Robots

KR 10 R1100 EX 2G

Specification

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Version: Spez KR 10 R1100 EX 2G V2
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1 Introduction

1.1 Industrial robot documentation

The industrial robot documentation consists of the following parts:

- Documentation for the robot arm
- Documentation for the robot controller
- Operating and programming instructions for the System Software
- Supplier documentation for the pressure monitoring system
- Instructions for options and accessories
- Parts catalog on storage medium

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** 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 engineering
- Advanced knowledge of working in potentially explosive areas according to ATEX guidelines
- 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

- Handling and machining workpieces in explosion protection zone 1.

The robot may only be operated with the KR C4 EX 2G controller and with the supplied connecting cable set.

The system integrator must issue an EC declaration of conformity for the complete system in accordance with the Machinery Directive and the ATEX Directive. In non-EU countries, any potential danger of explosion must be analyzed and evaluated according to country-specific laws.

Using it for any other or additional purpose is considered misuse and is not allowed. The manufacturer cannot be held liable for any resulting damage. The risk lies entirely with the user.

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

The industrial robot must be operated in compliance with Directive 2014/34/EU and with a pressure monitoring system.

Misuse

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

- Transportation of persons and animals
- Use as a climbing aid
- Use outside the permissible operating parameters
- Operation without additional safeguards
- Outdoor operation
- Underground operation
- Operation in a more restrictive environment than the permitted explosion protection zone

**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.

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 (>>> 3.1 "Overview of the robot system" Page 11) 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 following robot belongs to the KR AGILUS sixx product family:

- KR 10 R1100 EX 2G

An industrial robot of this type comprises the following components:

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

![Fig. 3-1: Representation of the robot system](image)

1  Manipulator
2  smartPAD control panel
3  Connecting cable, smartPAD
4  Robot controller
5  Connecting cable, data cable
6  Connecting cable, motor cable
7  Connecting cable / safe data cable to pressure sensor
8  Air line
9  Ground conductor

⚠️ **CAUTION**

The controller is not designed for installation in an Ex zone 1 environment and must be installed outside of the Ex zone.
3.2 Description of the manipulator

Overview

The manipulators are 6-axis jointed-arm manipulators made of cast light alloy. Each axis is fitted with a brake. Sealed covers protect the inner components against fouling and water spray.

In order to be able to use the manipulator in a potentially explosive environment of category 2G in accordance with the ATEX Directive, the interior of the manipulator (housing) must be pressurized with compressed air. The required compressed air is supplied via the connection at interface A1 and monitored at the pressure sensor.

The robot consists of the following principal components:

- In-line wrist
- Arm
- Link arm
- Rotating column
- Base frame
- Electrical installations
- Pressure sensor

The robot is fitted with a 3-axis in-line wrist. The in-line wrist consists of axes 4, 5 and 6.

The arm is the link between the in-line wrist and the link arm. The arm is driven by the motor of axis 3.
Link arm A2

The link arm is the assembly located between the arm and the rotating column. It houses the motor and gear unit of axis 2. The supply lines of the cable set for axes 2 to 6 are routed inside the link arm.

Rotating column A1

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. Interface A1 is located at the rear of the base frame. It constitutes the interface for the connecting cables between the manipulator and the controller and the pressurization unit.

Pressure sensor

The pressure sensor, together with the compressed air controller, constitutes a pressure monitoring system. Before start-up of the robot, the pressure monitoring system purges the manipulator and eliminates explosive gases from it. Throughout operation, the pressure monitoring system ensures constant pressure in the robot arm and thus prevents explosive gas from entering into the robot arm during operation.

