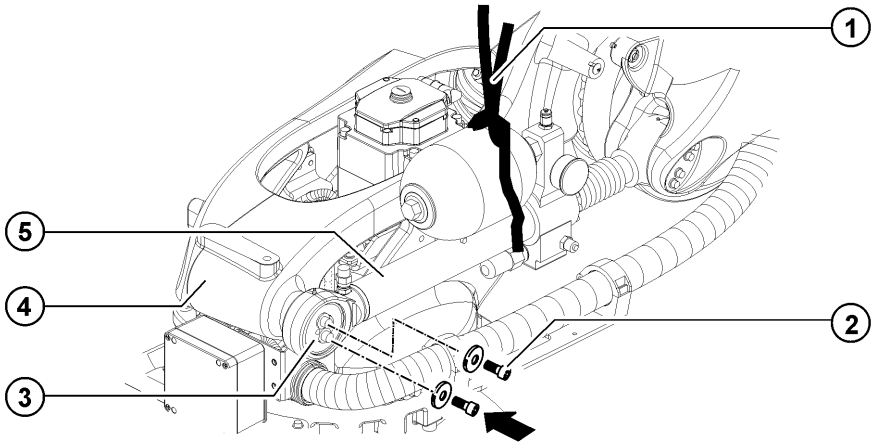


Fig. 11-24: Installing the counterbalancing system: rotating column

1	Rope sling	3	Cover
2	Allen screw	4	Counterbalancing system

10. Put the robot into operation.
11. 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. 11-25).

12. Lower the counterbalancing system, insert the articulated head with the thrust ring and spacer ring into the link arm, and align.
13. Move the link arm and counterbalancing system until the holes are aligned.
14. Insert the pin using the device (00-190-157).
15. Mount the retaining plate and fasten it with 4 M8x20-10.9 Allen screws and conical spring washers.
16. Tighten the 4 Allen screws with a torque wrench; M_A = 31 Nm.
17. Remove the rope sling from the counterbalancing system and the link arm.

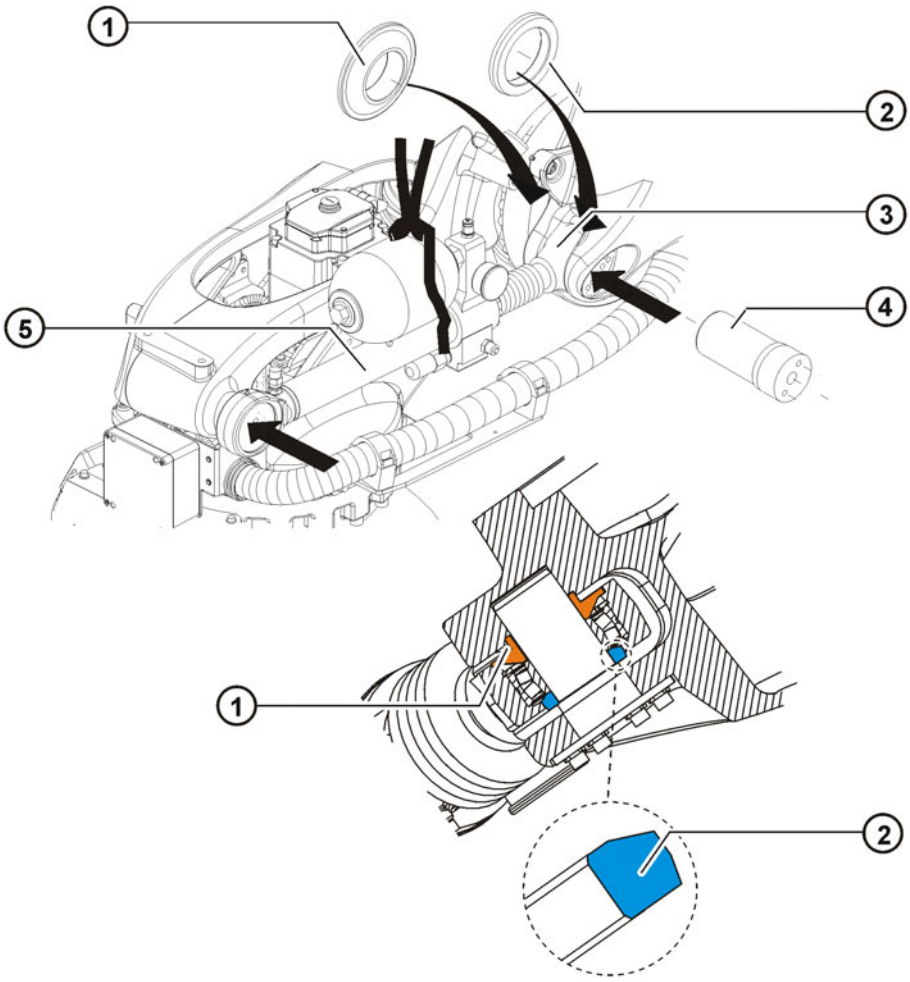


Fig. 11-25: Installing the counterbalancing system: pin

1	Thrust ring	4	Pin
2	Spacer ring	5	Counterbalancing system
3	Articulated head		

18. Put the robot into operation.
19. Move the link arm in the plus direction until the locking pin is released, and unscrew the locking pin (>>> Fig. 11-26).

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

20. Secure the robot by pressing the E-STOP device.
21. Insert and tighten the M18x1.5 screw plugs; M_A = 20 Nm.

22. Check the pressure on the counterbalancing system (>>> 10.3 "Filling and adjusting the counterbalancing system" Page 114).

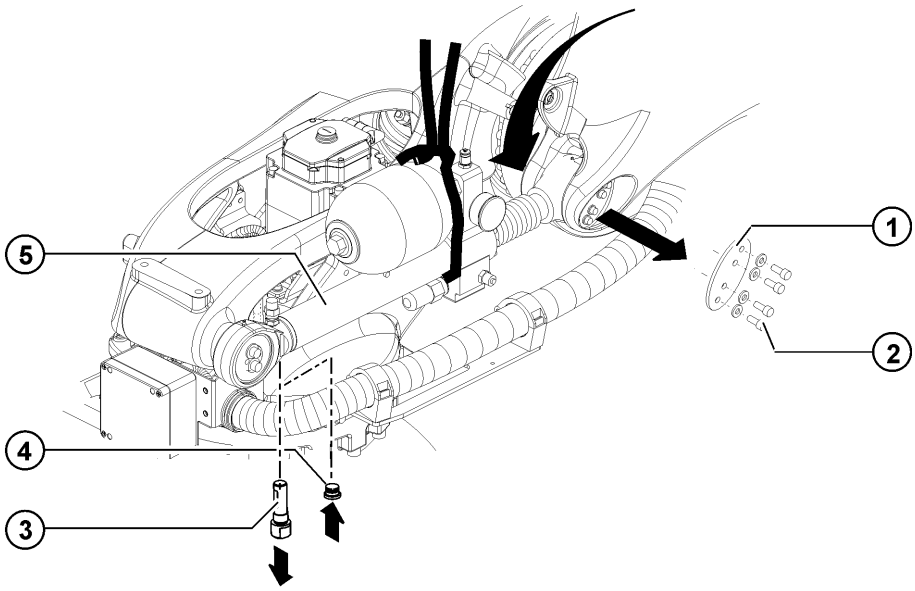


Fig. 11-26: Installing the counterbalancing system: link arm

1	Retaining plate	4	Screw plug
2	Allen screws	5	Counterbalancing system
3	Locking pin		

11.8 Exchanging the in-line wrist

11.8.1 Removing the in-line wrist

Description

All of the in-line wrist variants are removed in the same way, irrespective of the payload or arm length. In the following description, only the removal of the IW 270/300 in-line wrist will be described.

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

Preconditions

- The arm is in the horizontal position as shown in (>>> Fig. 11-27).
- Axes 4, 5 and 6 should, if possible, be in their zero positions.
- A crane, appliance or rope with adequate carrying capacity must be available.
- Remove the payload (tool or device) from the in-line wrist.

⚠ WARNING The in-line wrist and the arm can be damaged or persons injured if the in-line wrist is not safely secured. The in-line wrist weighs approx. 130 kg. The crane and rope must therefore be able to support this load safely.

Procedure for removal

1. Fasten the lifting device to the in-line wrist and the crane (>>> Fig. 11-27).

2. Move the crane until the weight of the in-line wrist is supported by the crane.
3. Remove 20 Allen screws. In the same hole circle there are also two M6 Allen screws, one at the top and one at the bottom; these must not be slackened.
4. Pull the in-line wrist out of the arm until connectors XM6 and XP6 are accesssible.

