Robots

KR QUANTEC nano F exclusive

Specification

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Spez KR QUANTEC nano F exclusive V5

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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.

KIM-PS5-DOC

Translation of the original documentation

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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 System Software
- Instructions for options and accessories
- Parts catalog on storage medium

Each of these sets of instructions is a separate document.

1.2 Representation of warnings and notes

Safety

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

DANGER
These warnings mean that it is certain or highly probable that death or severe injuries **will** occur, if no precautions are taken.

WARNING
These warnings mean that death or severe injuries **may** occur, if no precautions are taken.

CAUTION
These warnings mean that minor injuries **may** occur, if no precautions are taken.

NOTICE
These warnings mean that damage to property **may** occur, if no precautions are taken.

These warnings contain references to safety-relevant information or general safety measures. These warnings do not refer to individual hazards or individual precautionary measures.

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

SAFETY INSTRUCTION
The following procedure must be followed exactly!

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

Notices

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

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

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.

This manipulator is suitable for use in component washing cells, but must only be operated when all the covers are completely mounted. Only neutral cleaners or other approved cleaning agents may be used.

NOTICE

The special requirements and application conditions for the intended use of this robot necessitate additional measures to be taken by the user. The following points must be complied with:

- If operation is interrupted, the robot must be washed thoroughly with tap water (see operating instructions).
- Supplemental corrosion protection and anti-corrosion agents are the responsibility of the user.
- Before performing work on the robot, it must be ensured that the ambient conditions are within the permissible limits for the personnel.

  Additional protective equipment may be necessary.

Misuse

Any use or application deviating from the intended use is deemed to be misuse and is not allowed. This includes e.g.:

- Transportation of persons and animals
- Use as a climbing aid
- Use outside the permissible operating parameters
- Use in potentially explosive environments
- Operation in underground mining
- Use with non-approved cleaning agents. Only neutral cleaners may be used as cleaning agents.

- Use at non-approved operating pressures and temperatures

NOTICE

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

NOTICE

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

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

3 Product description

3.1 Overview of the robot system

A robot system (>>> *Fig. 3-1*) comprises all the assemblies of an industrial robot, including the manipulator (mechanical system and electrical installations), control cabinet, connecting cables, end effector (tool) and other equipment. The KR QUANTEC nano F exclusive product family comprises the variants:

- KR 120 R2100 nano F exclusive
- KR 180 R2100 nano F exclusive

An industrial robot of this type comprises the following components:

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

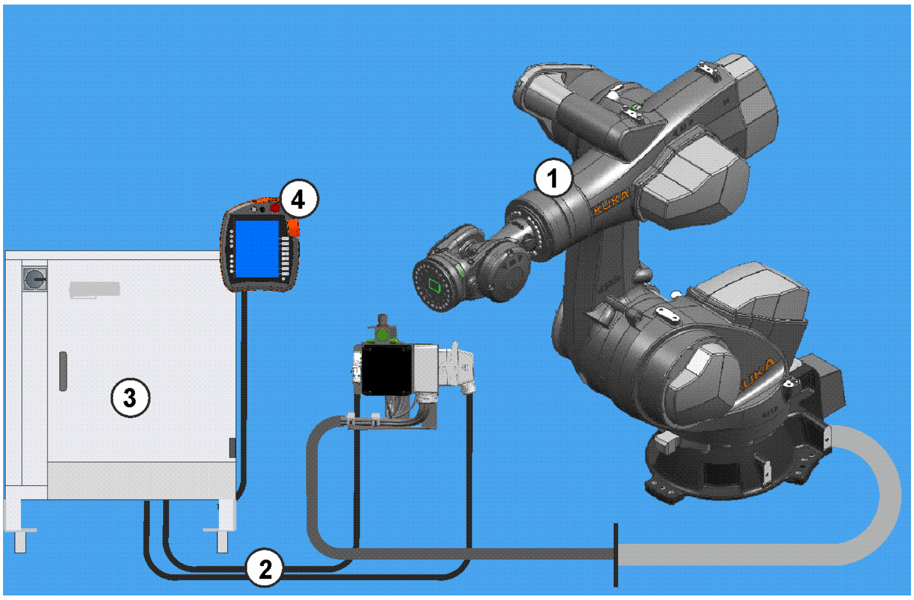


Fig. 3-1: Representation of the robot system

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

3.2 Description of the manipulator

Overview

The manipulators (robot = robot arm and electrical installations) (>>> *Fig. 3-2*) of the Quantec nano 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
- Electrical installations

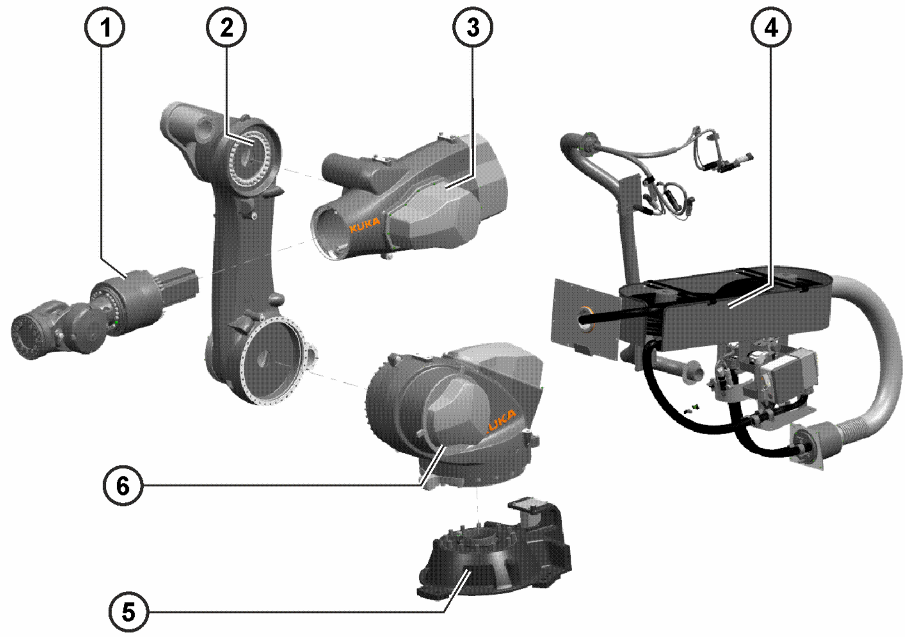


Fig. 3-2: Principal components

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

In-line wrist

The robot is fitted with a 3-axis in-line wrist for a rated payload of 120 kg or 180 kg. 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. A mounting flange with a 160 mm hole circle is used on the in-line wrist. The mounting flange conforms, with minimal deviations, to ISO 9409-1:2004.

The mounting flange also has an O-ring groove for a 174x3 O-ring to enable a static seal to be established between the tool and the mounting flange if necessary.

Arm

The arm is the link between the in-line wrist and the link arm. It houses the motors of wrist axes 3, 4 and 5. The arm is driven by the motor and the gear unit 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. The gear unit of axis 3 is integrated into the arm. There is an interface on the arm with 4 holes for fastening supplementary loads.

The arm is completely encapsulated and has a sealing air supply.

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.

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.

The rotating column is enclosed such that all components are protected from water spray. The assembly has a sealing air supply.

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. All cables are routed out at the rear and grouped together in a remote junction box.

The removable fork slots are also fastened to the base frame.

Electrical installations

The electrical installations include all the motor and control cables for the motors of axes 1 to 6. All connections are implemented as connectors in order to enable the motors to be exchanged quickly and reliably. The electrical installations also include the RDC box and the multi-function housing (MFH). The RDC box, MFH and pressure regulators for the pressurization (sealing air) are grouped together on a holder to form a module and installed externally. The compressed air supply and the connecting cables from the robot controller are connected here by means of connectors.

The electrical installation is available in designs of 5 m, 7.5 m and 10 m – always with a length of 2.50 m within the wet cell.

Together, the MFH, RDC box, pressure regulators and holder form the connection unit. This unit must be located outside the area around the robot that is exposed to water spray (if necessary, in another room) (>>> *Fig. 6-3*).

The electrical installations also include a protective circuit.

Options

The robot can be fitted and operated with various options, e.g. working range limitation for A1. A sealing air monitoring system is also available.

The options are described in separate documentation.

4 Technical data

4.1 Technical data, KR 120 R2100 nano F exclusive

4.1.1 Basic data, KR 120 R2100 nano F exclusive

Basic data

	KR 120 R2100 nano F exclusive
Number of axes	6
Number of controlled axes	6
Volume of working envelope	29.7 m³
Pose repeatability (ISO 9283)	± 0.05 mm
Weight	approx. 963 kg
Rated payload	120 kg
Maximum reach	2100 mm
Protection rating of base frame (IEC 60529)	IP65 / IP67 / IP69
Protection rating of rotating column / link arm / arm (IEC 60529)	IP65 / IP67 / IP69
Protection rating, in-line wrist (IEC 60529)	IP65 / IP67 / IP69
Sound level	< 75 dB (A)
Mounting position	Floor
Footprint	850 mm x 615 mm
Hole pattern: mounting surface for kinematic system	C590
Permissible angle of inclination	≤ 5 °
Default color	Cover: stainless steel
Controller	KR C4
Transformation name	KR C4: KR120R2100 NANO FEX C4 FLR

Ambient conditions

Humidity class (EN 60204)	-
Classification of environmental conditions (EN 60721-3-3)	3K3; 3Z10
Ambient temperature	
During operation	10 °C to 55 °C (283 K to 328 K)
During storage/transportation	-40 °C to 60 °C (233 K to 333 K)

pH value	7.0 to 9.5
Cleaning agents	Neutral cleaning agents Cleaner concentration 1% to 2% The use of salt-free cleaning agents with corrosion inhibitors is recommended.

Pressurization

Overpressure in the robot	0.03 MPa (0.3 bar)
Compressed air	Free of oil and water Class 4 in accordance with ISO 8573-1
Compressed air supply line	Air line in the cable set
Air consumption	3 l/min
Air line connection	Quick Star push-in fitting for hose PLN-6x1, black
Pressure regulator connection	R 1/8", internal thread
Input pressure	0.1 - 1.2 MPa (1 - 12 bar)
Pressure regulator	0.005 - 0.07 MPa (0.05 - 0.7 bar)
Manometer range	0.0 - 0.1 MPa (0.0 - 1.0 bar)
Filter gauge	25 - 30 µm

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	3 m, 7 m, 15 m, 25 m, 35 m

Minimum bending radius	5x D

For detailed specifications of the connecting cables, see Chapter (>>> 6 "Planning" Page 62).

4.1.2 Axis data, KR 120 R2100 nano F exclusive

Axis data

Motion range	
A1	±165 °
A2	-135 ° / 45 °
A3	-65 ° / 155 °

A4	±350 °
A5	±125 °
A6	±350 °
Speed with rated payload	
A1	136 °/s
A2	95 °/s
A3	120 °/s
A4	292 °/s
A5	258 °/s
A6	284 °/s

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

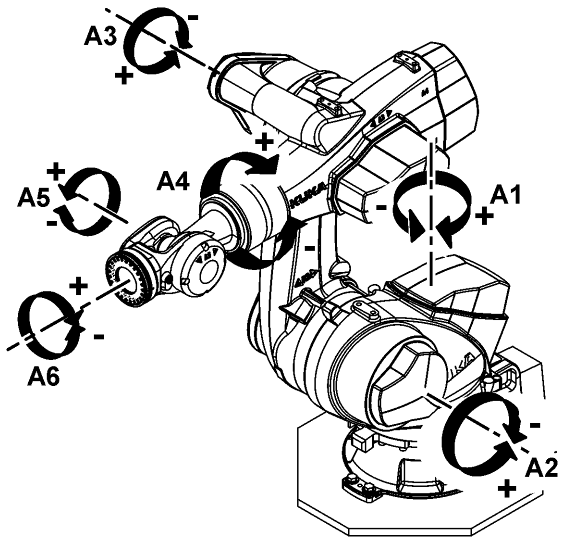


Fig. 4-1: Direction of rotation of the robot axes

Working envelope

The following diagrams (>>> *Fig. 4-2*) and (>>> *Fig. 4-3*) show the shape and size of the working envelope for the KR 120 R2100 nano F exclusive variants.

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

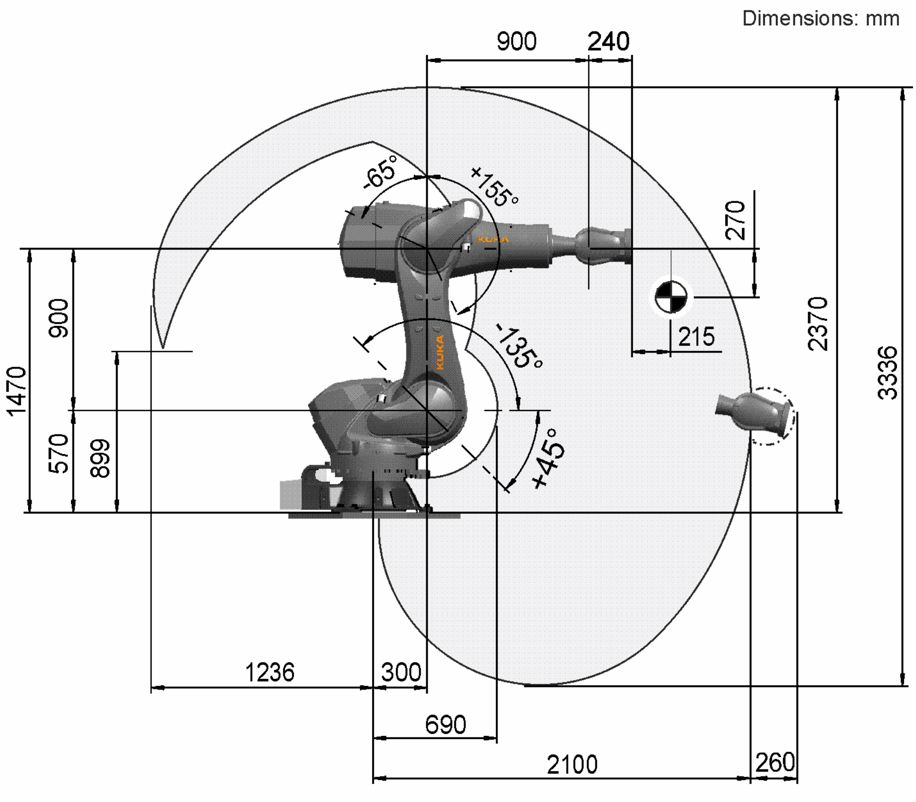


Fig. 4-2: Working envelope, side view, KR 120 R2100 nano F exclusive

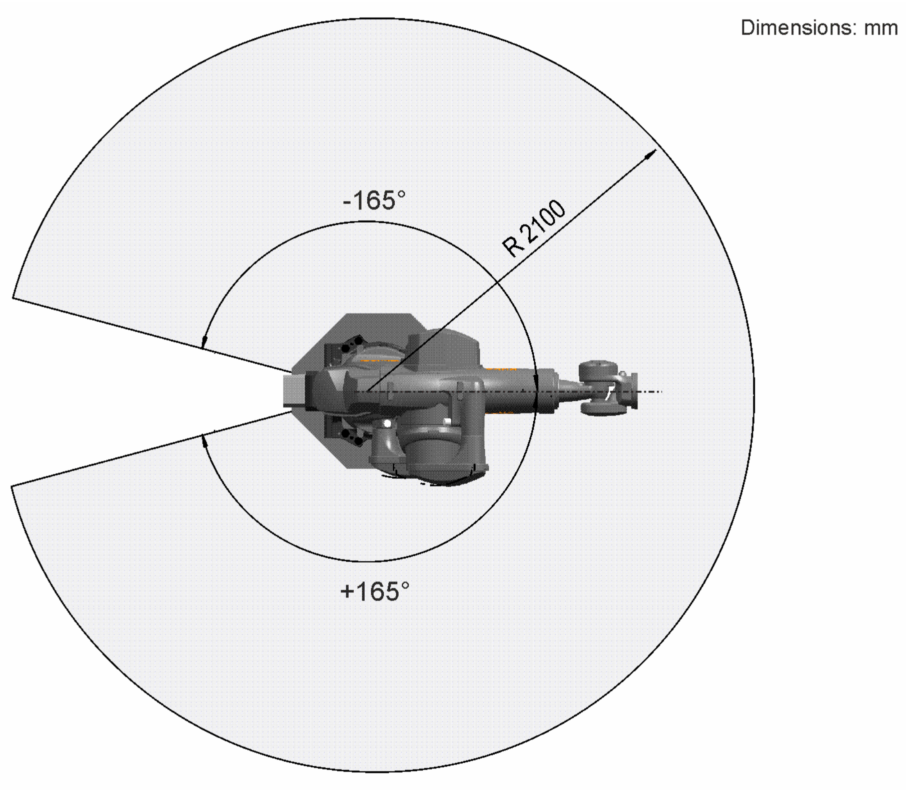


Fig. 4-3: Working envelope, top view, KR 120 R2100 nano F exclusive

4.1.3 Payloads, KR 120 R2100 nano F exclusive

Payloads

Rated payload	120 kg
Rated mass moment of inertia	60 kgm²
Rated total load	150 kg
Rated supplementary load, base frame	0 kg
Maximum supplementary load, base frame	0 kg
Rated supplementary load, rotating column	0 kg
Maximum supplementary load, rotating column	0 kg
Rated supplementary load, link arm	0 kg
Maximum supplementary load, link arm	0 kg
Rated supplementary load, arm	30 kg
Maximum supplementary load, arm	30 kg
Nominal distance to load center of gravity	
Lxy	270 mm
Lz	215 mm

NOTICE

Exceeding the payloads and supplementary loads will reduce the service life of the robot and overload the motors and the gears. We recommend always testing the specific application with KUKA.Load. In cases where individual values are exceeded, KUKA Deutschland GmbH must be consulted.