Electrical installations

The electrical installations include all the motor and data cables for the motors of axes 1 to 6. All connections are pluggable. The electrical installations also include an “RDC cool” and an “EDS cool” which are integrated into the robot. The connectors for the motor and 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, e.g. an energy supply system. The option is described in separate documentation.
4 Technical data

4.1 Technical data, overview

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

<table>
<thead>
<tr>
<th>Robot</th>
<th>Technical data</th>
</tr>
</thead>
</table>
| KR 10 R1100 EX 2G | - Technical data  
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- Supplementary loads  
  (>>> 4.3 "Supplementary load" Page 22)  
- Plates and labels  
  (>>> 4.4 "Plates and labels" Page 24)  
- Stopping distances and times  
  (>>> 4.6 "Stopping distances and times" Page 28) |

4.2 Technical data, KR 10 R1100 EX 2G

4.2.1 Basic data, KR 10 R1100 EX 2G

<table>
<thead>
<tr>
<th>Basic data</th>
<th>KR 10 R1100 EX 2G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of axes</td>
<td>6</td>
</tr>
<tr>
<td>Number of controlled axes</td>
<td>6</td>
</tr>
<tr>
<td>Volume of working envelope</td>
<td>5.2 m³</td>
</tr>
<tr>
<td>Pose repeatability (ISO 9283)</td>
<td>± 0.03 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>approx. 67 kg</td>
</tr>
<tr>
<td>Rated payload</td>
<td>10 kg</td>
</tr>
<tr>
<td>Maximum reach</td>
<td>1101 mm</td>
</tr>
<tr>
<td>Protection rating (IEC 60529)</td>
<td>IP67</td>
</tr>
<tr>
<td>Protection rating, in-line wrist (IEC 60529)</td>
<td>IP67</td>
</tr>
<tr>
<td>Sound level</td>
<td>&lt; 70 dB (A)</td>
</tr>
<tr>
<td>Mounting position</td>
<td>Floor; Ceiling; Wall; Desired angle</td>
</tr>
<tr>
<td>Footprint</td>
<td>600 mm x 320 mm</td>
</tr>
<tr>
<td>Hole pattern: mounting surface for kinematic system</td>
<td>C246</td>
</tr>
<tr>
<td>Permissible angle of inclination</td>
<td>-</td>
</tr>
<tr>
<td>Default color</td>
<td>Base frame: black (RAL 9011); Moving parts: KUKA orange 2567; Link arm cover: black (RAL 9011)</td>
</tr>
<tr>
<td>Controller</td>
<td>KR C4 EX (2G)</td>
</tr>
<tr>
<td>Transformation name</td>
<td>KR C4: KR10R1100 C4SR EX2G</td>
</tr>
</tbody>
</table>
Air requirements

<table>
<thead>
<tr>
<th>Compressed air for pressure monitoring</th>
<th>Oil-free, dry, filtered in accordance with: ISO 8573.1-1, 1.12 to 16.2</th>
</tr>
</thead>
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<tr>
<td>Air line connection</td>
<td>Plug-in connection for media controller, 6 mm</td>
</tr>
<tr>
<td>Min. purge volume</td>
<td>140 l</td>
</tr>
<tr>
<td>Min. air pressure</td>
<td>1.5 mbar</td>
</tr>
<tr>
<td>Max. air pressure</td>
<td>40 mbar</td>
</tr>
<tr>
<td>Min. volumetric flow rate</td>
<td>1.5 l/s</td>
</tr>
</tbody>
</table>

Ambient conditions

<table>
<thead>
<tr>
<th>Operation</th>
<th>+5 °C to +45 °C (278 K to 328 K)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Atmosphere corresponds to Ex zone 1 (according to 2014/34/EU)</td>
</tr>
<tr>
<td></td>
<td>Free from corrosive gases and liquids</td>
</tr>
<tr>
<td></td>
<td>Free from flying parts</td>
</tr>
<tr>
<td></td>
<td>Free from electromagnetic loads, e.g. from welding equipment or high-frequency converters</td>
</tr>
<tr>
<td>Storage and transportation</td>
<td>-40 °C to +60 °C (233 K to 333 K)</td>
</tr>
<tr>
<td>Ambient conditions</td>
<td>Ex zone 1 according to 2014/34/EU</td>
</tr>
</tbody>
</table>

NOTICE: If the manipulator is exposed to high-velocity fluids, particles and/or compressed air, it must be protected against direct exposure to these.