   Do not tilt it when removing it. The gap between the arm and the in-line wrist must be uniform at all times round the entire circumference. Also move the crane at the same time as pulling out the in-line wrist. The connecting shafts must not be subjected to any load while the in-line wrist is being pulled out.
5. Release and unplug connectors XM6 and XP6.
6. Place in-line wrist on suitable support.
7. If the in-line wrist is not to be reinstalled, it must be protected against corrosion before being put into storage.

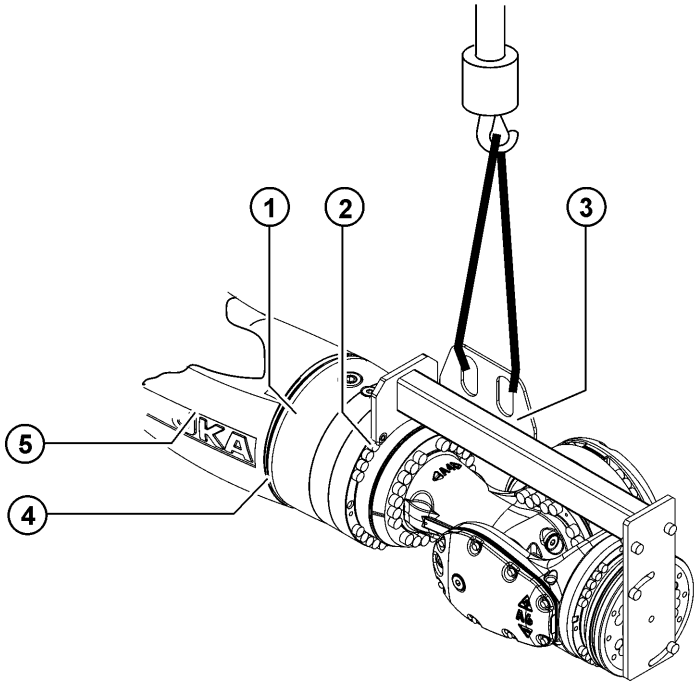


Fig. 11-27: Removing the in-line wrist

1	In-line wrist	4	Gap
2	Allen screws	5	Arm
3	Lifting device		

11.8.2 Installing the in-line wrist

Description

All of the in-line wrist variants are installed in the same way, irrespective of the payload or arm length. In the following description, only the removal of the IW 270/300 in-line wrist will be described.

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

Preconditions

- The arm is in the horizontal position.
- Axes 4, 5 and 6 should, if possible, be in their zero positions.
- A crane, lifting device and rope with adequate carrying capacity must be available.
- The motors of axes 4 and 5 must be removed.

⚠ WARNING The in-line wrist and the arm can be damaged or persons injured if the in-line wrist is not safely secured. The in-line wrist weighs approx. 130 kg. The crane and rope must therefore be able to support this load safely.

Procedure for installation

1. Remove all protective coatings and oil from new in-line wrist, if applicable.
   Clean the toothing on the connecting shafts and on the in-line wrist before installation and apply a thin but continuous coat of Microlube GL 261 grease (>>> Fig. 11-28).

NOTICE When installing the in-line wrist, it must be ensured that the toothing of the in-line wrist and connecting shafts is not damaged. Increased wear and premature failure may result.

2. Fasten the lifting device to the in-line wrist.
3. Pick up the in-line wrist with the crane, bring it to the installation site and ensure that axes 4 and 6 are in their zero positions.
4. Ensure that the connecting shafts are not damaged or subjected to any load during transportation and insertion.
5. Insert the in-line wrist into the arm until the connectors can be plugged in.
6. Plug in connectors XP6 and XM6 and then insert the in-line wrist all the way into the arm.
   Ensure that the cables are in the correct position in the arm. The position can be checked through the openings for the motors.
7. Insert 20 M10x200-10.9 Allen screws.
8. Tighten 20 Allen screws with a torque wrench in diagonally opposite sequence. Gradually increase the tightening torque to a value of 60 Nm.

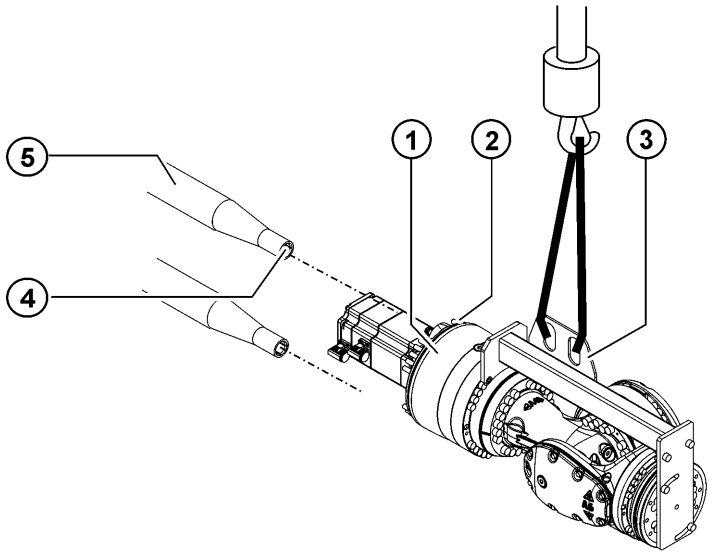


Fig. 11-28: Installing the in-line wrist

1	In-line wrist	4	Toothing

2 Allen screws
3 Lifting device
5 Connecting shaft

9. Remove the appliance or rope sling.
10. Install the motors of axes 4 and 5 (>>> 11.4.2 "Installing the motor on axis 4" Page 128), (>>> 11.5.2 "Installing the motor on axis 5" Page 132).
11. Carry out mastering of axes 4, 5 and 6.

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

11.9 Description of the electrical installations (robot)

Overview

The electrical installations of the robot consist of:

- Cable set
- Multi-function housing MFH for motor cable
- Junction box for data cable, RDC box

Description

The electrical installations (>>> Fig. 11-29) include all the supply and control cables for the motors of axes 1 to 6. All the connections on the motors are screwed plug-and-socket connections. The assembly consists of the cable set, the multi-function housing MFH on the push-in module and the RDC box in the rotating column. The interface for the connecting cables is located at the back of the base frame on the push-in module. The motor cable X30 and the data cable X31 are connected here via plug-in connections. The data and motor cables are routed through the axis 1 gear unit to the motors (XM connectors) or, in the case of the data cables, to the RDC box on the rotating column. From the RDC box, the motors are connected via the XP connectors. The connectors on motors A1 to A5 are freely accessible, whereas the connectors for motor A6 are only accessible after removal of the wrist.

The protective circuit is also integrated into the cable set. The ground conductor is connected to the base frame via a ground conductor bolt.

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

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

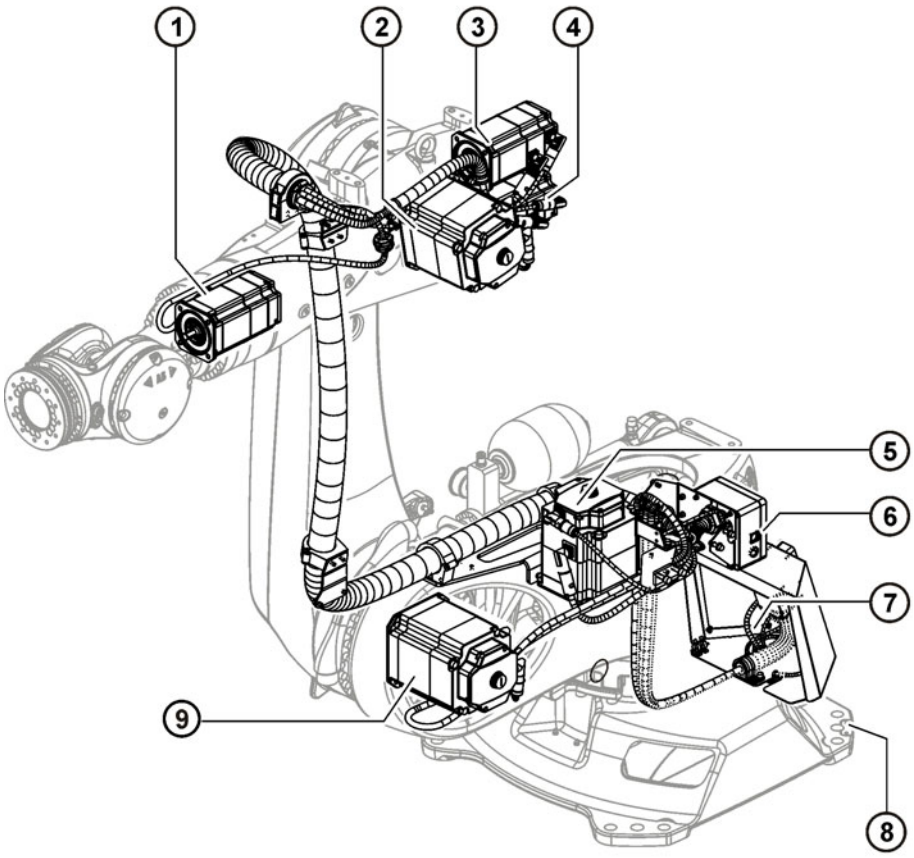


Fig. 11-29: Electrical installations, overview

1	Axis 6 motor	6	RDC box
2	Axis 3 motor	7	Push-in module
3	Axis 4 motor	8	Base frame
4	Axis 5 motor	9	Axis 2 motor
5	Axis 1 motor		