Load center of gravity

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.

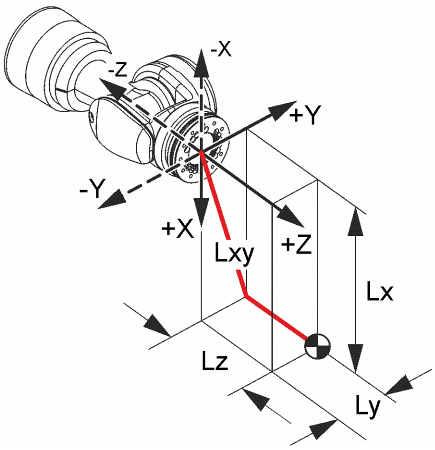


Fig. 4-4: Load center of gravity

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 KUKA Deutschland GmbH must be consulted beforehand.
> The values determined here are necessary for planning the robot application. For commissioning the robot, additional input data are required in accordance with the operating and programming instructions of the KUKA System Software.
> The mass inertia must be verified using KUKA.Load. It is imperative for the load data to be entered in the robot controller!

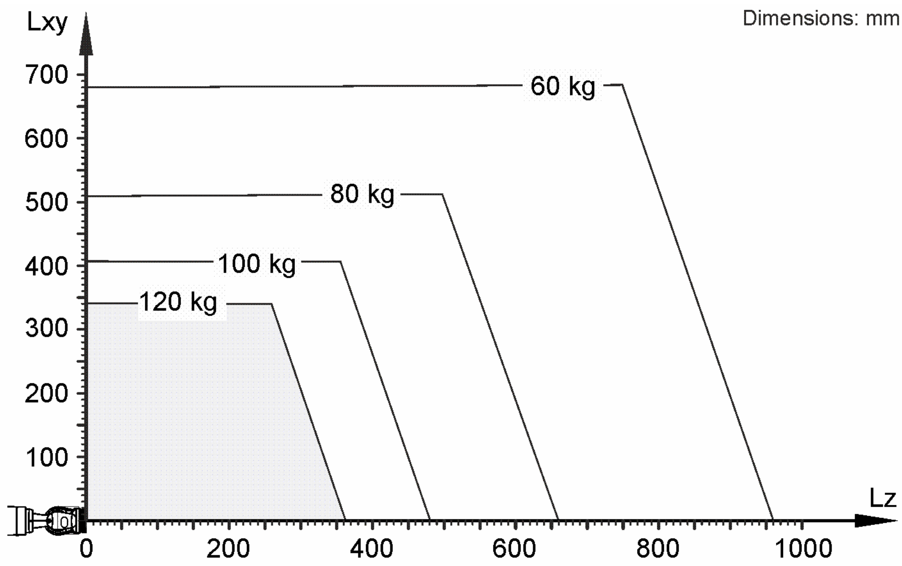


Fig. 4-5: Payload diagram, KR 120 R2100 nano F exclusive

Mounting flange D=160 mm

In-line wrist type	ZH 120
Mounting flange	see drawing

Mounting flange (hole circle)	160 mm
Screw grade	A4-80
Screw size	M10
Number of fastening threads	23
Clamping length	1.5 x nominal diameter
Depth of engagement	min. 12 mm, max. 16 mm
Locating element	10 ^{H7}

Mounting flange D=160 mm

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

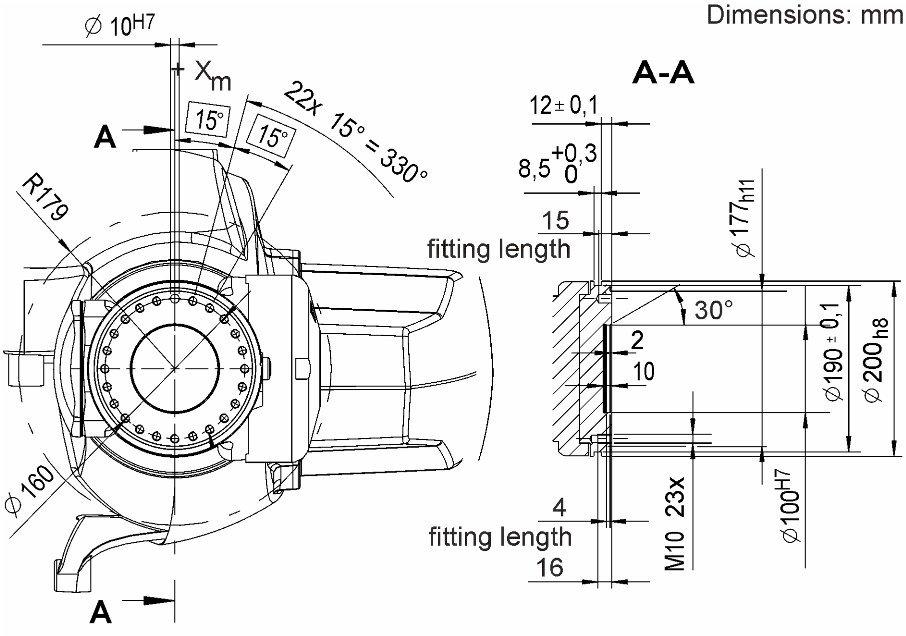


Fig. 4-6: Mounting flange D = 160

Flange loads

Due to the motion of the payload (e.g. tool) mounted on the robot, forces and torques act on the mounting flange. These forces and torques depend on the motion profile as well as the mass, load center of gravity and mass moment of inertia of the payload.

The specified values refer to nominal payloads at the nominal distance and do not include safety factors. It is imperative for the load data to be entered in the robot controller. The robot controller takes the payload into consideration during path planning. A reduced payload does not necessarily result in lower forces and torques.

The values are guide values determined by means of trial and simulation and refer to the most heavily loaded machine in the robot family. The actual forces and torques may differ due to internal and external influences on the mounting flange or a different point of application. It is therefore advisable to determine the exact forces and torques where necessary on site under the real conditions of the actual robot application.

The operating values may occur permanently in the normal motion profile. It is advisable to rate the tool for its fatigue strength.

The EMERGENCY STOP values may arise in the event of an Emergency Stop situation of the robot. As these should only occur very rarely during the service life of the robot, a static strength verification is usually sufficient.

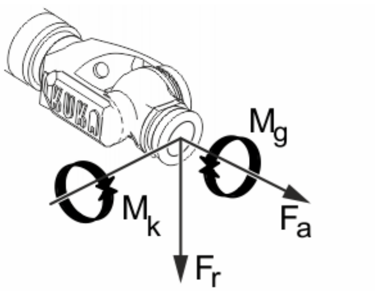


Fig. 4-7: Flange loads

Flange loads during operation	
F(a)	2720 N
F(r)	2570 N
M(k)	1766 Nm
M(g)	944 Nm
Flange loads in the case of EMERGENCY STOP	
F(a)	2724 N
F(r)	3155 N
M(k)	2119 Nm
M(g)	1973 Nm

Axial force F(a), radial force F(r), tilting torque M(k), torque about mounting flange M(g)

4.1.4 Loads acting on the foundation, KR 120 R2100 nano F exclusive

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

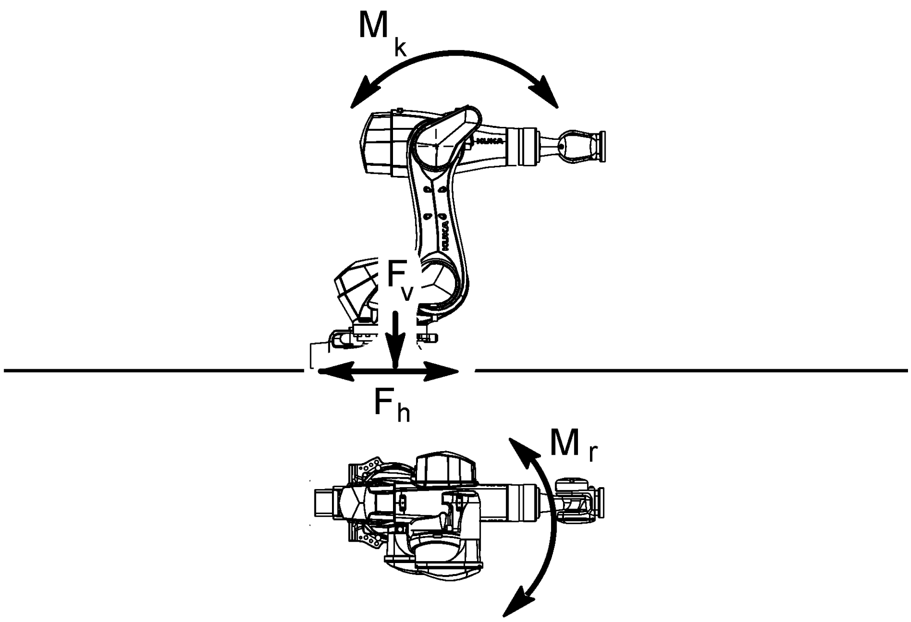


Fig. 4-8: Mounting base loads

Vertical force F(v)	
F(v normal)	13509 N
F(v max)	14324 N
Horizontal force F(h)	
F(h normal)	4039 N
F(h max)	4562 N
Tilting moment M(k)	
M(k normal)	13125 Nm
M(k max)	16660 Nm
Torque about axis 1 M(r)	

M(r normal)	4018 Nm
M(r max)	5144 Nm

Vertical force F(v), horizontal force F(h), tilting torque M(k), torque about axis 1 M(r)

WARNING

Normal loads and maximum loads for the foundations are specified in the table.
The maximum loads must be referred to when dimensioning the foundations and must be adhered to for safety reasons. Failure to observe this can result in personal injury and damage to property.
The normal loads are average expected foundation loads. The actual loads are dependent on the program and on the robot loads and may therefore be greater or less than the normal loads.
The supplementary loads (A1 and A2) are not taken into consideration in the calculation of the mounting base load. These supplementary loads must be taken into consideration for F_V.

4.2 Technical data, KR 180 R2100 nano F exclusive

4.2.1 Basic data, KR 180 R2100 nano F exclusive

Basic data

	KR 180 R2100 nano F exclusive
Number of axes	6
Number of controlled axes	6
Volume of working envelope	29.7 m³
Pose repeatability (ISO 9283)	± 0.05 mm
Weight	approx. 998 kg
Rated payload	180 kg
Maximum reach	2100 mm
Protection rating of base frame (IEC 60529)	IP65 / IP67 / IP69
Protection rating of rotating column / link arm / arm (IEC 60529)	IP65 / IP67 / IP69
Protection rating, in-line wrist (IEC 60529)	IP65 / IP67 / IP69
Sound level	< 75 dB (A)
Mounting position	Floor
Footprint	850 mm x 615 mm
Hole pattern: mounting surface for kinematic system	C590
Permissible angle of inclination	≤ 5 °
Default color	Cover: stainless steel
Controller	KR C4
Transformation name	KR C4: KR180R2100 NANO FEX C4 FLR

Ambient conditions

Humidity class (EN 60204)	-
Classification of environmental conditions (EN 60721-3-3)	3K3; 3Z10
Ambient temperature	
During operation	10 °C to 55 °C (283 K to 328 K)
During storage/transportation	-40 °C to 60 °C (233 K to 333 K)

pH value	7.0 to 9.5
Cleaning agents	Neutral cleaning agents Cleaner concentration 1% to 2% The use of salt-free cleaning agents with corrosion inhibitors is recommended.

Pressurization

Overpressure in the robot	0.03 MPa (0.3 bar)
Compressed air	Free of oil and water Class 4 in accordance with ISO 8573-1
Compressed air supply line	Air line in the cable set
Air consumption	3 l/min
Air line connection	Quick Star push-in fitting for hose PLN-6x1, black
Pressure regulator connection	R 1/8", internal thread
Input pressure	0.1 - 1.2 MPa (1 - 12 bar)
Pressure regulator	0.005 - 0.07 MPa (0.05 - 0.7 bar)
Manometer range	0.0 - 0.1 MPa (0.0 - 1.0 bar)
Filter gauge	25 - 30 µm

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	3 m, 7 m, 15 m, 25 m, 35 m

Minimum bending radius	5x D

For detailed specifications of the connecting cables, see Chapter (>>> 6 "Planning" Page 62).

4.2.2 Axis data, KR 180 R2100 nano F exclusive

Axis data

Motion range	
A1	±165 °
A2	-135 ° / 45 °
A3	-65 ° / 155 °
A4	±350 °
A5	±125 °
A6	±350 °
Speed with rated payload	
A1	136 °/s
A2	95 °/s
A3	120 °/s
A4	179 °/s
A5	172 °/s
A6	219 °/s

The direction of motion and the arrangement of the individual axes may be noted from the diagram (>>> Fig. 4-9).

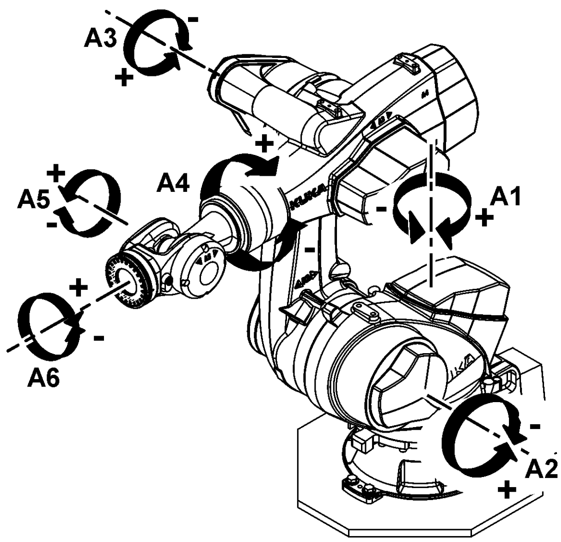


Fig. 4-9: Direction of rotation of the robot axes

Working envelope

The following diagrams (>>> *Fig. 4-10*) and (>>> *Fig. 4-11*) show the shape and size of the working envelope for the KR 180 R2100 nano F exclusive variants.

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

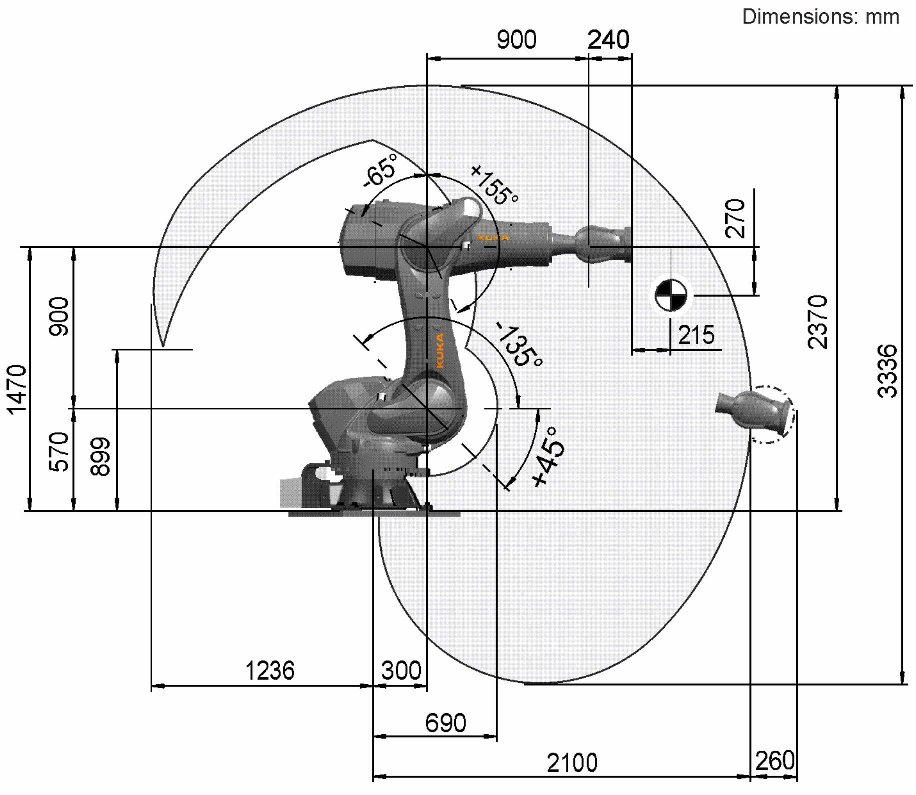


Fig. 4-10: Working envelope, side view, KR 180 R2100 nano F exclusive

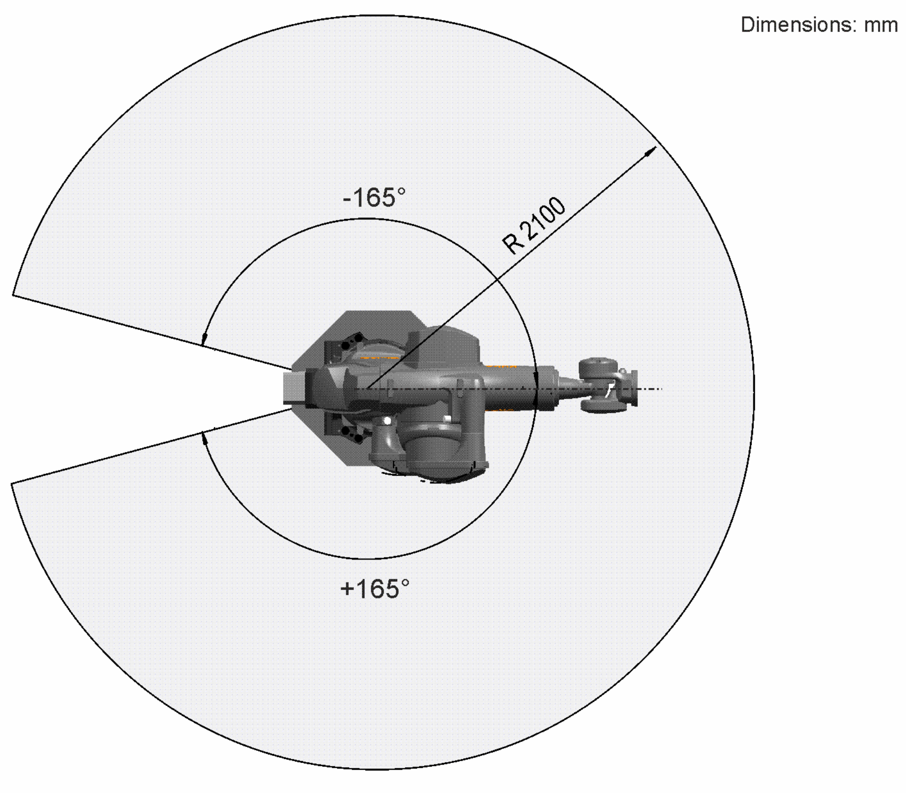


Fig. 4-11: Working envelope, top view, KR 180 R2100 nano F exclusive

4.2.3 Payloads, KR 180 R2100 nano F exclusive

Payloads

Rated payload	180 kg
Rated mass moment of inertia	60 kgm²
Rated total load	210 kg
Rated supplementary load, base frame	0 kg
Maximum supplementary load, base frame	0 kg
Rated supplementary load, rotating column	0 kg
Maximum supplementary load, rotating column	0 kg
Rated supplementary load, link arm	0 kg
Maximum supplementary load, link arm	0 kg
Rated supplementary load, arm	30 kg
Maximum supplementary load, arm	30 kg
Nominal distance to load center of gravity	
Lxy	270 mm

Lz	215 mm

NOTICE

Exceeding the payloads and supplementary loads will reduce the service life of the robot and overload the motors and the gears. We recommend always testing the specific application with KUKA.Load. In cases where individual values are exceeded, KUKA Deutschland GmbH must be consulted.