Connecting cables

<table>
<thead>
<tr>
<th>Cable designation</th>
<th>Connector designation robot controller - robot</th>
<th>Interface with robot</th>
</tr>
</thead>
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<tr>
<td>Motor cable</td>
<td>X20 - X30</td>
<td>Han Yellock 30</td>
</tr>
<tr>
<td>Data cable</td>
<td>X21 - X31</td>
<td>Han Q12</td>
</tr>
<tr>
<td>Equipotential bonding</td>
<td></td>
<td>M4 ring cable lug</td>
</tr>
<tr>
<td>CON-EX cable</td>
<td>X210 - X71</td>
<td>M12, 4-pole</td>
</tr>
<tr>
<td>Pneumatic line</td>
<td></td>
<td>PUN 6x1</td>
</tr>
</tbody>
</table>

Cable lengths

| Standard | 7 m |

For detailed specifications of the connecting cables, see .

Type examination

A type examination has been performed for the robot in accordance with ATEX Directive 2014/34/EU.

4.2.2 Axis data, KR 10 R1100 EX 2G

<table>
<thead>
<tr>
<th>Axis data</th>
<th>Motion range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>±170 °</td>
</tr>
<tr>
<td>A2</td>
<td>-190 ° / 45 °</td>
</tr>
<tr>
<td>A3</td>
<td>-120 ° / 156 °</td>
</tr>
<tr>
<td>A4</td>
<td>±185 °</td>
</tr>
<tr>
<td>A5</td>
<td>±120 °</td>
</tr>
<tr>
<td>A6</td>
<td>±350 °</td>
</tr>
</tbody>
</table>
The direction of motion and the arrangement of the individual axes may be noted from the diagram (>>> Fig. 4-1).

<table>
<thead>
<tr>
<th>Speed with rated payload</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>300 °/s</td>
</tr>
<tr>
<td>A2</td>
<td>225 °/s</td>
</tr>
<tr>
<td>A3</td>
<td>225 °/s</td>
</tr>
<tr>
<td>A4</td>
<td>286 °/s</td>
</tr>
<tr>
<td>A5</td>
<td>234 °/s</td>
</tr>
<tr>
<td>A6</td>
<td>439 °/s</td>
</tr>
</tbody>
</table>

The following diagrams (>>> Fig. 4-2) and (>>> Fig. 4-3) show the shape and size of the working envelope for the robot:

- KR 10 R1100 EX 2G
Distance to flange

The distance to the flange varies according to the position of the robot (>>> Fig. 4-4).

- KR 10 R1100 EX 2G
4.2.3 Payloads, KR 10 R1100 EX 2G

<table>
<thead>
<tr>
<th>Payloads</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated payload</td>
<td>10 kg</td>
</tr>
<tr>
<td>Maximum payload</td>
<td>10 kg</td>
</tr>
<tr>
<td>Rated mass moment of inertia</td>
<td>0.045 kgm²</td>
</tr>
<tr>
<td>Rated supplementary load, base frame</td>
<td>0 kg</td>
</tr>
<tr>
<td>Maximum supplementary load, base frame</td>
<td>-</td>
</tr>
<tr>
<td>Rated supplementary load, rotating column</td>
<td>0 kg</td>
</tr>
<tr>
<td>Maximum supplementary load, rotating column</td>
<td>-</td>
</tr>
<tr>
<td>Rated supplementary load, link arm</td>
<td>0 kg</td>
</tr>
<tr>
<td>Maximum supplementary load, link arm</td>
<td>-</td>
</tr>
<tr>
<td>Rated supplementary load, arm</td>
<td>0 kg</td>
</tr>
<tr>
<td>Maximum supplementary load, arm</td>
<td>-</td>
</tr>
<tr>
<td>Maximum total load</td>
<td>10 kg</td>
</tr>
<tr>
<td>Nominal distance to load center of gravity</td>
<td></td>
</tr>
<tr>
<td>$L_{xy}$</td>
<td>100 mm</td>
</tr>
<tr>
<td>$L_z$</td>
<td>80 mm</td>
</tr>
</tbody>
</table>

The sum of all loads mounted on the robot must not exceed the maximum total load.