Wiring diagrams

Designation	Connection	Figure
Wiring diagram A1	XM1	(>>> Fig. 11-30)
Wiring diagram A2	XM2	(>>> Fig. 11-31)
Wiring diagram A3	XM3	(>>> Fig. 11-32)
Wiring diagram A4	XM4	(>>> Fig. 11-33)
Wiring diagram A5	XM5	(>>> Fig. 11-33)
Wiring diagram A6	XM6	(>>> Fig. 11-35)
Data cable	Wiring diagram, RDC X31	(>>> Fig. 11-36)
Data cable	Wiring diagram, RDC X32	(>>> Fig. 11-37)
Protective circuit	Ring cable lug	(>>> Fig. 11-38)

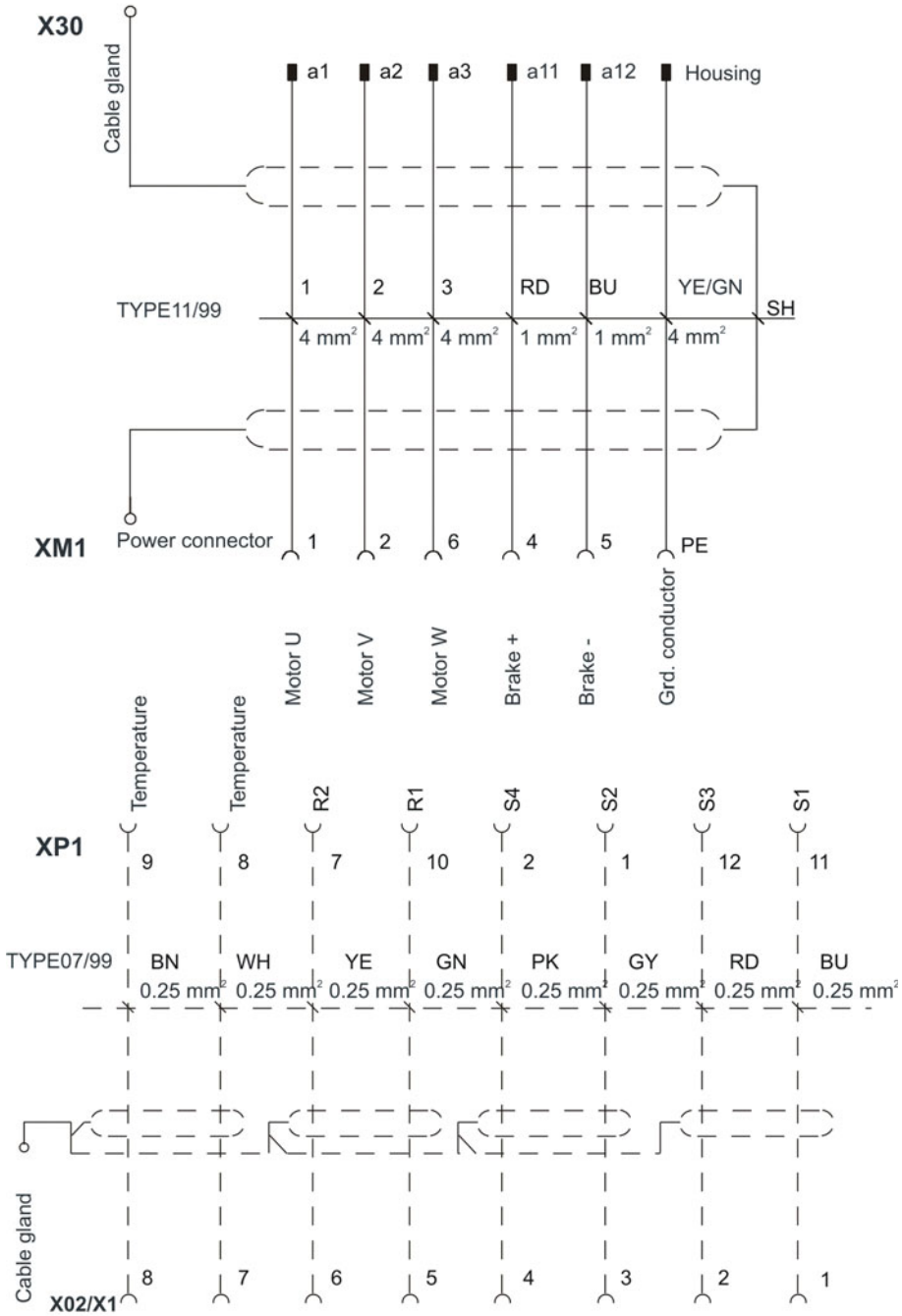


Fig. 11-30: Wiring diagram, axis 1

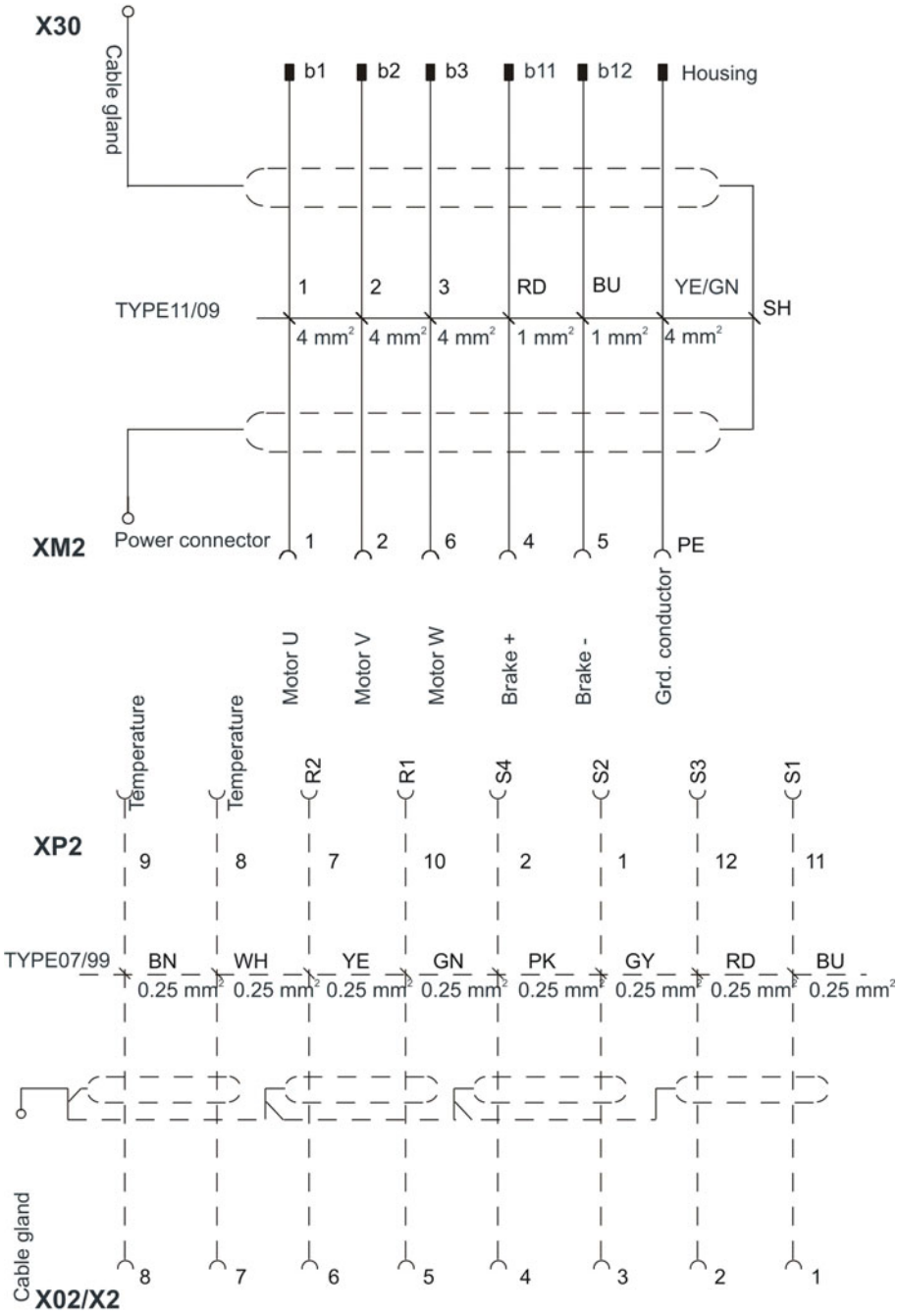


Fig. 11-31: Wiring diagram, axis 2

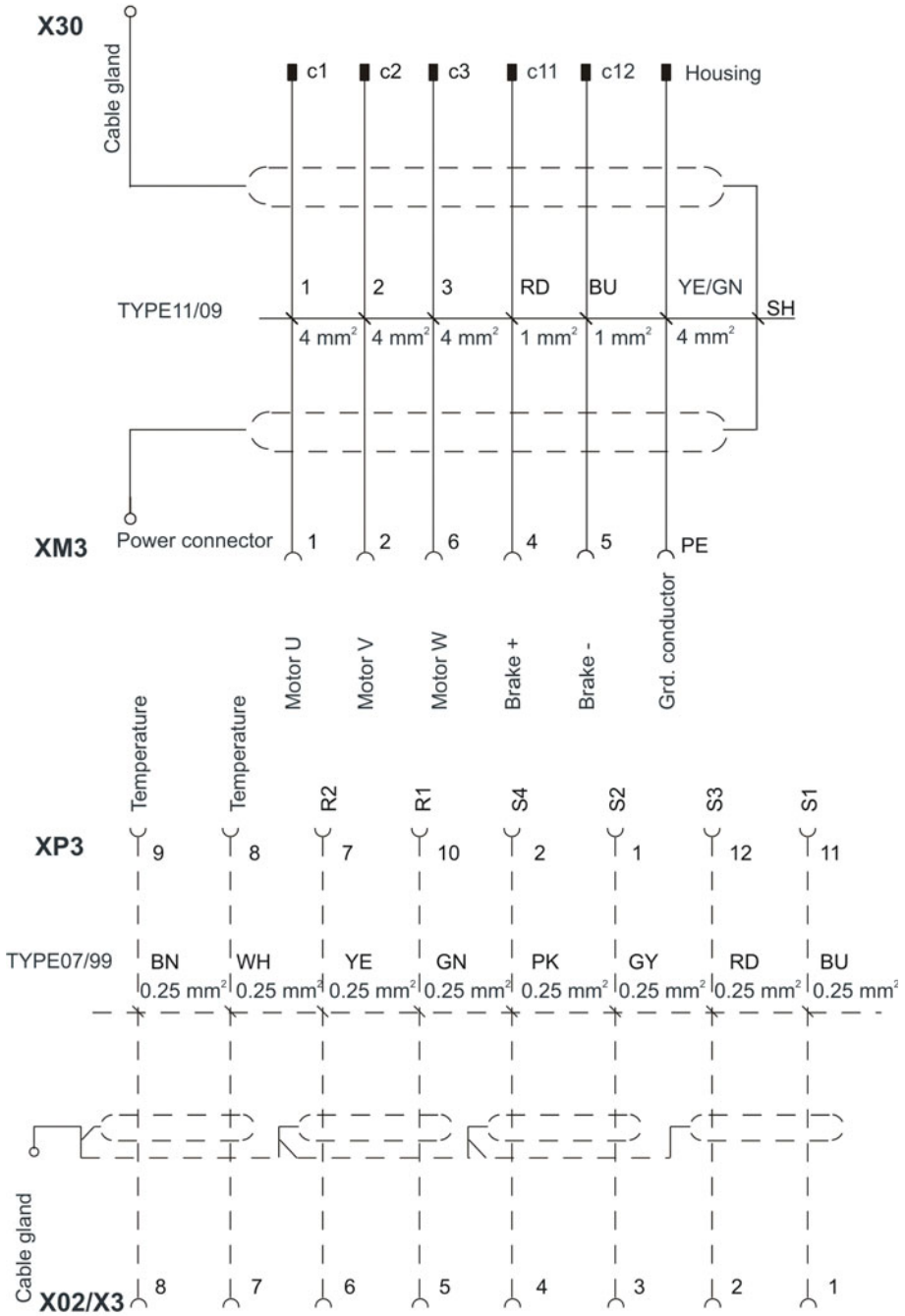


Fig. 11-32: Wiring diagram, axis 3

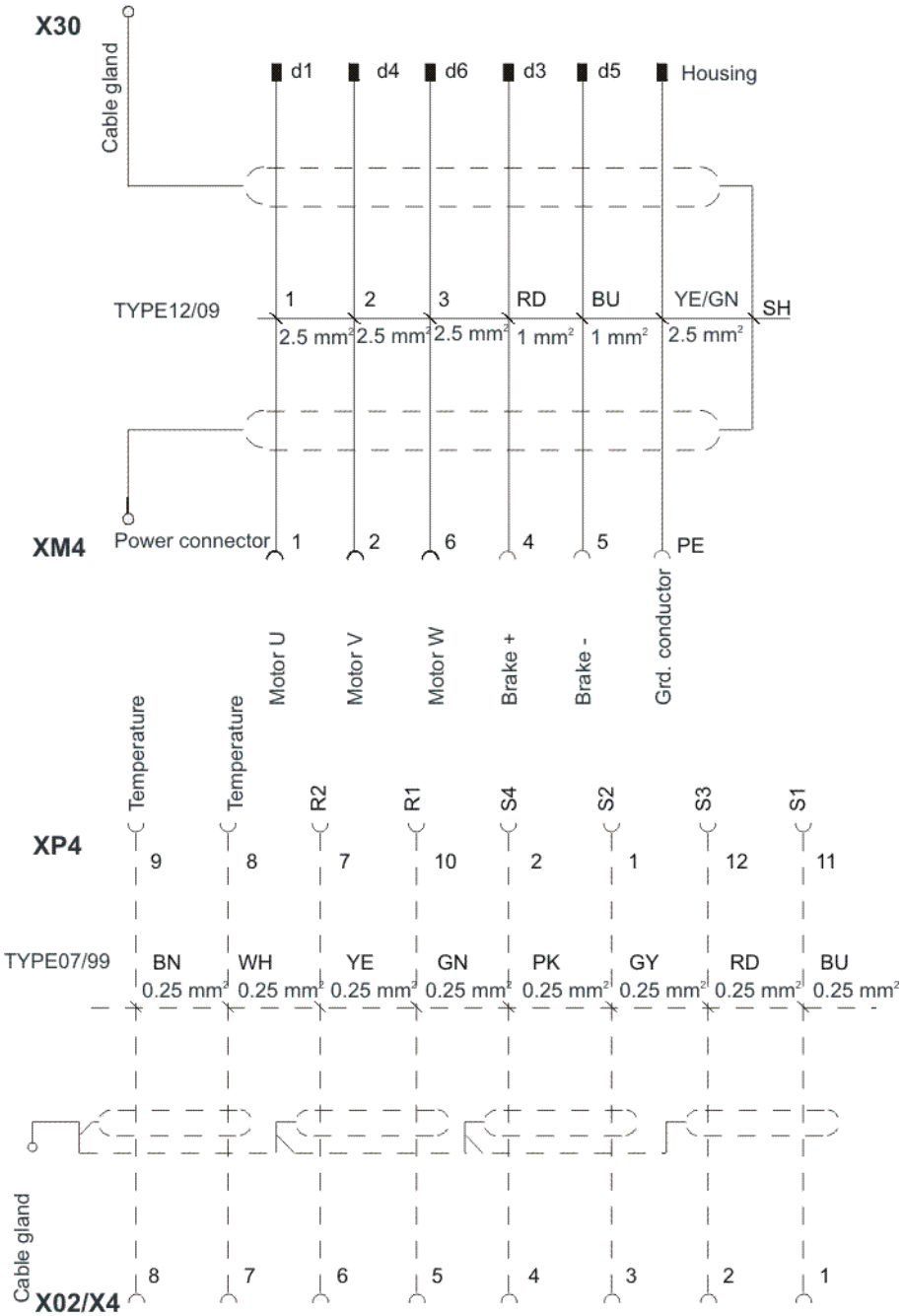


Fig. 11-33: Wiring diagram, axis 4

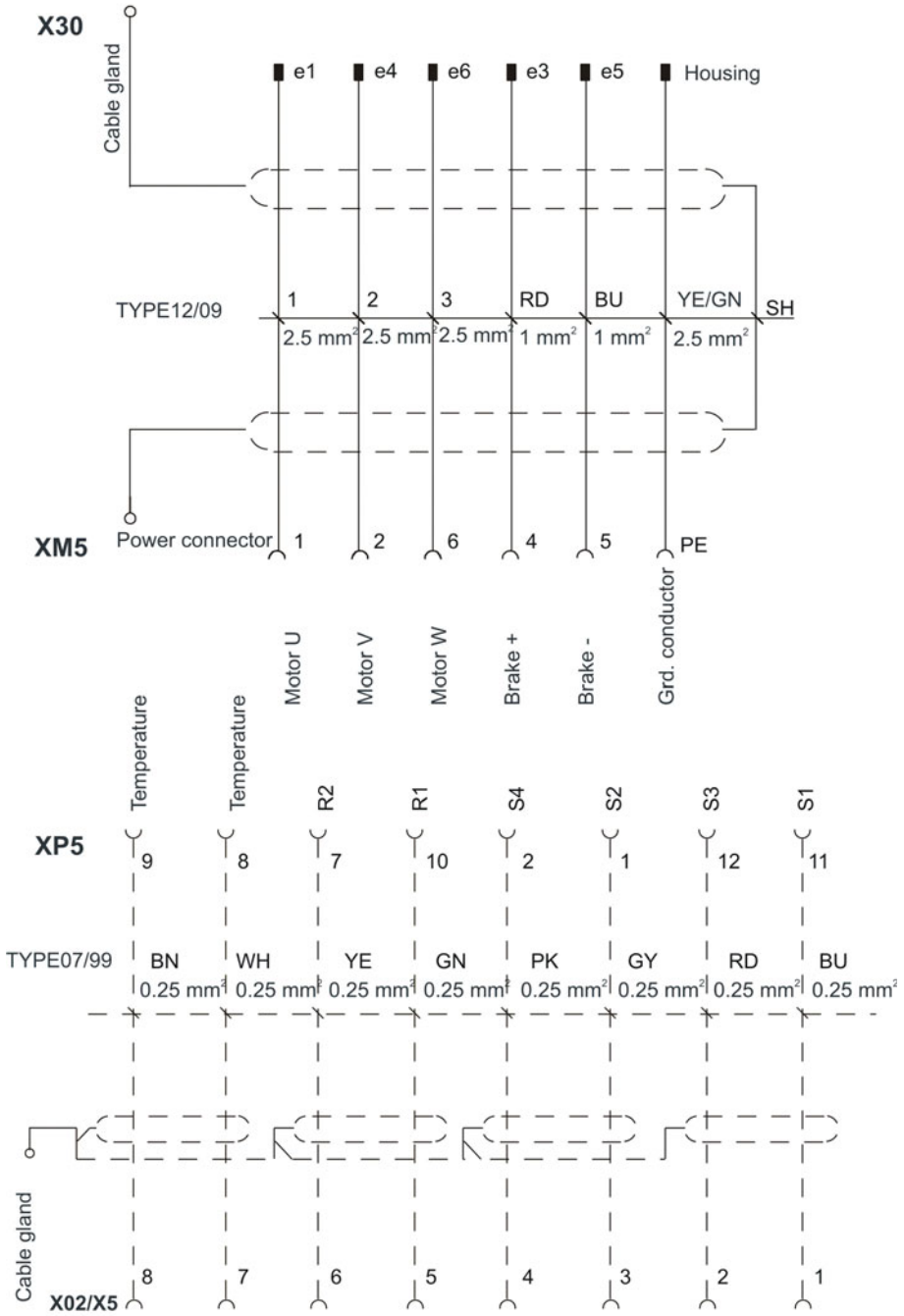


Fig. 11-34: Wiring diagram, axis 5

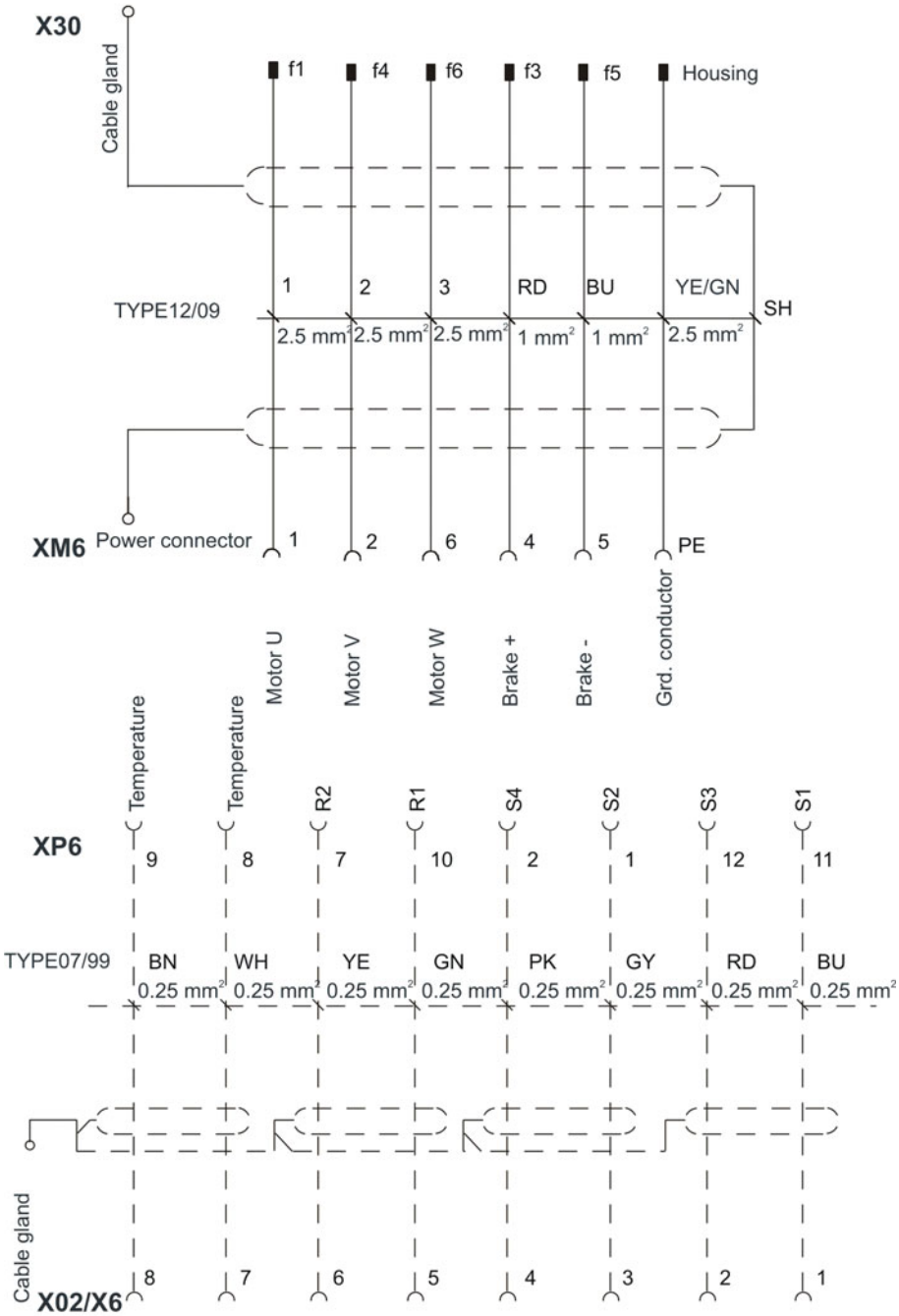


Fig. 11-35: Wiring diagram, axis 6

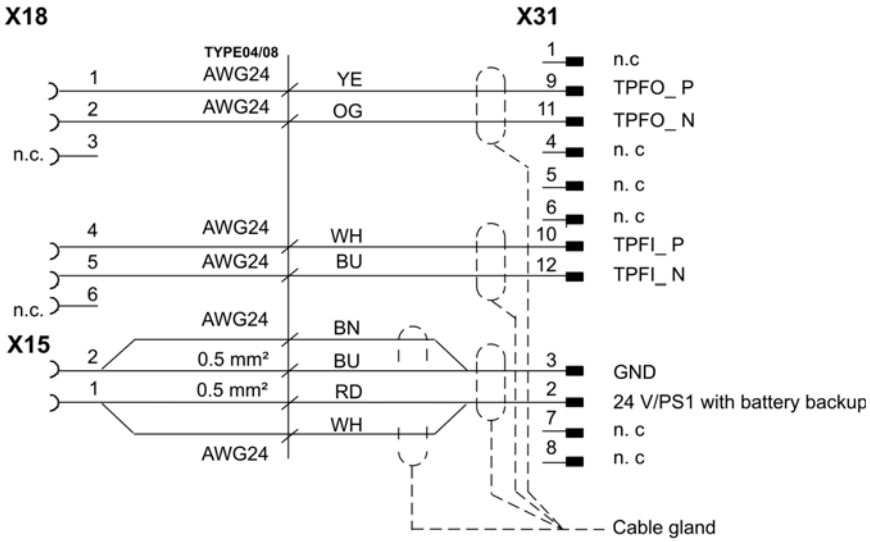


Fig. 11-36: Wiring diagram, RDC X31

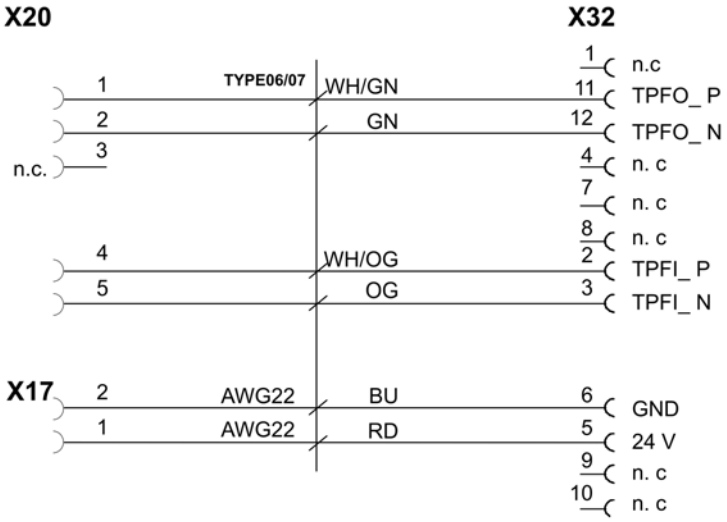
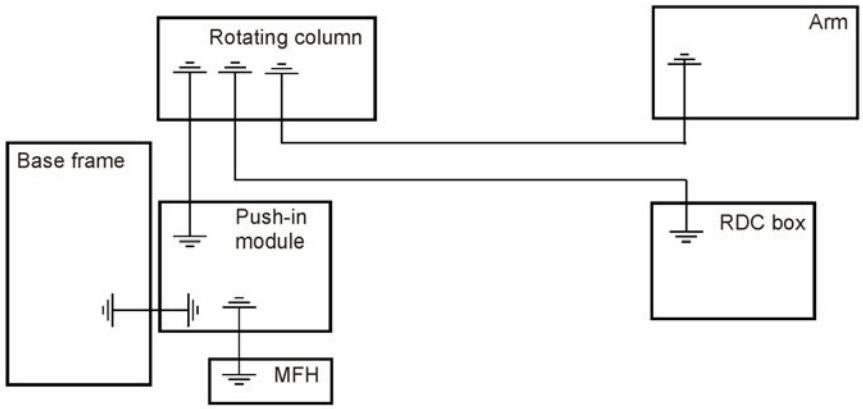


Fig. 11-37: Wiring diagram, RDC X32



All ground conductor cross-sections 10 mm²

Fig. 11-38: Wiring diagram, protective circuit

12 Decommissioning, storage and disposal

12.1 Decommissioning

Description