Load center of gravity

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.

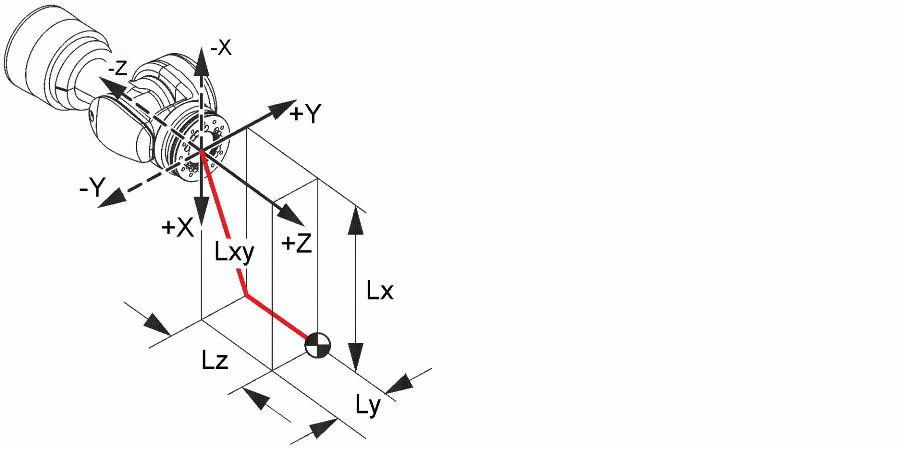


Fig. 4-12: Load center of gravity

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 KUKA Deutschland GmbH must be consulted beforehand.
The values determined here are necessary for planning the robot application. For commissioning the robot, additional input data are required in accordance with the operating and programming instructions of the KUKA System Software.
The mass inertia must be verified using KUKA.Load. It is imperative for the load data to be entered in the robot controller!

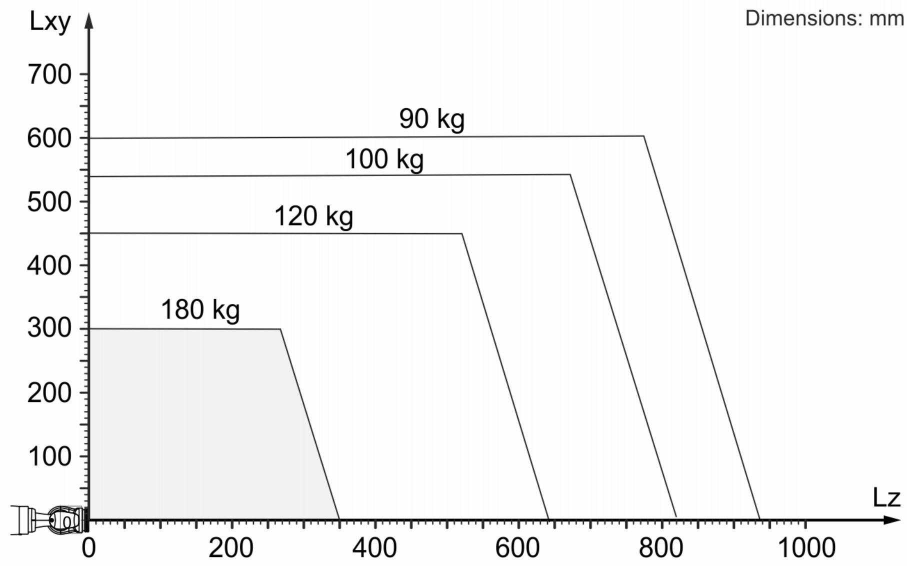


Fig. 4-13: Payload diagram, KR 180 R2100 nano F exclusive

In-line wrist

In-line wrist type	ZH 180
Mounting flange	see drawing

Mounting flange (hole circle)	160 mm
Screw grade	A4-80
Screw size	M10
Number of fastening threads	23
Clamping length	1.5 x nominal diameter
Depth of engagement	min. 12 mm, max. 16 mm
Locating element	10 ^{H7}

Mounting flange D=160 mm

The mounting flange is depicted (>>> *Fig. 4-14*) 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.

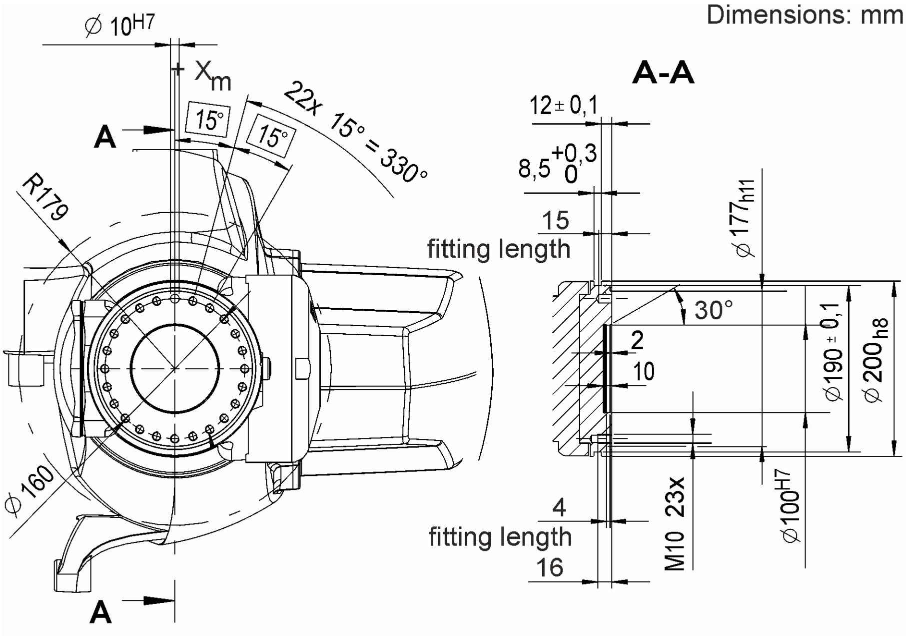


Fig. 4-14: Mounting flange D = 160

Flange loads

Due to the motion of the payload (e.g. tool) mounted on the robot, forces and torques act on the mounting flange. These forces and torques depend on the motion profile as well as the mass, load center of gravity and mass moment of inertia of the payload.

The specified values refer to nominal payloads at the nominal distance and do not include safety factors. It is imperative for the load data to be entered in the robot controller. The robot controller takes the payload into consideration during path planning. A reduced payload does not necessarily result in lower forces and torques.

The values are guide values determined by means of trial and simulation and refer to the most heavily loaded machine in the robot family. The actual forces and torques may differ due to internal and external influences on the mounting flange or a different point of application. It is therefore advisable to determine the exact forces and torques where necessary on site under the real conditions of the actual robot application.

The operating values may occur permanently in the normal motion profile. It is advisable to rate the tool for its fatigue strength.

The EMERGENCY STOP values may arise in the event of an Emergency Stop situation of the robot. As these should only occur very rarely during the service life of the robot, a static strength verification is usually sufficient.

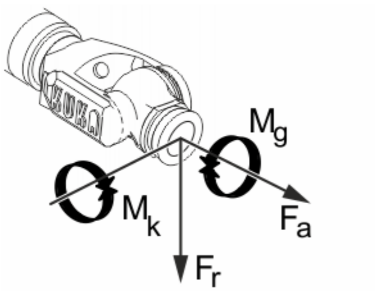


Fig. 4-15: Flange loads

Flange loads during operation	
F(a)	3124 N
F(r)	3090 N
M(k)	2082 Nm
M(g)	929 Nm
Flange loads in the case of EMERGENCY STOP	
F(a)	4091 N
F(r)	4184 N
M(k)	2777 Nm
M(g)	2107 Nm

Axial force F(a), radial force F(r), tilting torque M(k), torque about mounting flange M(g)

4.2.4 Loads acting on the foundation, KR 180 R2100 nano F exclusive

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

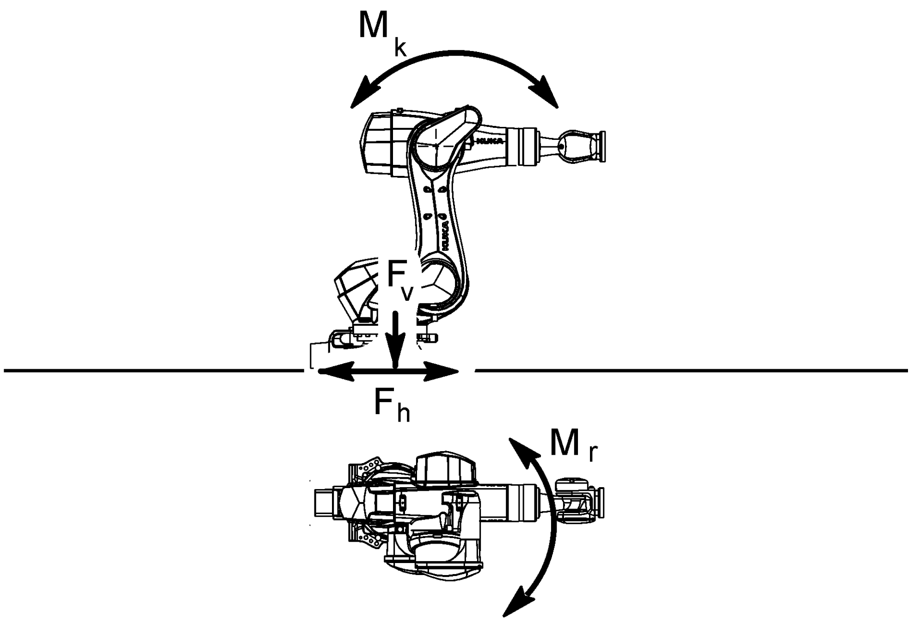


Fig. 4-16: Mounting base loads

Vertical force F(v)	
F(v normal)	14324 N
F(v max)	14909 N
Horizontal force F(h)	
F(h normal)	4025 N
F(h max)	4617 N
Tilting moment M(k)	
M(k normal)	13255 Nm
M(k max)	16946 Nm
Torque about axis 1 M(r)	

M(r normal)	4333 Nm
M(r max)	4918 Nm

Vertical force F(v), horizontal force F(h), tilting torque M(k), torque about axis 1 M(r)

WARNING

Normal loads and maximum loads for the foundations are specified in the table.
The maximum loads must be referred to when dimensioning the foundations and must be adhered to for safety reasons. Failure to observe this can result in personal injury and damage to property.
The normal loads are average expected foundation loads. The actual loads are dependent on the program and on the robot loads and may therefore be greater or less than the normal loads.
The supplementary loads (A1 and A2) are not taken into consideration in the calculation of the mounting base load. These supplementary loads must be taken into consideration for F_v.

4.3 Transport dimensions

The transport dimensions for this robot can be noted from the following diagrams (>>> *Fig. 4-17*) (>>> *Fig. 4-18*). The position of the center of gravity and the weight vary according to the specific configuration. The specified dimensions refer to the robot without equipment. The diagrams show the dimensions of the robot when it stands on the floor without wooden transport blocks.

If the tray with the connection unit is removed, it must be carried along with the robot manually during transport and the flexible tube must not be subjected to excessive loads.

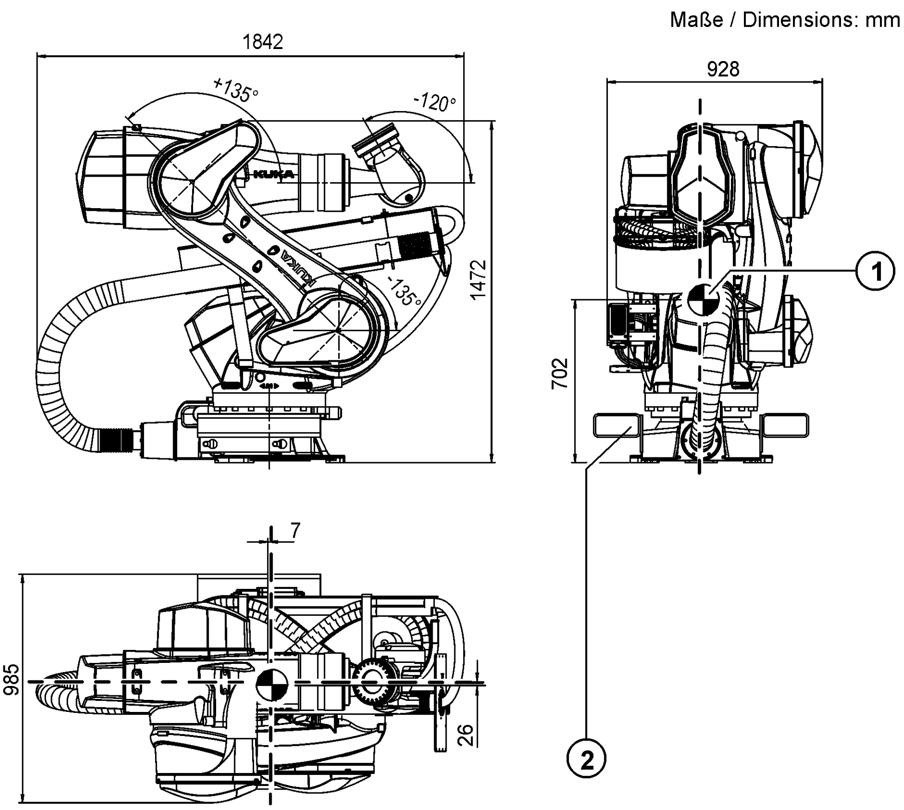


Fig. 4-17: Transport dimensions with tray

1 Center of gravity
2 Fork slots

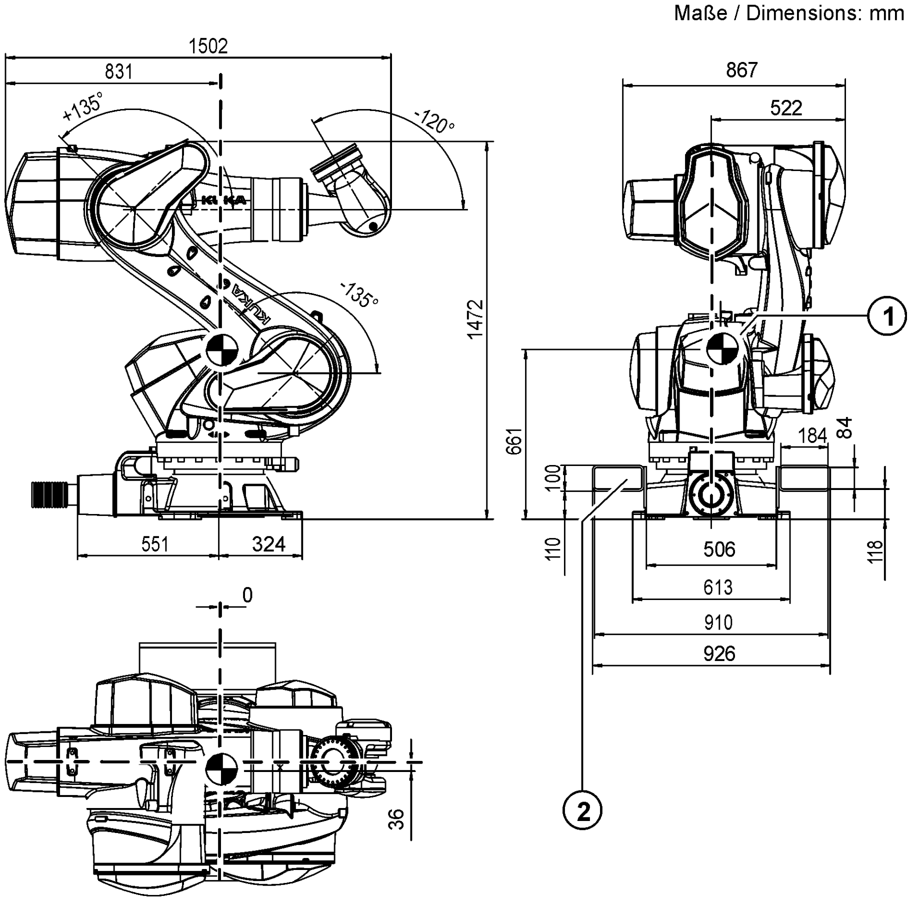


Fig. 4-18: Transport dimensions without tray

1 Center of gravity
2 Fork slots

4.4 Supplementary load

The robot can carry supplementary loads (>>> *Fig. 4-19*) 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.