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.
Payload diagram

Permissible mass inertia at the design point \((L_x, L_y, L_z)\) is 0.045 kgm². The following figure shows the payload diagram.

**Fig. 4-5: Load center of gravity**

**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!
### Technical data

#### In-line wrist

<table>
<thead>
<tr>
<th>In-line wrist type</th>
<th>ZH 10 R1100 WP</th>
</tr>
</thead>
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<tr>
<td>Mounting flange</td>
<td>see drawing</td>
</tr>
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</table>

#### Mounting flange

<table>
<thead>
<tr>
<th>Screw grade</th>
<th>12.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw size</td>
<td>M5</td>
</tr>
<tr>
<td>Clamping length</td>
<td>min. 1.5 x nominal diameter</td>
</tr>
<tr>
<td>Depth of engagement</td>
<td>min. 5.5 mm, max. 7 mm</td>
</tr>
<tr>
<td>Locating element</td>
<td>5 H7</td>
</tr>
</tbody>
</table>

The mounting flange is depicted with axis 6 in the zero position (Fig. 4-7). The symbol $X_m$ indicates the position of the locating element in the zero position.

Dimensions: mm

![Mounting flange diagram](image)

**Fig. 4-7:** Mounting flange

#### 4.2.4 Foundation data, KR 10 R1100 EX 2G

**Foundation loads**

The specified forces and moments already include the maximum payload and the inertia force (weight) of the robot.
The robot can carry supplementary loads on the arm, on the in-line wrist, on the link arm and on the rotating column. The fastening holes on the arm, link arm and rotating column are used for fastening the covers or external energy supply systems. Parts of the energy supply system (e.g. holders for compressed air hose) are fastened to the in-line wrist using the fastening holes.

### Supplementary load

The robot can carry supplementary loads on the arm, on the in-line wrist, on the link arm and on the rotating column. The fastening holes on the arm, link arm and rotating column are used for fastening the covers or external energy supply systems. Parts of the energy supply system (e.g. holders for compressed air hose) are fastened to the in-line wrist using the fastening holes.
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.

The sum of all loads mounted on the robot must not exceed the maximum total load.

The following diagrams (Fig. 4-9) show the dimensions and position of the installation options on the arm, in-line wrist, link arm and rotating column.

Fig. 4-9: Supplementary load on arm and in-line wrist

1 Support bracket for supplementary load
4.4 Plates and labels

The following plates and labels are attached to the robot. They must not be removed or rendered illegible. Illegible plates and labels must be replaced.
Fig. 4-11: Plates and labels
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1    | 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! |
| 2    | Work on the robot  
Before start-up, transportation or maintenance, read and follow the assembly and operating instructions. |
| 3    | Identification plate  
Content according to Machinery Directive. |
### 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!

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
</table>
| 4 | ![Warning symbol]  
| **CAUTION** | Move the robot into its transport position before removing the mounting base!  
| **ATTENTION** | Enter the danger zone of the robot is prohibited if the robot is in operation or ready for operation. Risk of injury!  
| **VORSICHT** | \(0^\circ\) - \(105^\circ\)  
<table>
<thead>
<tr>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-15^\circ)</td>
<td>(+15^\circ)</td>
<td>(0^\circ)</td>
<td>(+120^\circ)</td>
<td>(0^\circ)</td>
<td></td>
</tr>
</tbody>
</table>

### Danger zone

Entering the danger zone of the robot is prohibited if the robot is in operation or ready for operation. Risk of injury!

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
</table>
| 6 | Alle Abdeckungen dürfen nicht entfernt werden  
| All covers must not be removed  
| **Do not remove the cover.** |

### Air connection

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
</table>
| 7 | \(\text{min. Spülvolumen} / \text{min. Purge Volume}\) | 14.0 Liter  
| \(\text{min. Luftdruck} / \text{min. Pressure}\) | 1.5 mBar  
| \(\text{max. Luftdruck} / \text{max. Pressure}\) | 40.0 mBar  
| \(\text{min. Volumenstrom} / \text{min. Flow}\) | 1.5 l/s  
| **Air connection** |
4.5 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.