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

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

Preconditions

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

Procedure

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

1. Secure the robot.
2. Remove tools and equipment.
3. Put the robot into operation and move it into the transport position (>>> Fig. 12-1).

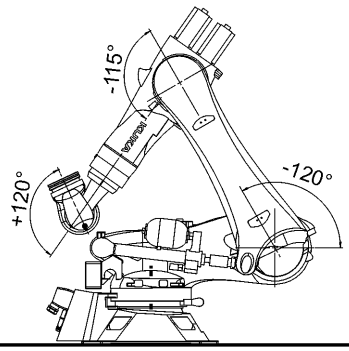


Fig. 12-1: Transport position

4. Secure the robot by activating the E-STOP device and then shut down the robot (>>> Fig. 12-2).
5. Release and unplug all peripheral connections.
6. Release and unplug the motor cable and data cable connectors.
7. Unscrew the hexagon nut from the ground conductor, take off the washers and lock washers and pull off the ground conductor.
8. Screw in the eyebolts and attach lifting tackle to the robot or prepare the robot for transportation with the fork lift truck. Minimum payload capacity of the fork lift truck for transportation: approx. 2.0 t.

   If, due to its installation position, it is not possible to lift the robot with a fork lift truck or with a crane and lifting tackle, the “Recovery aid” accessory (00-187-214) is available as an option.
9. Unscrew and remove the 8 hexagon bolts and conical spring washers.