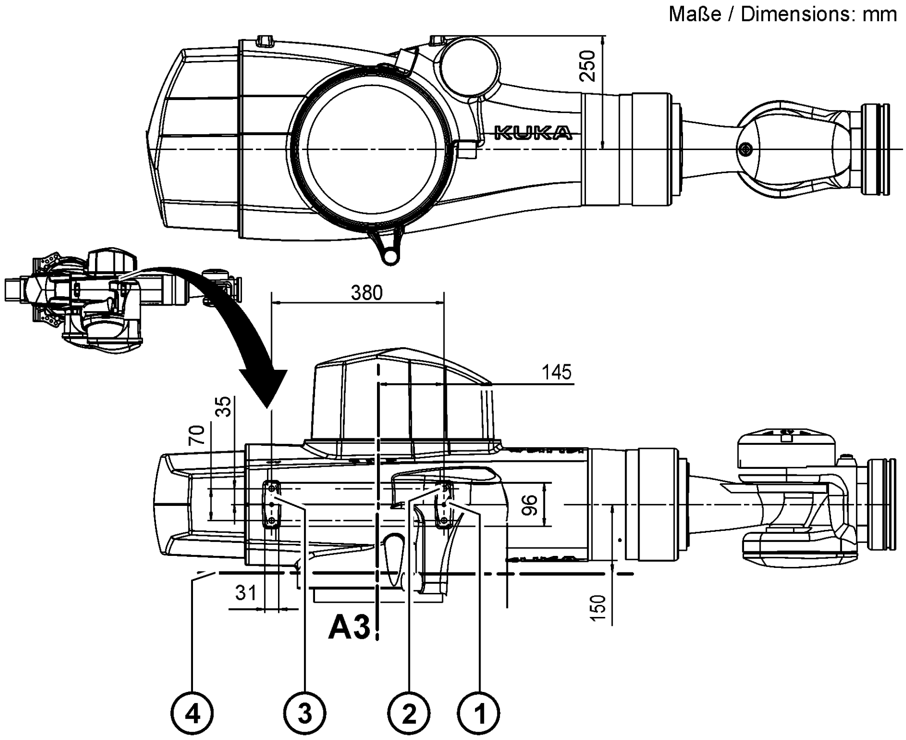


Fig. 4-19: Supplementary load, arm

1 Fastening borehole, 8 mm, 15 deep, 2x
2 Fastening threads, M12, 24 deep, 4x
3 Mounting surface, 2x
4 Interference contour, arm

4.5 Plates and labels

Plates and labels

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

Plates 7 to 9 must be attached in a clearly visible position at the entrance to the cell.

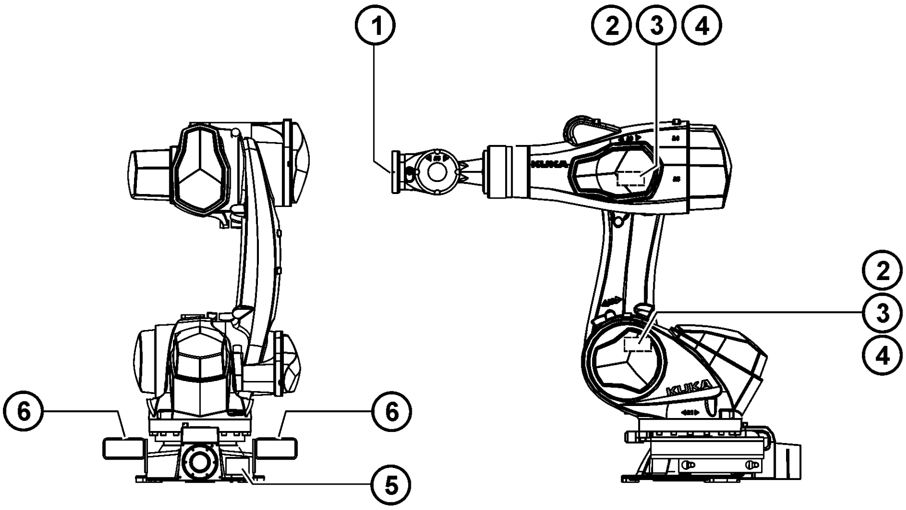
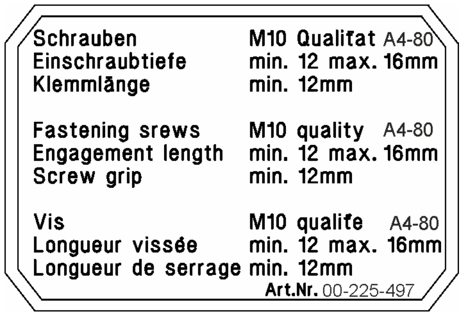
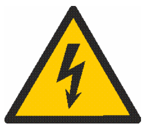
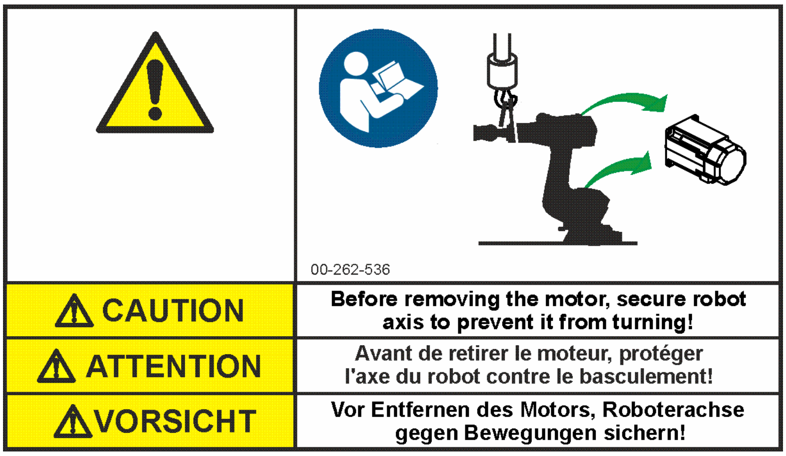
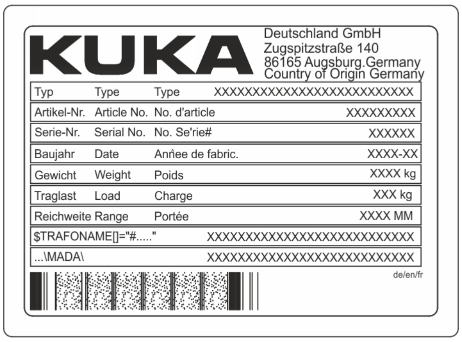
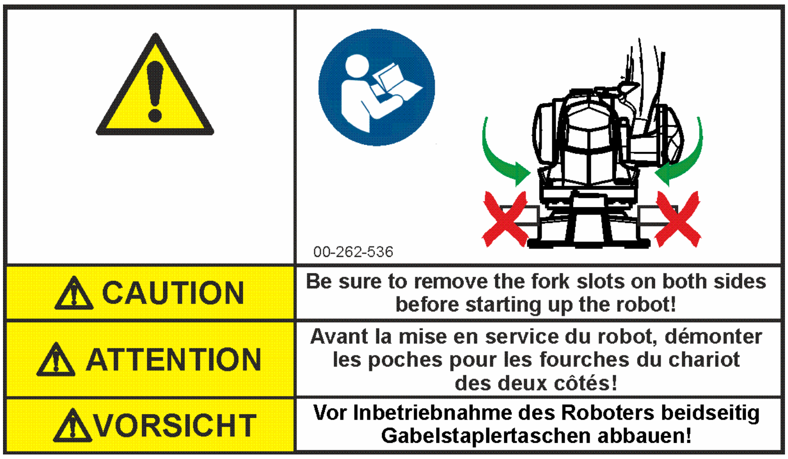


Fig. 4-20: Location of plates and labels

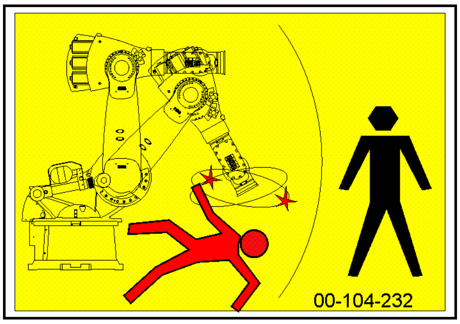
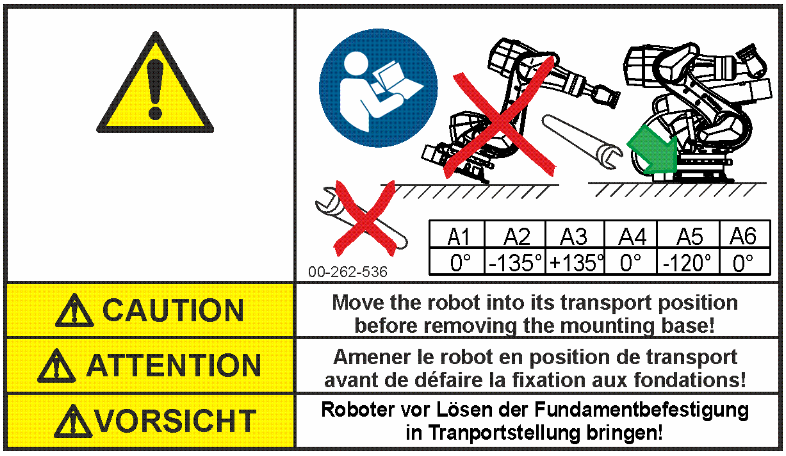
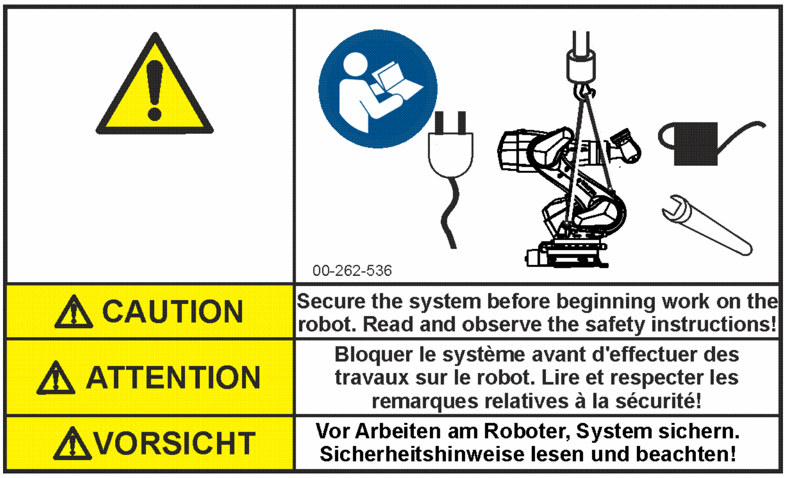
Item	Description
1	 **Mounting flange on in-line wrist** The values specified on this plate apply for the installation of tools on the mounting flange of the wrist and must be observed.
2	 **High voltage** Any improper handling can lead to contact with current-carrying components. Electric shock hazard!
3	 **Hot surface** During operation of the robot, surface temperatures may be reached that could result in burn injuries. Protective gloves must be worn!

<table>
<tr><th>Item</th><th>Description</th></tr>
<tr><td>4</td><td>


Secure the axes
Before exchanging any motor, secure the corresponding axis through safeguarding by suitable means/devices to protect against possible movement. The axis can move. Risk of crushing!
</td></tr>
<tr><td>5</td><td>


Identification plate
Content according to Machinery Directive.
</td></tr>
<tr><td>6</td><td>


Remove the fork slots
The fork slots are located within the interference range of axis 1. Before starting up the robot, the fork slots must be removed. Risk of damage to the rotating column and fork slots!
</td></tr>
</table>

Item	Description
7	 **Danger zone** Entering the danger zone of the robot is prohibited if the robot is in operation or ready for operation. Risk of injury!
8	 **Transport position** Before loosening the bolts of the mounting base, the robot must be in the transport position as indicated in the table. Risk of toppling!
9	 **Work on the robot** Before start-up, transportation or maintenance, read and follow the assembly and operating instructions.

4.6 REACH duty to communicate information acc. to Art. 33 of Regulation (EC) 1907/2006

On the basis of the information provided by our suppliers, this product and its components contain no substances included on the "Candidate List" of

Substances of Very High Concern (SVHCs) in a concentration exceeding 0.1 percent by mass.

4.7 Stopping distances and times

4.7.1 General information

Information concerning the data:

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

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

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

4.7.2 Terms used

Term	Description
m	Mass of the rated load and the supplementary load on the arm.
Phi	Angle of rotation (°) about the corresponding axis. This value can be entered in the controller via the KCP/smartPAD and can be displayed on the KCP/smartPAD.
POV	Program override (%) = velocity of the robot motion. This value can be entered in the controller via the KCP/smartPAD and can be displayed on the KCP/smartPAD.
Extension	Distance (l in %) (>>> *Fig. 4-21*) between axis 1 and the intersection of axes 4 and 5. With parallelogram

Term	Description
	robots, the distance between axis 1 and the intersection of axis 6 and the mounting flange.
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.
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.

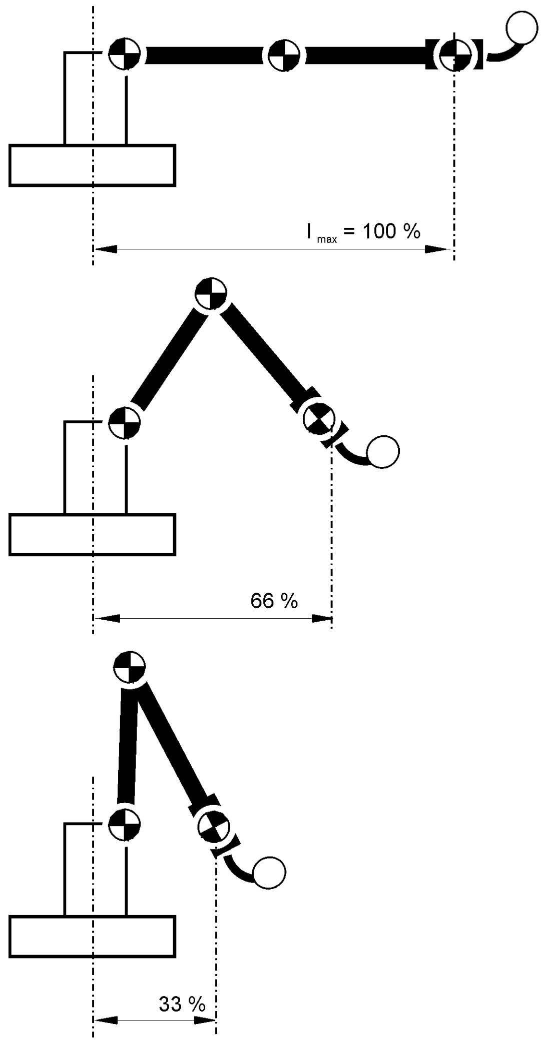


Fig. 4-21: Extension

4.7.3 Stopping distances and stopping times, KR 120 R2100 nano F exclusive

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

	Stopping distance (°)	Stopping time (s)
Axis 1	46.81	0.61
Axis 2	19.97	0.36
Axis 3	23.23	0.30