4.6 Stopping distances and times

4.6.1 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

---

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>No step</td>
</tr>
</tbody>
</table>
| 9    | Nicht unter Spannung ein- / ausstecken  
      Do not plug/unplug when energized  
      Do not plug / unplug when energized |
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.

### 4.6.2 Terms used

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>Mass of the rated load and the supplementary load on the arm.</td>
</tr>
<tr>
<td>Phi</td>
<td>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.</td>
</tr>
<tr>
<td>POV</td>
<td>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.</td>
</tr>
<tr>
<td>Extension</td>
<td>Distance (l in %) (&gt;&gt;&gt; Fig. 4-12) 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.</td>
</tr>
</tbody>
</table>
| KCP    | KUKA Control Panel  
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. |
4.6.3 Stopping distances and times, KR 10 R1100 EX 2G, floor-mounted or ceiling-mounted

The following values are preliminary values and are valid for floor-mounted and ceiling-mounted KR 10 R1100 EX 2G robots.

4.6.3.1 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 $m = \text{maximum load (rated load + supplementary load on arm)}$

<table>
<thead>
<tr>
<th>Axis</th>
<th>Stopping distance (°)</th>
<th>Stopping time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axis 1</td>
<td>106.21</td>
<td>0.536</td>
</tr>
<tr>
<td>Axis 2</td>
<td>96.06</td>
<td>0.647</td>
</tr>
<tr>
<td>Axis 3</td>
<td>46.99</td>
<td>0.373</td>
</tr>
</tbody>
</table>

Fig. 4-12: Extension
4.6.3.2 Stopping distances and stopping times for STOP 1, axis 1

Fig. 4-13: Stopping distances for STOP 1, axis 1
Fig. 4-14: Stopping times for STOP 1, axis 1
4.6.3.3 Stopping distances and stopping times for STOP 1, axis 2

Fig. 4-15: Stopping distances for STOP 1, axis 2
Fig. 4-16: Stopping times for STOP 1, axis 2
4.6.3.4 Stopping distances and stopping times for STOP 1, axis 3

The following values are preliminary values and are valid for the wall-mounted KR 10 R1100 EX 2G robot.

4.6.4 Stopping distances and times, KR 10 R1100 EX 2G, wall-mounted

The following values are preliminary values and are valid for the wall-mounted KR 10 R1100 EX 2G robot.

4.6.4.1 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)
<table>
<thead>
<tr>
<th>Axis</th>
<th>Stopping distance (°)</th>
<th>Stopping time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axis 1</td>
<td>163.11</td>
<td>0.745</td>
</tr>
<tr>
<td>Axis 2</td>
<td>67.78</td>
<td>0.404</td>
</tr>
<tr>
<td>Axis 3</td>
<td>60.96</td>
<td>0.387</td>
</tr>
</tbody>
</table>
4.6.4.2 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
4.6.4.3  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
4.6.4.4 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
5 Safety

5.1 General

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
- Software
- Options, accessories

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

The industrial robot may only be used in perfect technical condition in accordance with its intended use and only by safety-conscious persons who are fully aware of the risks involved in its operation. Use of the industrial robot is subject to compliance with this document and with the declaration of incorporation supplied together with the industrial robot. Any functional disorders, especially those 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 shall be liable if these components violate Ex zone 1 or if they cause any damage to the industrial robot or to other material property.

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

5.1.2 Intended use of the industrial robot

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

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

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

Misuse

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

- Transportation of persons and animals
- Use as a climbing aid
- Operation outside the specified operating parameters
- Operation of the robot controller in the potentially explosive area
- Use in radioactive environments
- Operation without additional safeguards
- Outdoor operation
- Operation in underground mining

### 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 system conforms to the EC Machinery Directive for equipment and protective systems for the intended use in potentially explosive areas. This has been confirmed by means of an assessment of conformity.

**EC declaration of conformity**

The robot system also receives an EC declaration of conformity according to Directive 2014/34/EU through a notified body for ATEX certifications. For use in an Ex zone 1 environment, the robot must be certified according to Directive 2014/34/EU.