10. Lift the robot vertically off the mounting surface and transport it away.
    Take care not to damage the two pins when lifting off the robot.

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

11. Prepare the robot for storage.

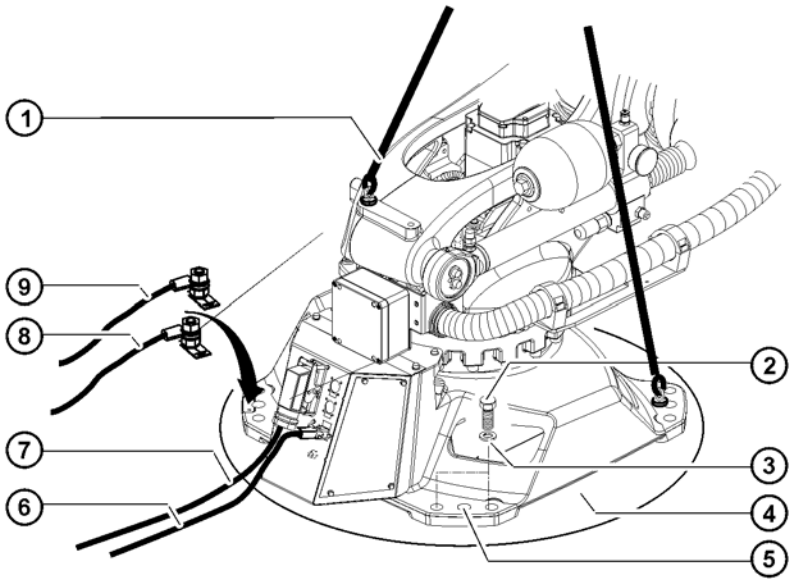


Fig. 12-2: Removing the robot

1	Lifting tackle	6	Data cable
2	Hexagon bolts	7	Motor cable
3	Conical spring washers	8	Ground conductor
4	Mounting surface	9	Ground conductor, controller
5	Pin		

12.2 Storage

Description

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

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

Procedure

1. Remove the robot.
2. Remove tools and equipment.

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

12.3 Disposal

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

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

Material, designation	Subassembly, component	Note
Light alloy casting	In-line wrist housing, spur gear housing, swivel housing, arm	
Cast-iron material	Base frame, rotating column, link arm, wrist main body	
Steel	Gear units, screws and washers	
	Motors	Dispose of motors without dismantling them.
PUR	Cable sheaths	
ETFE	Flexible tube, protective fabric sleeve	
Copper	Cables, wires	
PU	Hoses	