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

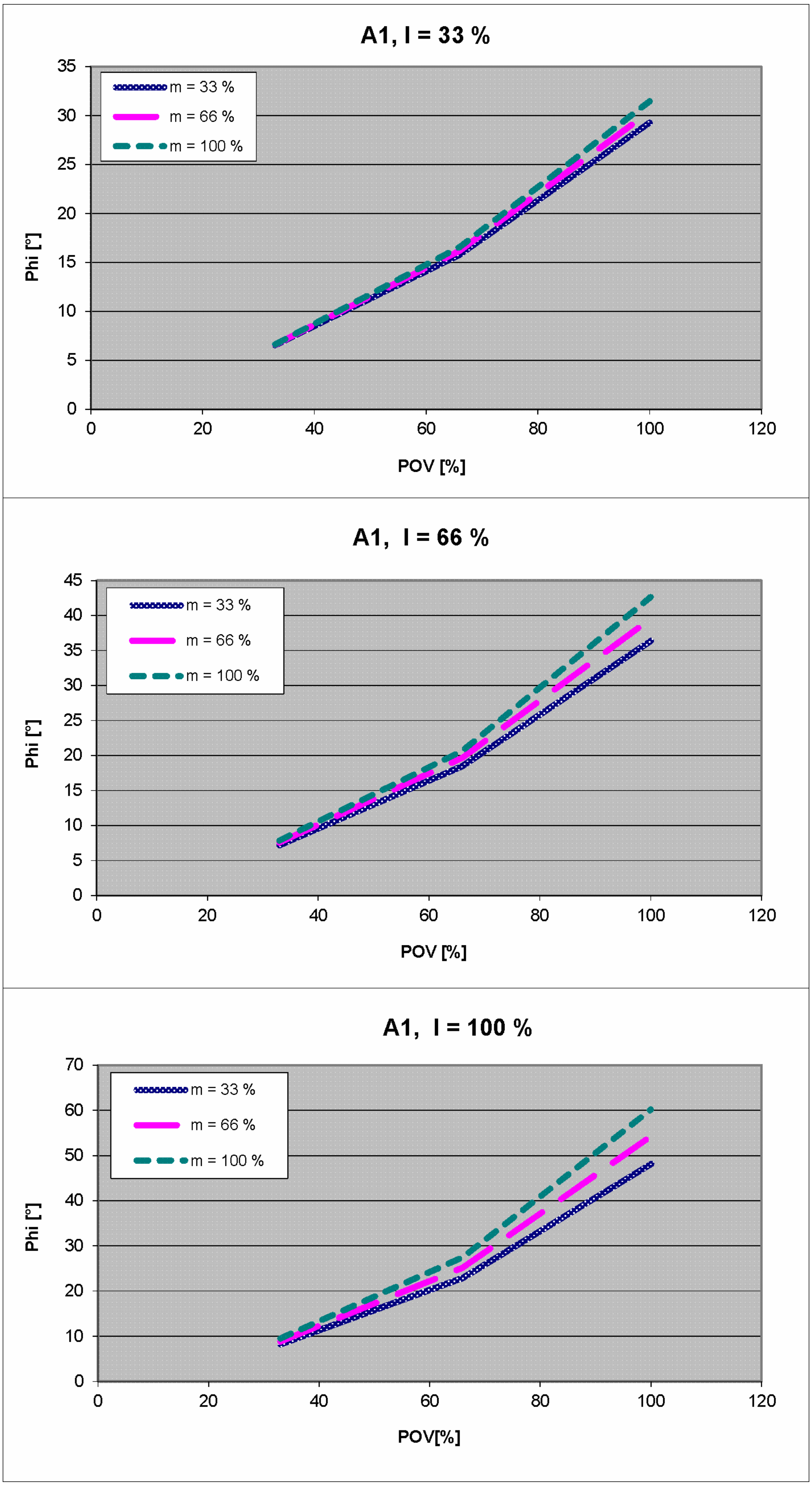


Fig. 4-22: Stopping distances for STOP 1, axis 1

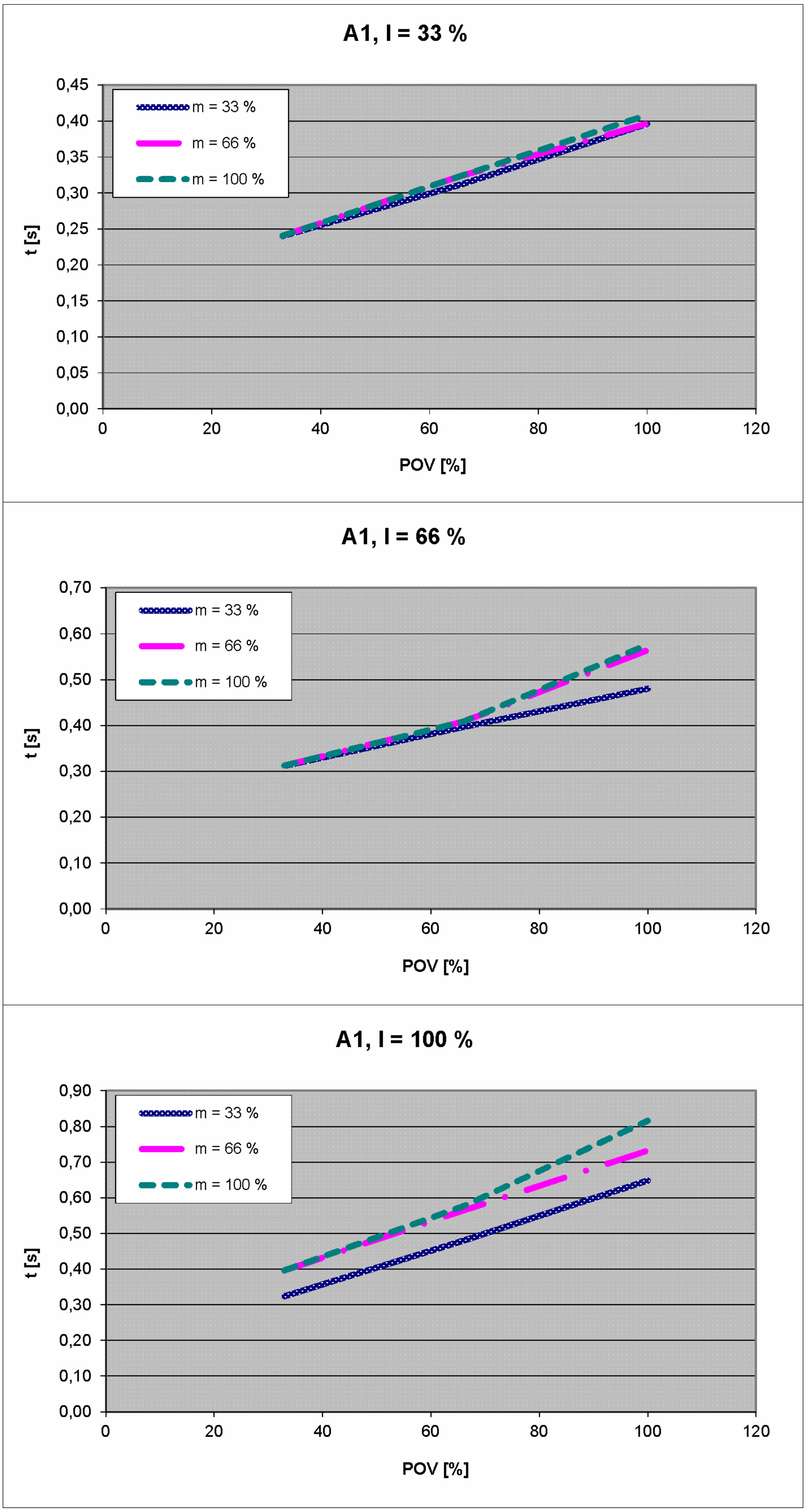


Fig. 4-23: Stopping times for STOP 1, axis 1

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

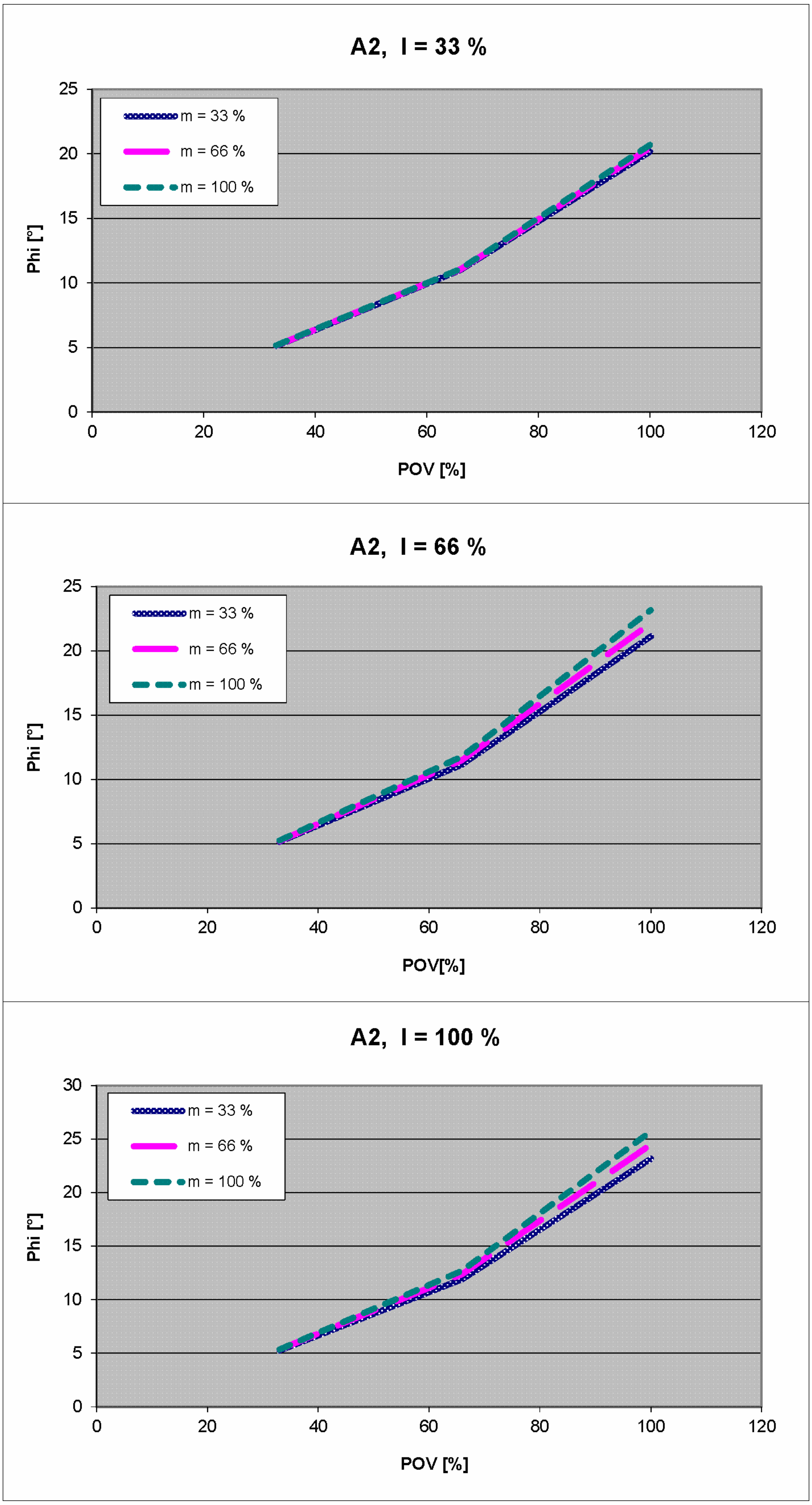


Fig. 4-24: Stopping distances for STOP 1, axis 2

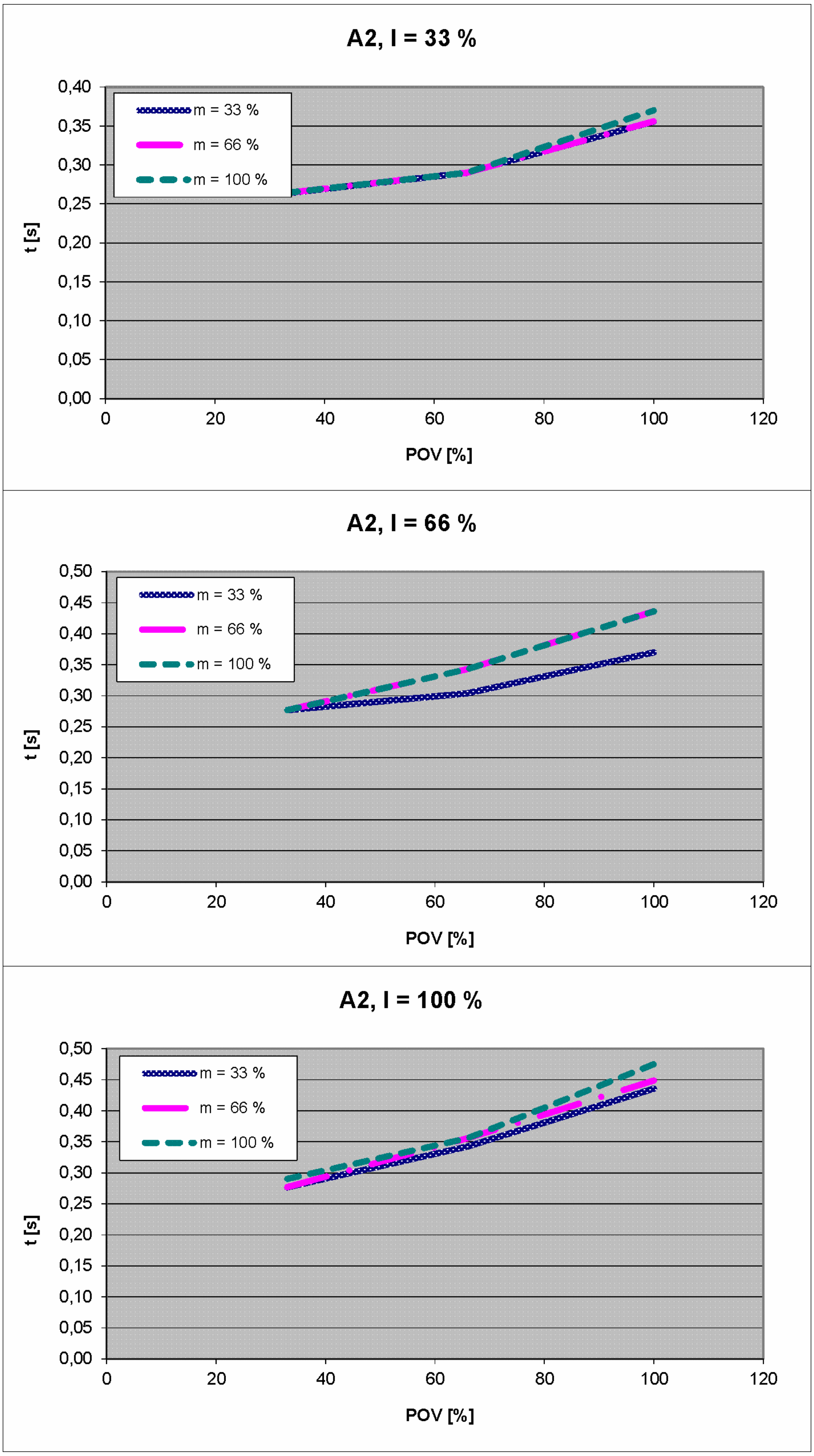


Fig. 4-25: Stopping times for STOP 1, axis 2

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

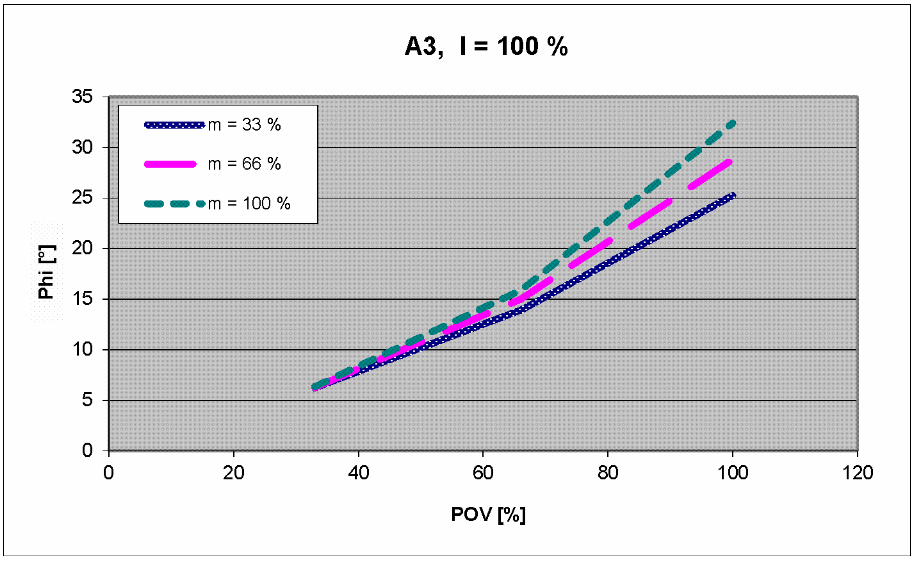


Fig. 4-26: Stopping distances for STOP 1, axis 3

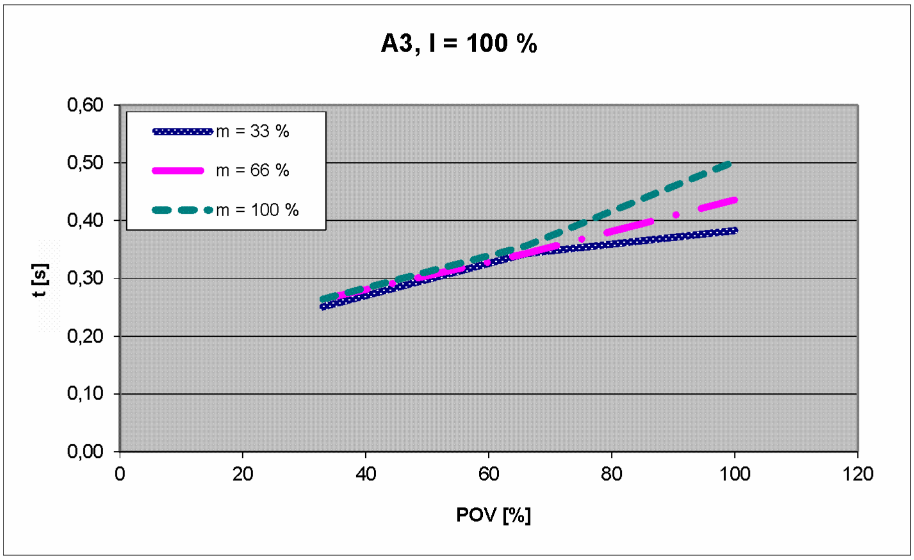


Fig. 4-27: Stopping times for STOP 1, axis 3

4.7.4 Stopping distances and stopping times, KR 180 R2100 nano F exclusive

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

	Stopping distance (°)	Stopping time (s)
Axis 1	50.89	0.68
Axis 2	19.09	0.43
Axis 3	18.27	0.30