Cable grease	Cabling	See safety data sheet, consumables (>>> 14.2.1 "Safety data sheet for Optitemp RB1 cable grease" Page 161)
Oil	Gear units	See safety data sheet, consumables (>>> 14.2.5 "Safety data sheet for Optigear Synthetic RO 150 oil" Page 182)
Hydraulic oil	Counterbalancing system	See safety data sheet, consumables (>>> 14.2.4 "Safety data sheet for Castrol Hyspin ZZ 46 hydraulic oil" Page 175)

Material, designation	Subassembly, component	Note
Lubricating grease	Gear teeth	See safety data sheet, consumables (>>> 14.2.2 "Safety data sheet for Microlube GL 261 lubricating grease" Page 166)
Lubricating grease	Counterbalancing system, bearing on arm / link arm	See safety data sheet, consumables (>>> 14.2.3 "Safety data sheet for LGEP 2 extreme pressure grease" Page 171)
PA 6, PA R AB	Hinged clamps, flexible tubes	
Vition, FKM, FPM	O-rings	
PE 500	End stop buffer	

13 Options

13.1 Mounting flange, adapter (optional)

Description

This mounting flange (adapter) (>>> 13.1 "Mounting flange, adapter (optional)" Page 159) can be fitted on the 150/180/210 kg in-line wrist to convert it to a mounting flange with D=160. This enables e.g. tools to be used which are dimensioned for the in-line wrist with the D=160 mounting flange. The design of the flange also allows mounting of the holder A6 of the energy supply systems A3-A6.