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

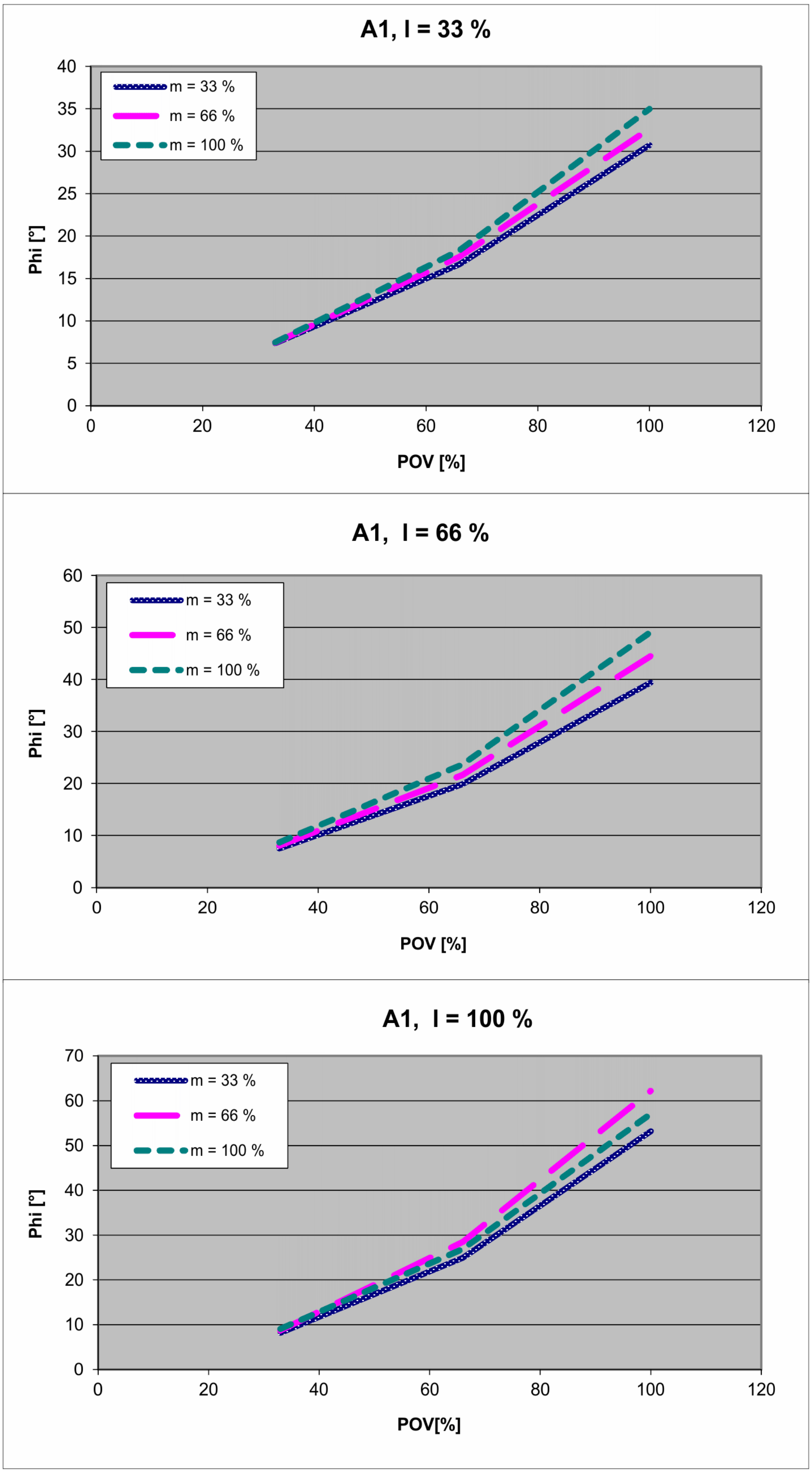


Fig. 4-28: Stopping distances for STOP 1, axis 1

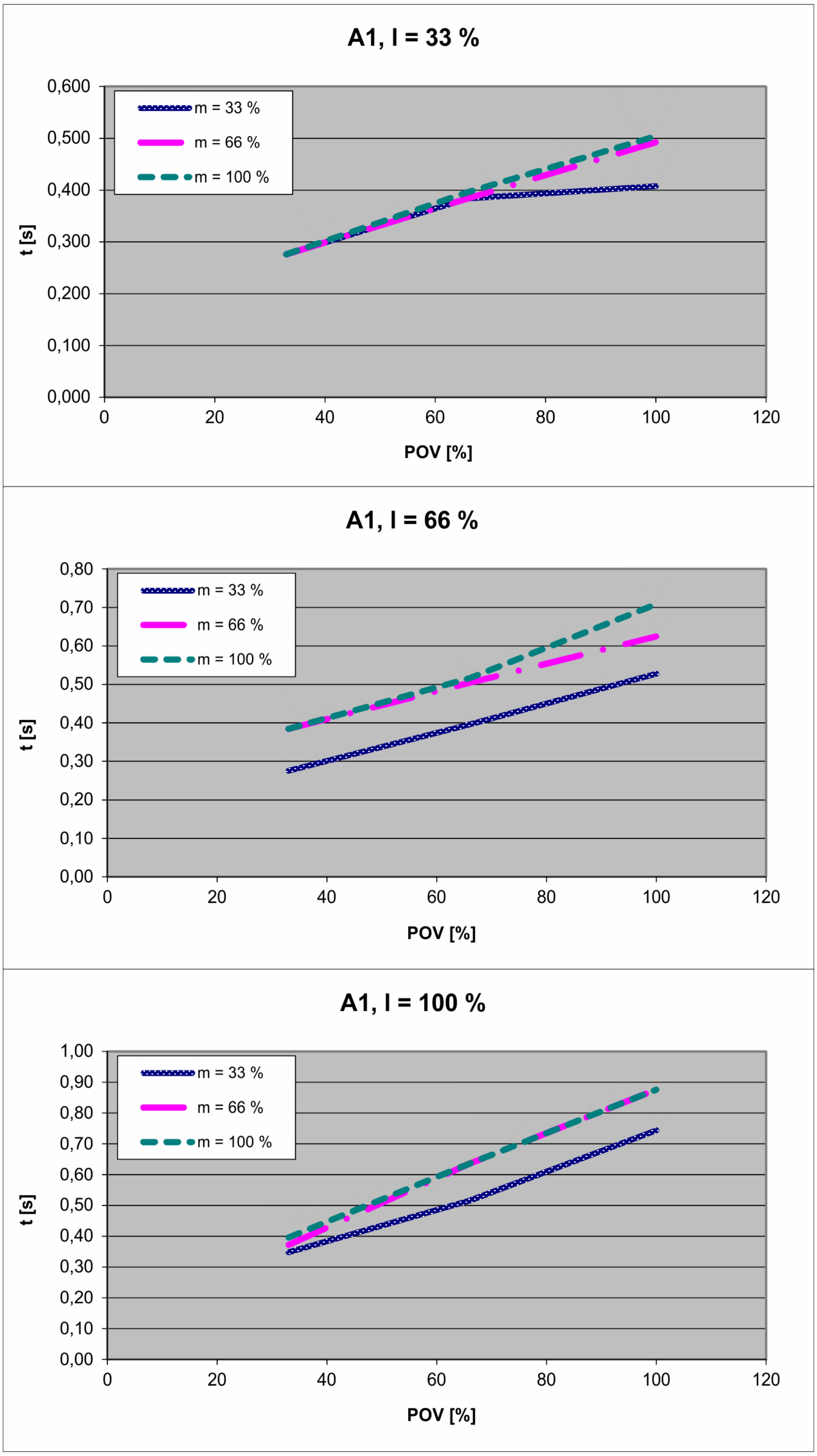


Fig. 4-29: Stopping times for STOP 1, axis 1

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

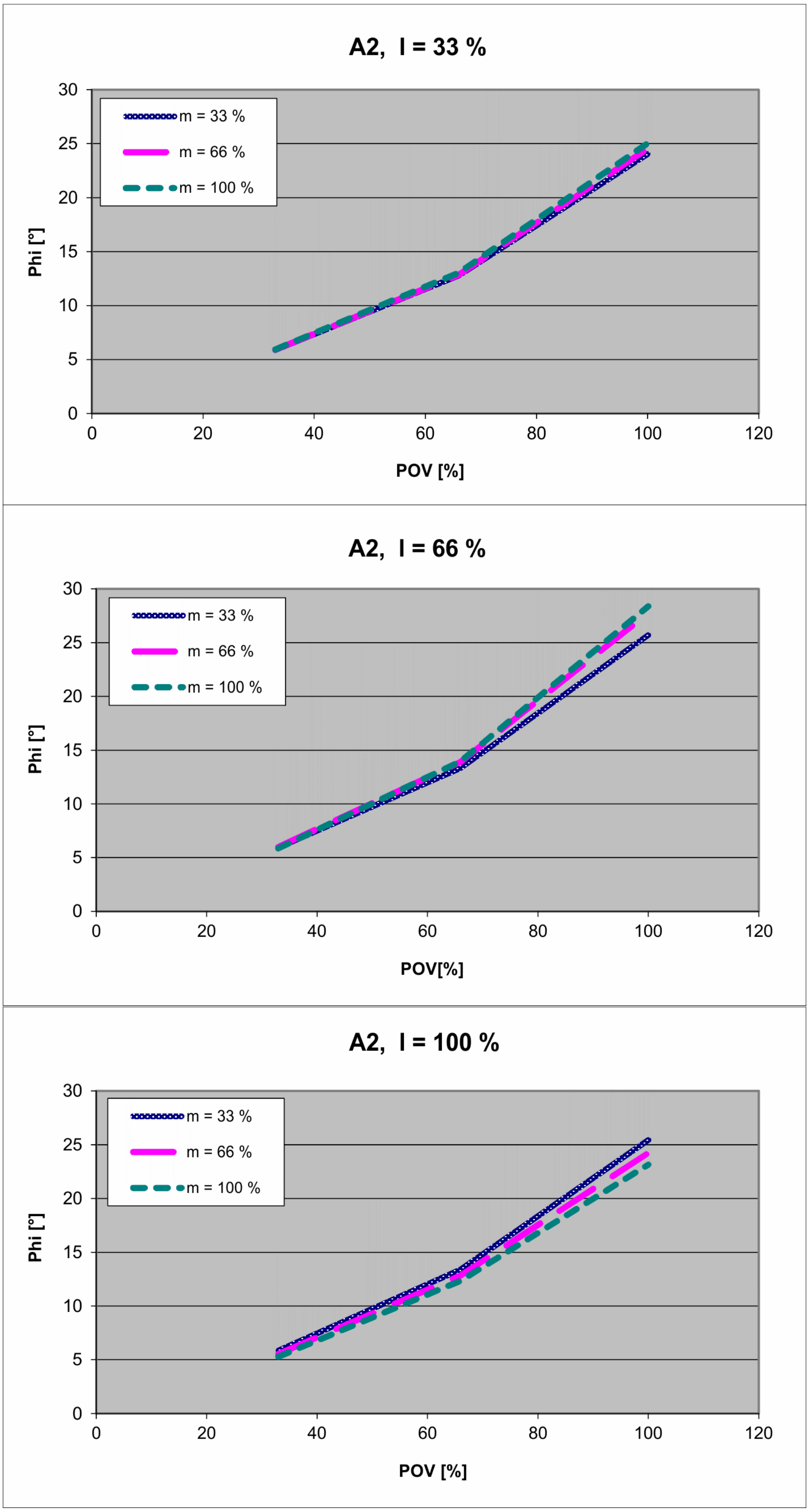


Fig. 4-30: Stopping distances for STOP 1, axis 2

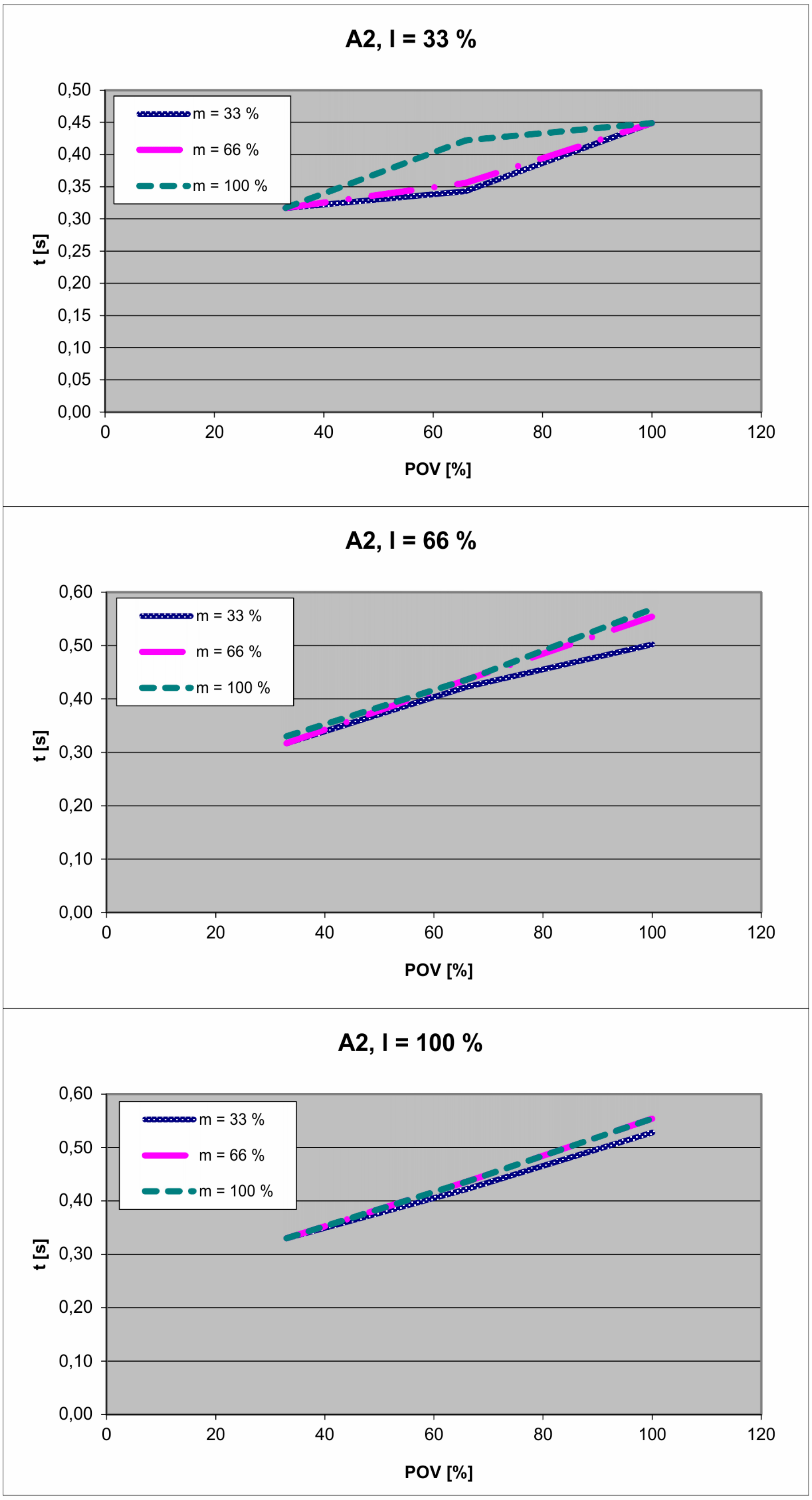


Fig. 4-31: Stopping times for STOP 1, axis 2

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

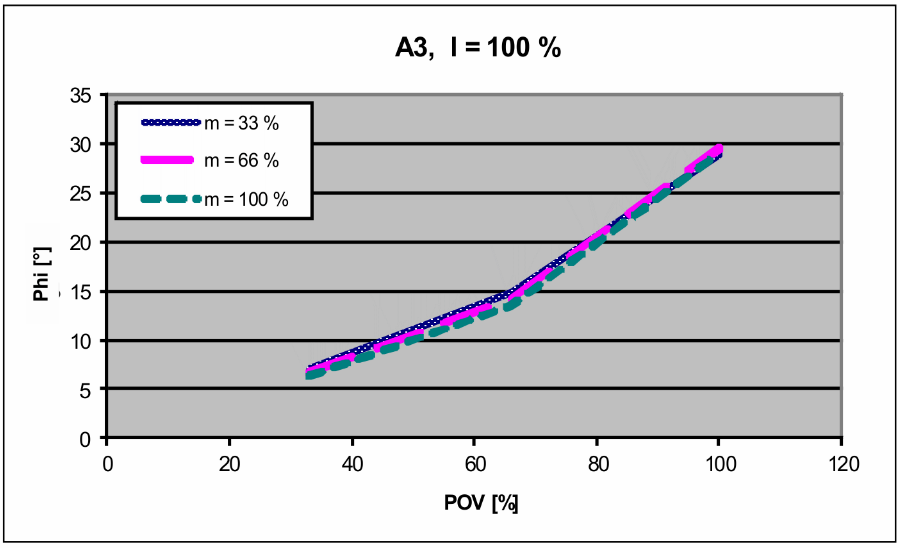


Fig. 4-32: Stopping distances for STOP 1, axis 3

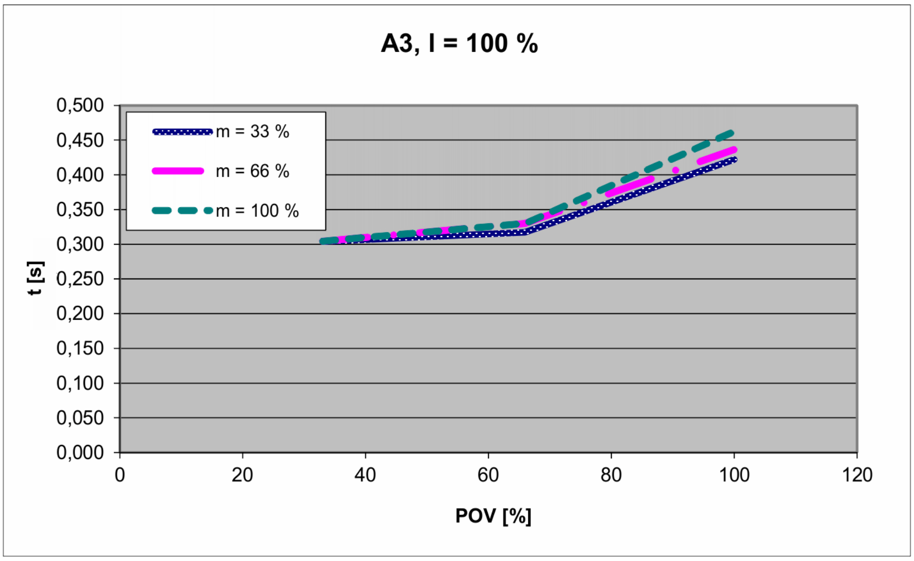


Fig. 4-33: Stopping times for STOP 1, axis 3

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

Information about safety may not be construed against KUKA Deutschland 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 Deutschland GmbH. Additional components (tools, software, etc.), not supplied by KUKA Deutschland GmbH, may be integrated into the industrial robot. The user is liable for any damage these components may cause to the industrial robot or to other material property.

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

5.1.2 Intended use of the industrial robot

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

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

Operation of the industrial robot in accordance with its intended use also requires compliance with the operating and assembly instructions for the individual components, with particular reference to the maintenance specifications.

Misuse

Any use or application deviating from the intended use is deemed to be misuse and is not allowed. This includes e.g.:

- Use as a climbing aid
- Operation outside the specified operating parameters
- Operation without the required safety equipment

5.1.3 EC declaration of conformity and declaration of incorporation

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

- The industrial robot is integrated into a complete system.

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

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

EC declaration of conformity

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

The robot controller has a CE mark in accordance with the EMC Directive and the Low Voltage Directive.

Declaration of incorporation

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

The declaration of incorporation declares that the start-up of the partly completed machinery is not allowed until the partly completed machinery has been incorporated into machinery, or has been assembled with other parts to form machinery, and this machinery complies with the terms of the EC Machinery Directive, and the EC declaration of conformity is present in accordance with Annex II A.

5.1.4 Terms used

Term	Description
Axis range	Range of each axis, in degrees or millimeters, within which it may move. The axis range must be defined for each axis.
Stopping distance	Stopping distance = reaction distance + braking distance The stopping distance is part of the danger zone.
Workspace	The manipulator is allowed to move within its workspace. The workspace is derived from the individual axis ranges.
Operator (User)	The user of the industrial robot can be the management, employer or delegated person responsible for use of the industrial robot.
Danger zone	The danger zone consists of the workspace and the stopping distances.
Service life	The service life of a safety-relevant component begins at the time of delivery of the component to the customer. The service life is not affected by whether the component is used in a controller or elsewhere or not, as safety-relevant components are also subject to aging during storage
KCP	KUKA Control Panel Teach pendant for the KR C2/KR C2 edition2005 The KCP has all the operator control and display functions required for operating and programming the industrial robot.
KUKA smartPAD	see “smartPAD”
Manipulator	The robot arm and the associated electrical installations
Safety zone	The safety zone is situated outside the danger zone.
Safety options	Generic term for options which make it possible to configure additional safe monitoring functions in addition to the standard safety functions. Example: SafeOperation
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	Axis of motion that does not belong to the manipulator, yet is controlled with the same 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 briefing 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 EC declaration of conformity
- Attaching the CE mark
- Creating the operating instructions for the system

Operators

The operator must meet the following preconditions:

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

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

5.3 Workspace, safety zone and danger zone

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

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

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

5.4 Overview of protective equipment

The protective equipment of the mechanical component may include:

- Mechanical end stops
- Mechanical axis limitation (optional)
- Release device (optional)
- Brake 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 mechanical axis limitation, the manipulator can no longer be operated safely. The manipulator must be taken out of operation and KUKA Deutschland GmbH must be consulted before it is put back into operation.

5.4.2 Mechanical axis limitation (optional)

Some manipulators can be fitted with mechanical axis limitation systems in axes A1 to A3. The axis 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 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 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 Deutschland GmbH.

5.4.3 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 Deutschland GmbH.

NOTICE

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

5.4.4 Labeling on the industrial robot

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

Labeling on the industrial robot consists of:

- Identification plates
- Warning signs
- Safety symbols

- Designation labels
- Cable markings
- Rating plates

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

5.5 Safety measures

5.5.1 General safety measures

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

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

DANGER

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

DANGER

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

CAUTION

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

KCP/smartPAD

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

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

WARNING

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

External keyboard, external mouse

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

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

The KCP/smartPAD must not be used as long as an external keyboard and/or external mouse are connected to the control cabinet.

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

Modifications

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

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

After modifications to the industrial robot, existing programs must always be tested first in Manual Reduced Velocity mode (T1). This applies to all components of the industrial robot and includes e.g. modifications of the external axes or 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 (tagout).
- Keep a record of the faults.
- Eliminate the fault and carry out a function test.

5.5.2 Transportation

Manipulator

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

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

Robot controller

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

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

External axis (optional)

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

5.5.3 Start-up and recommissioning

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

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

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

⚠ **WARNING**

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 Deutschland 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 is no damage to the robot that could be attributed to external forces. Example: Dents or abrasion that could be caused by an impact or collision.

WARNING

In the case of such damage, the affected components must be exchanged. In particular, the motor and counterbalancing system must be checked carefully.
External forces can cause non-visible damage. For example, it can lead to a gradual loss of drive power from the motor, resulting in unintended movements of the manipulator. Death, injuries or considerable damage to property may otherwise result.

- 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.

5.5.4 Manual mode

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

- Jog mode
- Teaching
- Programming
- Program verification

The following must be taken into consideration in manual mode:

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

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

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

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

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

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

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

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

- This mode may only be used if the application requires a test at a velocity higher than possible in T1 mode.
- 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 devices 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.

DANGER

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. The system must then be checked to ensure that it is deenergized.
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. 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 Deutschland GmbH for this purpose.

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

Robot controller

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

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

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

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

Counterbalancing system

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

The hydropneumatic and gas cylinder counterbalancing systems are pressure equipment and, as such, are subject to obligatory equipment monitoring and the provisions of the Pressure Equipment Directive.

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

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

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

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

Hazardous substances

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

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

To ensure safe use of our products, we recommend regularly requesting up-to-date safety data sheets for 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/Edition	Definition
2006/42/EU:2006	**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)
2014/68/EU:2014	**Pressure Equipment Directive**: Directive 2014/68/EU of the European Parliament and of the Council dated 15 May 2014 on the approximation of the laws of the Member States concerning pressure equipment (Only applicable for robots with hydropneumatic counterbalancing system.)
EN ISO 13850:2015	**Safety of machinery:** Emergency stop - Principles for design
EN ISO 13849-1:2015	**Safety of machinery:** Safety-related parts of control systems - Part 1: General principles of design
EN ISO 13849-2:2012	**Safety of machinery:** Safety-related parts of control systems - Part 2: Validation
EN ISO 12100:2010	**Safety of machinery:** General principles of design, risk assessment and risk reduction
EN ISO 10218-1:2011	**Industrial robots – Safety requirements:** Part 1: Robots **Note:** Content equivalent to **ANSI/RIA R.15.06-2012, Part 1**
EN 614-1:2006+A1:2009	**Safety of machinery:** Ergonomic design principles - Part 1: Terms and general principles
EN 61000-6-2:2005	**Electromagnetic compatibility (EMC):** Part 6-2: Generic standards; Immunity for industrial environments
EN 61000-6-4:2007 + A1:2011	**Electromagnetic compatibility (EMC):** Part 6-4: Generic standards; Emission standard for industrial environments
EN 60204-1:2006/ A1:2009	**Safety of machinery:**

Electrical equipment of machines - Part 1: General requirements

6 Planning

6.1 Information for planning

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

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

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

If the robot reaches its corresponding operation limit or if it is operated near the limit for a period of time, the built-in monitoring functions come into effect and the robot is automatically switched off.

This protective function can limit the availability of the robot system.

NOTICE
When planning the system, it must be ensured that the robot is largely protected against extraneous rust. If there is a risk of extraneous rust, the robot must be checked at appropriate time intervals. Any extraneous rust is to be removed as required. Extraneous rust can result in substantial damage to the robot.

NOTICE
If the robot is operated with an external energy supply system, it must be ensured that the energy supply system never slides over or touches the surface of the robot. Damage to the corrosion-protected surfaces might otherwise result. The energy supply system must be installed, adjusted and operated in such a way that no contact can be made. Programs must be adapted accordingly. The user is responsible for contact-free operation and must take appropriate additional measures if required.

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 the carriage of a KUKA linear unit (>>> *Fig. 6-1*). The mounting surface for the robot must be machined and of an appropriate quality. For the machine frame mounting, the robot is fastened using 6 hexagon bolts with conical spring washers. Two locating pins are used for centering.

The substructure used by the customer must be designed in such a way that the forces generated (mounting base load, maximum load (>>> *4 "Technical data" Page 11*)) are safely transmitted via the screw connection and the necessary stiffness is ensured. The specified surface values and tightening torques must be observed.

The following values must be taken into consideration in the design of the substructure:

- Bolt force: Fs = 125 kN
- Stripping safety: The material of the substructure must be selected so that the stripping safety is ensured (e.g. 1.4404 or S355J2G3).

The machine frame mounting assembly consists of:

- Locating pin, cylindrical
- Locating pin, flat-sided
- Hexagon bolts with conical spring washers

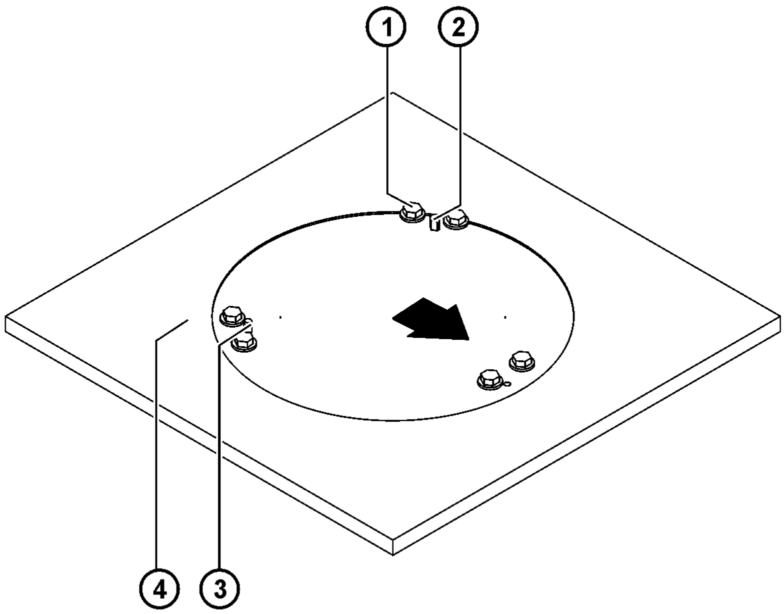


Fig. 6-1: Machine frame mounting

1 Hexagon bolt with conical spring washer
2 Locating pin, flat-sided
3 Locating pin, cylindrical
4 Substructure

Dimensioned drawing

The following diagram contains all the necessary information that must be observed when preparing the mounting surface and the holes (>>> *Fig. 6-2*).

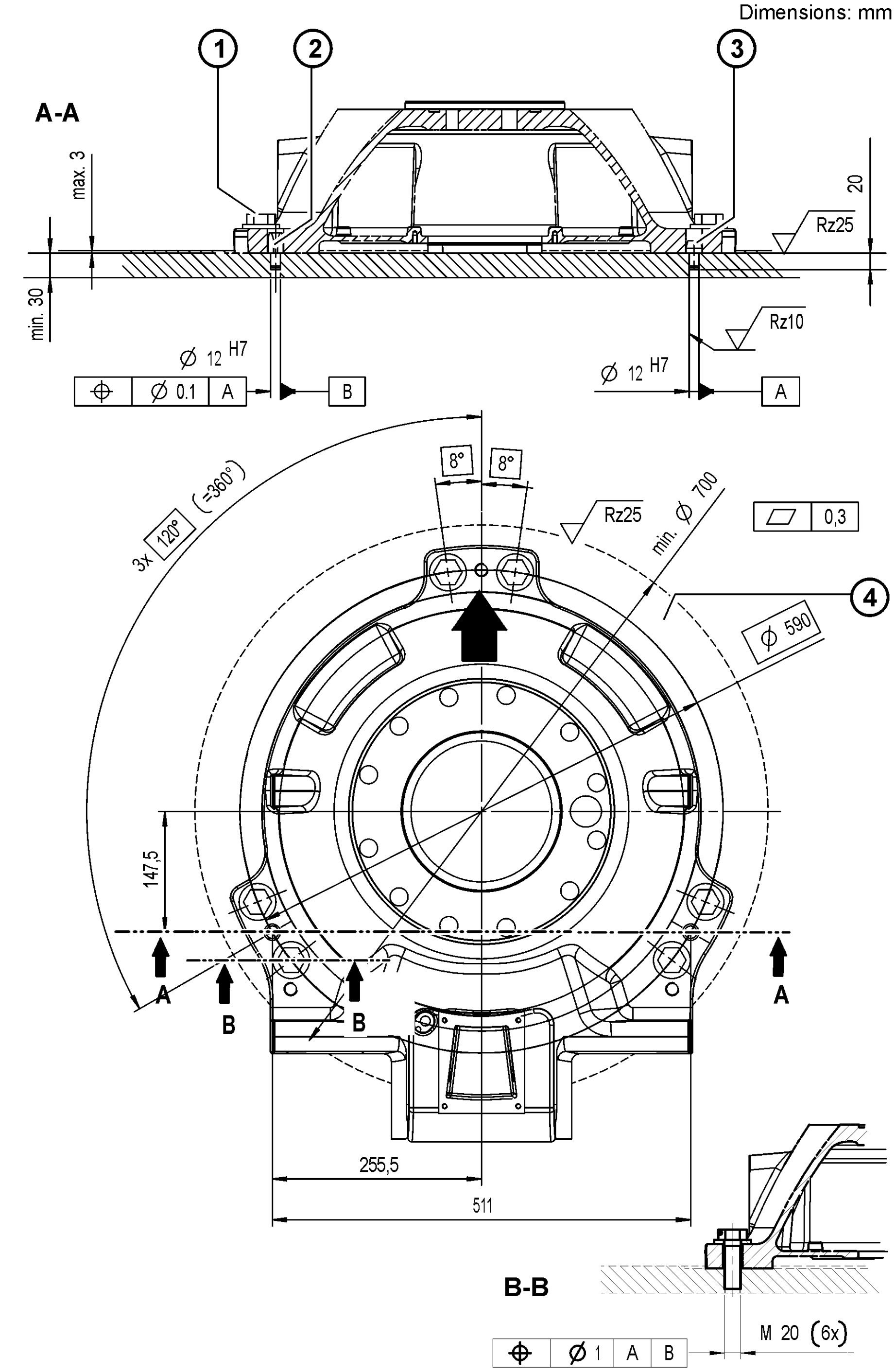


Fig. 6-2: Machine frame mounting, dimensioned drawing

1 Hexagon bolt with conical spring washer, 6x
2 Locating pin, flat-sided
3 Locating pin, cylindrical
4 Mounting surface

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. On the robot side, they are connected to the remote RDC box and the multi-function housings (MFH) with connectors. The set of connecting cables comprises:

- Motor cable, X20 - X30
- Data cable, X21 - X31
- Ground conductor (optional)

Depending on the equipment of the robot, various connecting cables are used (>>> *Fig. 6-3*). Cable lengths of 3 m, 7 m, 15 m, 25 m and 35 m are available. The maximum length of the connecting cables must not exceed 35 m.

For the connecting cables, an additional ground conductor is always required to provide a low-resistance connection between the robot and the control cabinet in accordance with DIN EN 60204. A second ground conductor connection of the same type must be present between the robot and the system. Connection is by means of ring cable lugs in each case. Both threaded bolts for connecting the ground conductor are located on the holder for the remote RDC box of the robot.