When this adapter is mounted, the distance between the intersection of A4/A5 and the face of the mounting flange is offset forward by 25 mm.

The reference point for the load center of gravity remains unchanged and thus corresponds to the values for the in-line wrist IW 150/180/210.

The mounting flange is depicted (>>> Fig. 13-1) with axes 4 and 6 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

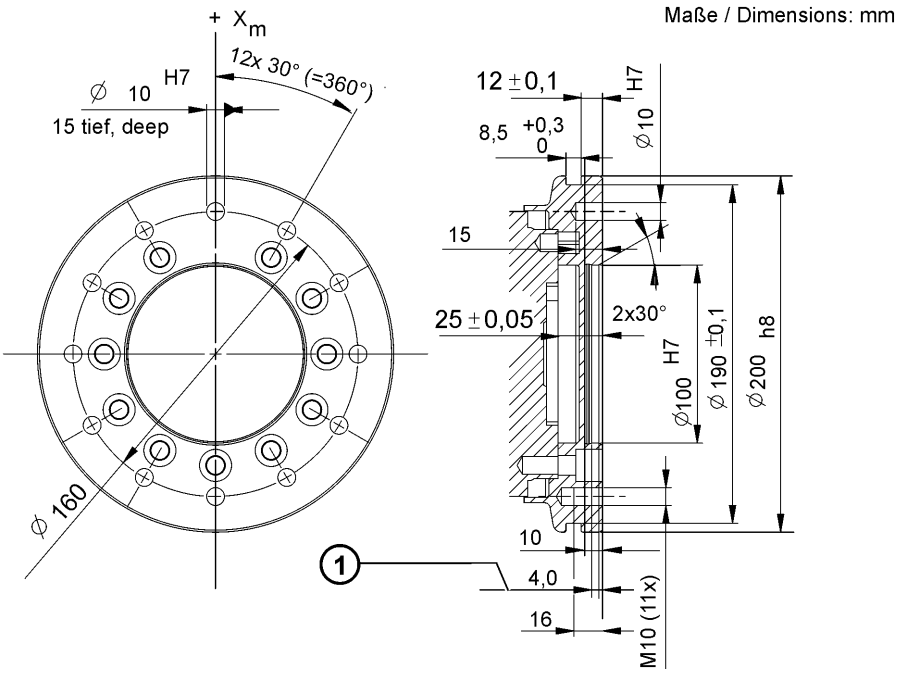


Fig. 13-1: Mounting flange, adapter

1 Fitting length

Mounting flange, adapter	IW 150/180/210 to IW 210/240
Hole circle	160 mm
Screw grade	10.9
Screw size	M10
Number of fastening threads	11
Grip length	1.5 x nominal diameter
Depth of engagement	min. 12 mm, max. 16 mm
Locating element	10^{H7}

13.2 Control cable for single axis (optional)

Description

The control cable for single axis is used when additional axes (e.g. KUKA linear unit or turntables) are controlled via the robot. In this case, the control cable is guided from the RDC box through the hollow shaft of axis 1 to a connector interface on the push-in module.

13.3 Release device (optional)

Description

The release device can be used to move the manipulator manually after an accident or malfunction. The release device can be used for the motors of axes 1 to 5. It cannot be used for axis 6, as this motor is not accessible. It is only for use in exceptional circumstances and emergencies (e.g. for freeing people).

The release device is mounted on the base frame of the manipulator. This assembly also includes a ratchet and a set of plates with one plate for each motor. The plate specifies the direction of rotation for the ratchet and shows the corresponding direction of motion of the manipulator.

14 Appendix

14.1 Tightening torque

Tightening torque

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

	Strength class		
Screw size	8.8	10.9	12.9
M1.6	0.17 Nm	0.24 Nm	0.28 Nm
M2	0.35 Nm	0.48 Nm	0.56 Nm
M2.5	0.68 Nm	0.93 Nm	1.10 Nm
M3	1.2 Nm	1.6 Nm	2.0 Nm
M4	2.8 Nm	3.8 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.

14.2 Safety data sheets

14.2.1 Safety data sheet for Optitemp RB1 cable grease

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

14.2.1.1 Designation of substance/formulation and manufacturer

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

Manufacturer designation	
Company:	**Deutsche BP Aktiengesellschaft, Industrial Lubricants & Services**
Address:	Erkelenzer Strasse 20, D-41179 Mönchengladbach
Country:	Germany
Tel.:	+49 (0)2161 909-319
Fax:	+49 (0)2161 909-392
Emergency hotline:	Carechem: +44 (0)208 762 8322
e-mail address:	MSDSadvice@bp.com

14.2.1.2 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.

14.2.1.3 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).

14.2.1.4 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.

14.2.1.5 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.

14.2.1.6 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.

14.2.1.7 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

14.2.1.8 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.

14.2.1.9 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

14.2.1.10 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.

14.2.1.11 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.

14.2.1.12 Ecological information

Persistence / degradability:	Biodegradable.

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

14.2.1.13 Disposal information

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

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

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

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

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

14.2.1.14 Transport information

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

14.2.1.15 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

14.2.1.16 Other information

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

14.2.2 Safety data sheet for Microlube GL 261 lubricating grease

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

14.2.2.1 Designation of substance/formulation and manufacturer

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

Manufacturer designation	
Company:	**Klüber Lubrication München AG**
Address:	Geisenhausenerstr. 7
Postal code:	D-81379 München

Manufacturer designation	
Country:	Germany
Telephone:	+49 (0)89 7876 0
Fax:	+49 (0)89 7876 333
Information center:	Material Compliance Management
Emergency hotline:	+49 (0)89 7876-700

14.2.2.2 Composition / Information about the components

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

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

14.2.2.3 Possible hazards

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

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

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

14.2.2.4 First aid measures

Contact with eyes:	Rinse eyes immediately with plenty of water for several minutes. If irritation occurs, consult a doctor.
Skin contact:	Wash affected areas of skin with soap and water, or use suitable cleaning agent. Change clothing and shoes if they become contaminated with product. Wash clothing before reuse. Clean shoes thoroughly before reuse. If irritation occurs consult a doctor.
Inhalation:	Take affected person into fresh air. Consult a doctor if symptoms persist.

Ingestion:	Do **not** induce vomiting. If the person is unconscious, do not give anything by mouth. Consult a physician immediately.
Notes to physician:	Treatment should in general be symptomic and directed at relieving any effects. Note regarding high-pressure applications. Injection into the skin due to contact with a product under high pressure constitutes a major medical emergency. Within a few hours the tissue swells up and becomes discolored and extremely painful, with severe subcutaneous necrosis. Surgical treatment is absolutely imperative. Comprehensive opening of the wound and the tissue beneath it is necessary in order to reduce tissue loss and to prevent or limit lasting damage. The high pressure can cause the product to penetrate extensive areas of tissue layers.

14.2.2.5 Fire-fighting measures

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

14.2.2.6 Measures after unintended release

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

14.2.2.7 Handling and storage

Handling:	Prevent contact with skin or clothing. Spilled and leaked product must be prevented from coming into contact with soil and surface waters. Wash thoroughly after handling.
Storage:	Keep containers tightly sealed. Keep containers in a cool, well-ventilated area.
Unsuitable:	Avoid prolonged exposure to increased temperatures.

VCI storage class:	11

14.2.2.8 Exposure limits and personal protective equipment

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

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

14.2.2.9 Physical and chemical properties

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

14.2.2.10 Stability and reactivity

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

14.2.2.11 Toxicological information

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

14.2.2.12 Ecological information

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

14.2.2.13 Disposal information

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

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

14.2.2.14 Transport information

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

14.2.2.15 Regulations

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

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

14.2.2.16 Other information

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

14.2.3 Safety data sheet for LGEP 2 extreme pressure grease

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

14.2.3.1 Designation of substance/formulation and manufacturer

Name of substance/preparation	
Trade name:	**LGEP 2**
Use:	KF extreme pressure grease

Manufacturer designation	
Company:	**SKF Maintenance Products**
Address:	P.O. Box 1008
Postal code:	NL-3430, BA Nieuwegein
Country:	Netherlands
Telephone:	+31 30 6307200
Fax:	+31 30 6307205
Contact:	Sébastien David
e-mail address:	sebastien.david@skf.com

14.2.3.2 Composition / Information about the components

Chemical description	CAS no.	%	EC no.	Classification
Base oil – unspecified	-	60 - 100	-	-
Zinc dialkyl dithiophosphate	68649-42-3	<2,5	272-028-3	Xi; N; R38; R41; R51/53

14.2.3.3 Possible hazards

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

Effects and symptoms	
Eyes:	May cause 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).

14.2.3.4 First aid measures

Contact with eyes:	Rinse eyes immediately with plenty of water for several minutes. If irritation occurs, consult a doctor.
Skin contact:	Wash affected areas of skin with soap and water, or use suitable cleaning agent. Change clothing and shoes if they become contaminated with product. Wash clothing before reuse. Clean shoes thoroughly before reuse. If irritation occurs consult a doctor.
Inhalation:	Take affected person into fresh air. Consult a doctor if symptoms persist.
Ingestion:	Do **not** induce vomiting. If the person is unconscious, do not give anything by mouth. Consult a physician immediately.
Notes to physician:	Treatment should in general be symptomic and directed at relieving any effects. Note regarding high-pressure applications. Injection into the skin due to contact with a product under high pressure constitutes a major medical emergency. Within a few hours the tissue swells up and becomes discolored and extremely painful, with severe subcutaneous necrosis. Surgical treatment is absolutely imperative. Comprehensive opening of the wound and the tissue beneath it is necessary in order to reduce tissue loss and to prevent or limit lasting damage. The high pressure can cause the product to penetrate extensive areas of tissue layers.

14.2.3.5 Fire-fighting measures

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

14.2.3.6 Measures after unintended release

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

14.2.3.7 Handling and storage

Handling:	Prevent contact with skin or clothing. Spilled and leaked product must be prevented from coming into contact with soil and surface waters. Wash thoroughly after handling.
Storage:	Keep containers tightly sealed. Keep containers in a cool, well-ventilated area.
Unsuitable:	Avoid prolonged exposure to increased temperatures.

14.2.3.8 Exposure limits and personal protective equipment

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

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

14.2.3.9 Physical and chemical properties

Physical state:	Paste
Color:	Tan
Odor:	Mineral oil
Flash point:	> 150 °C

Density:	<1000 kg/m^3 (<1 g/cm^3) at 25 °C
Solubility:	Insoluble in water

14.2.3.10 Stability and reactivity

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

14.2.3.11 Toxicological information

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

14.2.3.12 Ecological information

Persistence / degradability:	Not easily biodegradable.
Mobility:	The product is insoluble in water. It floats on water.
Environmental hazards:	Prevent from entering wastewater and soil.

14.2.3.13 Disposal information

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

Unused product	
European Waste Catalog (EWC):	Waste code 13 02 08*: Other machine oils, gear oils and lubricating oils

Used/contaminated product	
European Waste Catalog (EWC):	Waste code 13 02 08*: Other 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.

Hazardous waste
This product is listed as a hazardous substance by the EU Directive on hazardous waste. Dispose of in accordance with all national and local regulations and statutory provisions in force.

14.2.3.14 Transport information

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

14.2.3.15 Regulations

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

Labeling requirements	
Safety warning	Irritant
R Phrases:	R38 - Irritating to skin. R41 - Risk of serious damage to eyes. R51/53: Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
Safety (S) phrases:	S24/25 - Avoid contact with eyes and skin. S37 - Wear suitable gloves.

List of relevant R phrases
R38 - Irritating to skin. R41 - Risk of serious damage to eyes. R51/53: Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

14.2.3.16 Other information

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

14.2.4 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.

14.2.4.1 Designation of substance/formulation and manufacturer

Name of substance/preparation	
Product name:	**Castrol Hyspin ZZ 46**

Name of substance/preparation	
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
Telephone:	Central customer service/environment/product safety: +49 (0)40 3594 01
Emergency hotline:	Carechem: +44 (0)208 762 8322 (24 hours)

14.2.4.2 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.

14.2.4.3 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:	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. Note regarding 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.

14.2.4.4 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. Note regarding 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.

14.2.4.5 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.

14.2.4.6 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.

14.2.4.7 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.

14.2.4.8 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.

14.2.4.9 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.

14.2.4.10 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).

14.2.4.11 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).

14.2.4.12 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.

14.2.4.13 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.

14.2.4.14 Transport information

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

14.2.4.15 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.

14.2.4.16 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.

14.2.5 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.

14.2.5.1 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**
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Country:	Germany
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Fax:	+49 (0)2161 909-392
Emergency hotline:	Carechem: +44 (0)208 762 8322
e-mail address:	MSDSadvice@bp.com

14.2.5.2 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 (>>> 14.2.5.11 "Toxicological information" Page 186) and (>>> 14.2.5.12 "Ecological information" Page 186) contain more detailed information on health hazards, symptoms and environmental risks.

14.2.5.3 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 (>>> 14.2.5.16 "Other information" Page 188) for the full text of the above R-phrases.

The occupational exposure limit values, where available, are specified in Section (>>> 14.2.5.8 "Exposure limits and personal protective equipment" Page 185).

14.2.5.4 First aid measures

Contact with eyes:	In case of contact, rinse eyes immediately with plenty of water for at least 15 minutes. If irritation occurs, consult a doctor.
Skin contact:	Wash affected areas of skin with soap and water, or use suitable cleaning agent. Change clothing and shoes if they become contaminated with product. Wash clothing before reuse. Clean shoes thoroughly before reuse. If irritation occurs consult a doctor.
Inhalation:	Take affected person into fresh air. Consult a doctor if symptoms persist.
Ingestion:	Do **not** induce vomiting unless explicitly directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this product have been swallowed, call a physician immediately.
Notes to physician:	Treatment should in general be symptomic and directed at relieving any effects. Note regarding high-pressure applications. Injection into the skin due to contact with a product under high pressure constitutes a major medical emergency. Within a few hours the tissue swells up and becomes discolored and extremely painful, with severe subcutaneous necrosis. Surgical treatment is absolutely imperative. Comprehensive opening of the wound and the tissue beneath it is necessary in order to reduce tissue loss and to prevent or limit lasting damage. The high pressure can cause the product to penetrate extensive areas of tissue layers.

14.2.5.5 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.

14.2.5.6 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 (>>> 14.2.5.8 "Exposure limits and personal protective equipment" Page 185)).
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 (>>> 14.2.5.13 "Disposal information" Page 187)). Disposal should be entrusted to a recognized waste disposal company. Contaminated absorbents can be just as dangerous as spilled material. Note: See (>>> 14.2.5.1 "Designation of substance/formulation and manufacturer" Page 182) for contact in emergencies and (>>> 14.2.5.13 "Disposal information" Page 187) 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.

14.2.5.7 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

14.2.5.8 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.

14.2.5.9 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.

14.2.5.10 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.

14.2.5.11 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.

14.2.5.12 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.

14.2.5.13 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.

14.2.5.14 Transport information

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

14.2.5.15 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.

14.2.5.16 Other information

List of R-phrases referred to in Section (>>> 14.2.5.11 "Toxicological information" Page 186) and Section (>>> 14.2.5.3 "Composition / Information about the components" Page 183)	R41 - Risk of serious damage to eyes. R38 - Irritating to skin. R50/53 - Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment. R52/53 - Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

History	
Date of issue:	23/11/2007.
Date of previous issue:	L31/08/2007.
Created by:	Product Stewardship Group.

Notes for the reader
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15 KUKA Service

15.1 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 KUKA System Software
- Optional software or modifications
- Archive of the software
- Application used
- External axes used
- Description of the problem, duration and frequency of the fault

15.2 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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