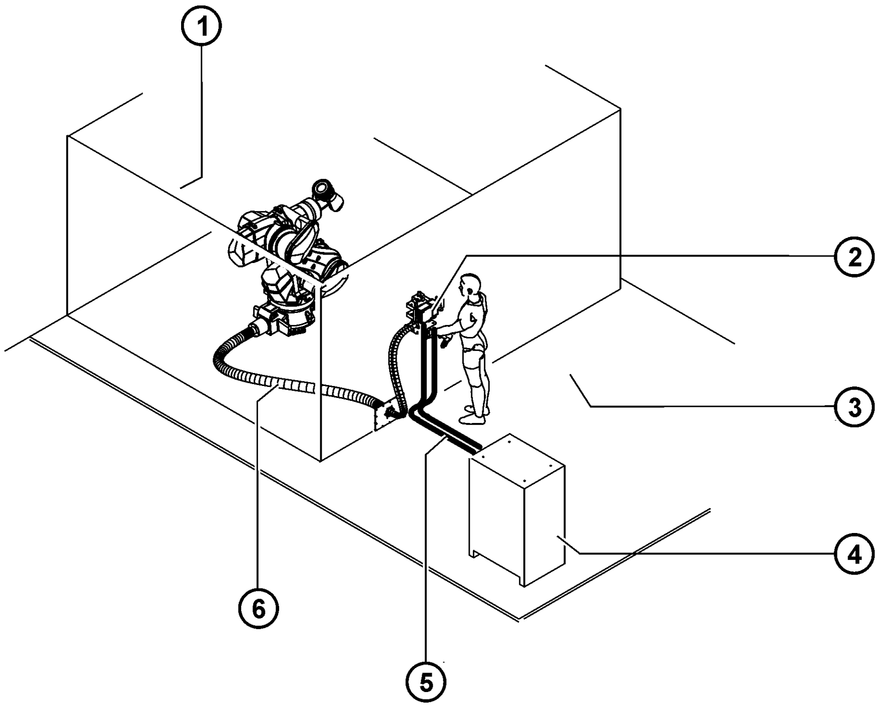


Fig. 6-3: Interfaces

1 Wet area (wet cell)
2 Remote RDC with MFH (connection unit)
3 Normal area
4 Control cabinet
5 Connecting cables with ground conductor
6 Electrical installations for robots with a protective tube in the wet area

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 the 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).

Electrical installations

Within the wet area, the electrical installations of the robot are routed through a stainless steel protective tube to the wall of the wet cell (>>> *Fig. 6-4*). Installation of the stainless steel protective tube must comply with the minimum bending radius of 200 mm.

The size and connection dimensions of the cell wall may be noted from the following diagram.

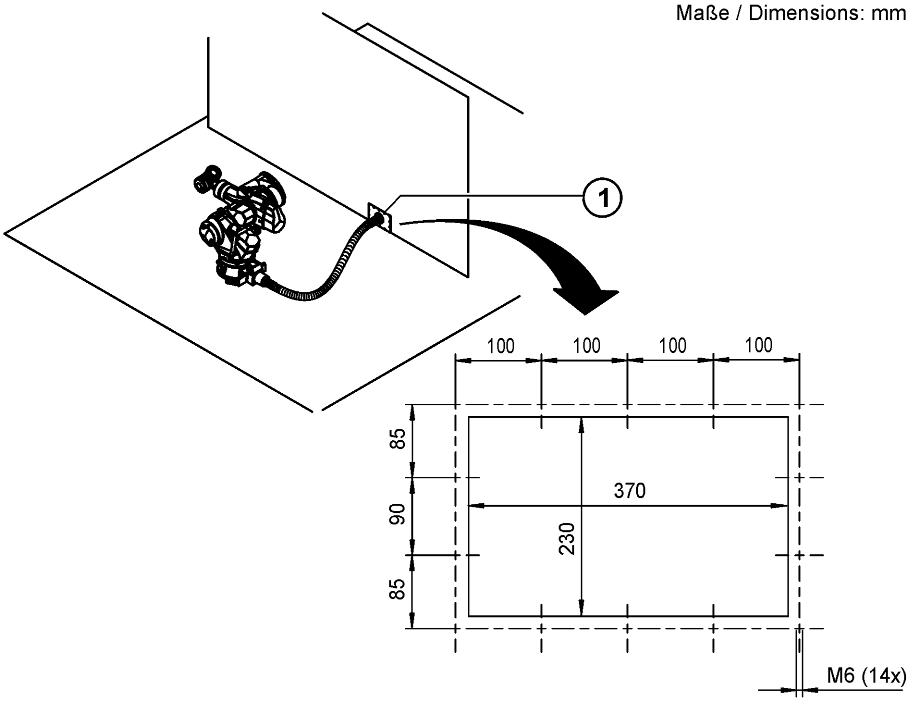


Fig. 6-4: Cell wall connection

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°	-135°	+135°	0º	-120º	0º

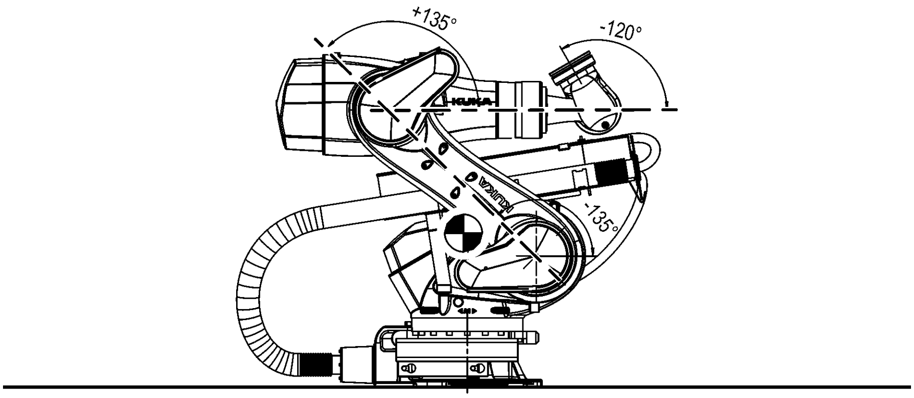


Fig. 7-1: Transport position

Transport dimensions

The transport dimensions (>>> *Fig. 7-2*) for the robot may be noted from the following diagrams. The position of the center of gravity and the weight vary according to the specific configuration. The specified dimensions refer to the robot without equipment and when the robot is standing on the floor without wooden transport blocks.

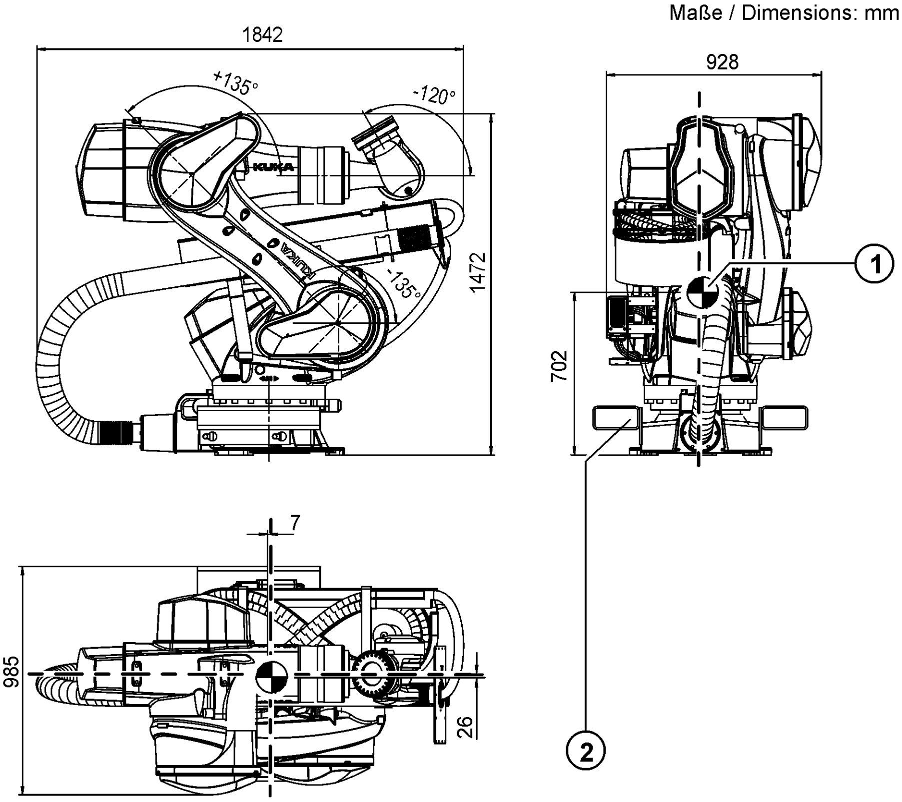


Fig. 7-2: Transport dimensions with tray

1 Center of gravity

2 Fork slots

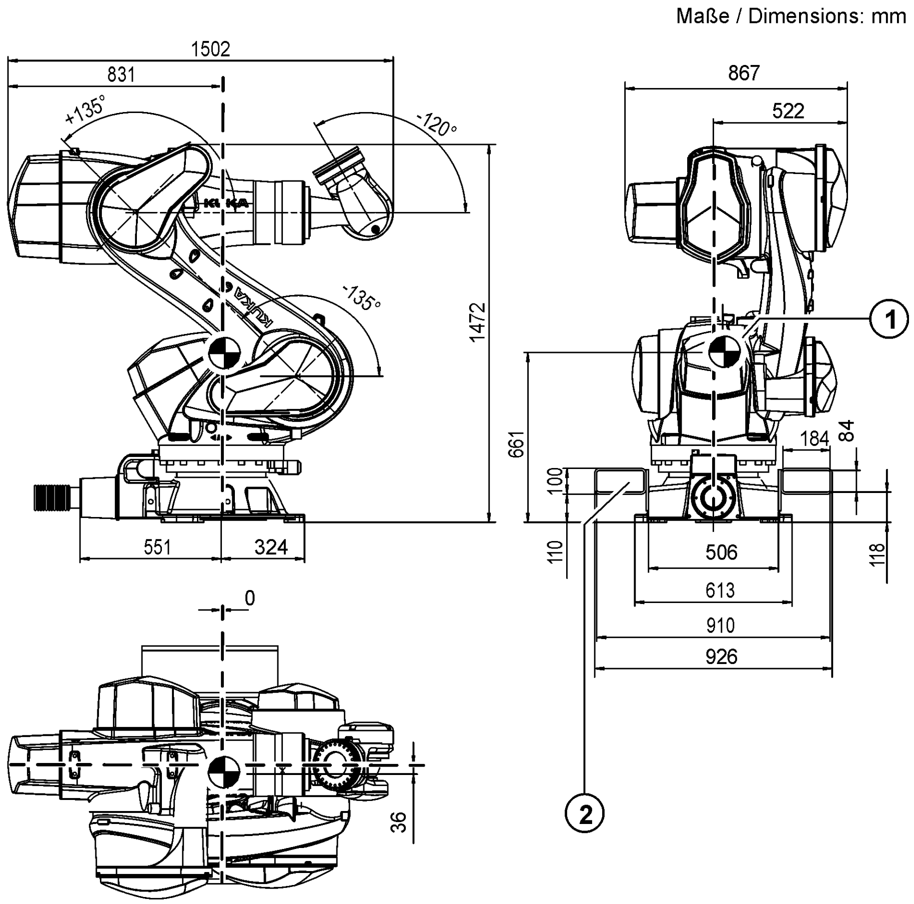


Fig. 7-3: Transport dimensions without tray

1 Center of gravity
2 Fork slots

Transportation

The robot can be transported by fork lift truck or using lifting tackle. If the transport container for the electric cables is attached, transportation using lifting tackle is not possible since the holes for the eyebolts are occupied.

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. 7-4*), two fork slots must be installed in the base frame. The robot can be picked up by the fork lift truck from the front and rear. The tapped holes for the fork slots are covered. If necessary, the screw plugs must be removed. Following the removal of the fork slots, these holes must be closed again using screw plugs and USIT rings. 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 1.0 t and an adequate fork length.

CAUTION

The fork slots are situated within the interference circle of the rotating column. Operation with installed fork slots can result in significant damage to components. Be sure to remove the fork slots before starting up the robot.

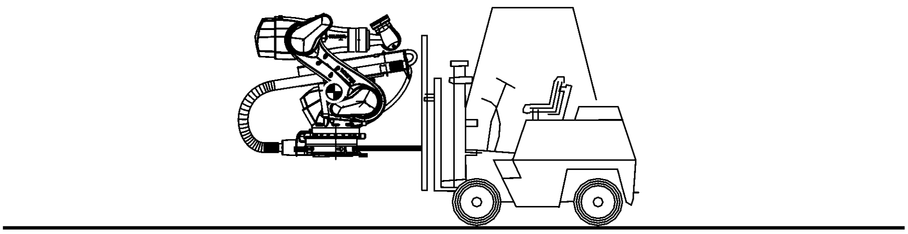


Fig. 7-4: Transportation by fork lift truck

NOTICE

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

Fork slots

The fork slots are fastened with 2 M20x40-8.8 Allen screws on each side. The tightening torque for the Allen screws is 370 Nm (>>> *Fig. 7-5*).

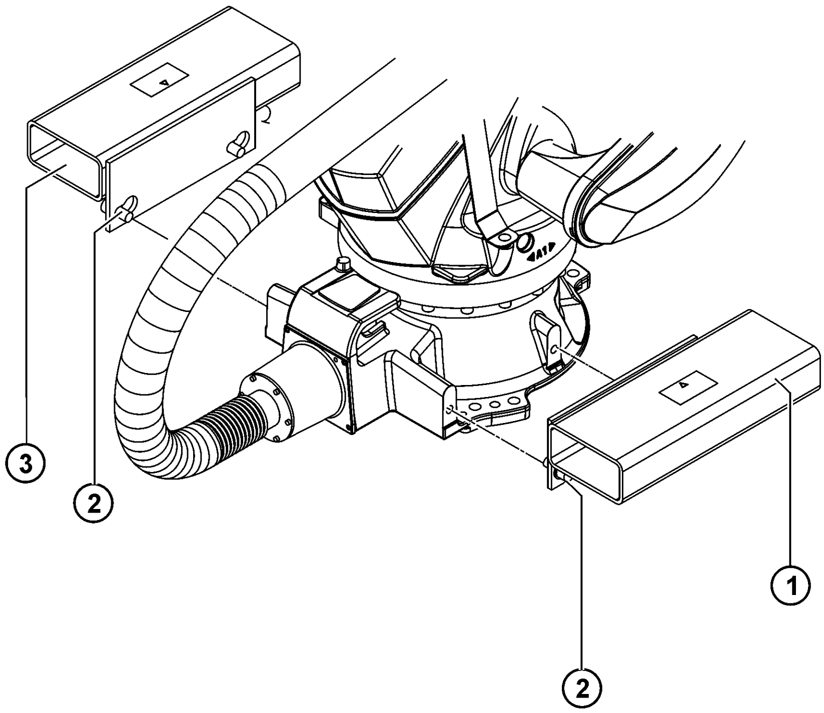


Fig. 7-5: Fork slots

1 Fork slot, right
2 Allen screws and washers
3 Fork slot, left

Transportation with lifting tackle

The robot can also be transported using lifting tackle (>>> *Fig. 7-6*) if the transport container for the electric cables is not attached. If the transport container is not attached, it must be ensured that the electric cables and the remote RDC box can be transported together with the robot in a proper manner. A tensile load on the electric cables is not permitted.

For transportation using lifting tackle, the robot must be in the transport position. The lifting tackle is attached at 3 points to M16 DIN 580 eyebolts.

The tapped holes for the eyebolts are covered. If necessary, the Allen screws must be removed. Following the removal of the eyebolts, these holes must be closed again using Allen screws and USIT rings.

All the legs of the lifting tackle 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. The legs must be adjusted so that the robot is suspended vertically from the crane. If necessary, the robot must be set down again and the legs readjusted.

If the robot is transported using lifting tackle, the transport tray must be transported with it in such a manner that the cables and the connection unit are not subjected to a load.

Installed tools and items of equipment can cause undesirable shifts in the center of gravity.

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!

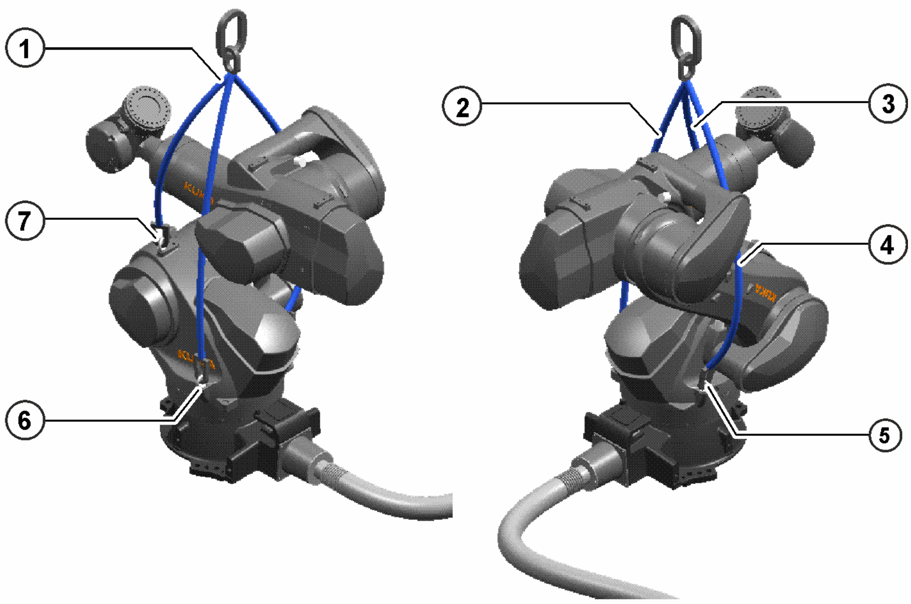


Fig. 7-6: Transportation using lifting tackle

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

8 Options

8.1 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.

9 KUKA Service

9.1 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:

- Description of the problem, including information about the duration and frequency of the fault
- As comprehensive information as possible about the hardware and software components of the overall system

  The following list gives an indication of the information which is relevant in many cases:

  - Model and serial number of the kinematic system, e.g. the manipulator
  - Model and serial number of the controller
  - Model and serial number of the energy supply system
  - Designation and version of the system software
  - Designations and versions of other software components or modifications
  - Diagnostic package KRCDiag

    Additionally for KUKA Sunrise: Existing projects including applications

    For versions of KUKA System Software older than V8: Archive of the software (KRCDiag is not yet available here.)
  - Application used
  - External axes used

9.2 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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