**Declaration of incorporation**

The robot system is provided with a declaration of incorporation as partly completed machinery according to 2006/42/EC and 2014/30/EU.

### 5.1.4 Terms used

STOP 0, STOP 1 and STOP 2 are the stop definitions according to EN 60204-1:2006.

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axis range</td>
<td>Range of each axis, in degrees or millimeters, within which it may move. The axis range must be defined for each axis.</td>
</tr>
<tr>
<td>Stopping distance</td>
<td>Stopping distance = reaction distance + braking distance. The stopping distance is part of the danger zone.</td>
</tr>
<tr>
<td>Workspace</td>
<td>Area within which the robot may move. The workspace is derived from the individual axis ranges.</td>
</tr>
<tr>
<td>User</td>
<td>The user of the industrial robot can be the management, employer or delegated person responsible for use of the industrial robot.</td>
</tr>
<tr>
<td>Danger zone</td>
<td>The danger zone consists of the workspace and the stopping distances of the manipulator.</td>
</tr>
<tr>
<td>Service life</td>
<td>The service life of a safety-relevant component begins at the time of delivery of the component to the customer. The service life is</td>
</tr>
<tr>
<td></td>
<td>not affected by whether the component is used or not, as safety-relevant components are also subject to aging during storage.</td>
</tr>
<tr>
<td>KUKA smartPAD</td>
<td>see “smartPAD”</td>
</tr>
<tr>
<td>Manipulator</td>
<td>The robot arm and the associated electrical installations</td>
</tr>
<tr>
<td>Safety zone</td>
<td>The safety zone is situated outside the danger zone.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Safe shutdown</td>
<td>Safety stop reaction. If the pressure in the pressurized enclosure drops, the safety shutdown is activated. The motor phases, brake voltage, supply voltage and RDC data connections are interrupted.</td>
</tr>
<tr>
<td>Safe operational stop</td>
<td>The safe operational stop is a standstill monitoring function. It does not stop the robot motion, but monitors whether the robot axes are stationary. If these are moved during the safe operational stop, a safety stop STOP 0 is triggered. The safe operational stop can also be triggered externally. When a safe operational stop is triggered, the robot controller sets an output to the field bus. The output is set even if not all the axes were stationary at the time of triggering, thereby causing a safety stop STOP 0 to be triggered.</td>
</tr>
<tr>
<td>Safety STOP 0</td>
<td>A stop that is triggered and executed by the safety controller. The safety controller immediately switches off the drives and the power supply to the brakes. <strong>Note:</strong> This stop is called safety STOP 0 in this document.</td>
</tr>
<tr>
<td>Safety STOP 1</td>
<td>A stop that is triggered and monitored by the safety controller. The braking operation is carried out by the non-safety-oriented section of the robot controller and monitored by the safety controller. As soon as the manipulator has stopped, the safety controller deactivates the drives and the power supply of the brakes. When a safety STOP 1 is triggered, the robot controller sets an output to the field bus. The safety STOP 1 can also be triggered externally. <strong>Note:</strong> This stop is called safety STOP 1 in this document.</td>
</tr>
<tr>
<td>Safety STOP 2</td>
<td>A stop that is triggered and monitored by the safety controller. The braking operation is carried out by the non-safety-oriented section of the robot controller and monitored by the safety controller. The drives remain activated and the brakes released. As soon as the manipulator is at a standstill, a safe operational stop is triggered. When a safety STOP 2 is triggered, the robot controller sets an output to the field bus. The safety STOP 2 can also be triggered externally. <strong>Note:</strong> This stop is called safety STOP 2 in this document.</td>
</tr>
<tr>
<td>Safety options</td>
<td>Generic term for options which make it possible to configure additional safe monitoring functions in addition to the standard safety functions. <strong>Example:</strong> SafeOperation</td>
</tr>
<tr>
<td>smartPAD</td>
<td>Programming device for the robot controller The smartPAD has all the operator control and display functions required for operating and programming the industrial robot. The smartPAD may not be taken into the Ex zone until there is no longer an explosive atmosphere in the zone.</td>
</tr>
<tr>
<td>Stop category 0</td>
<td>The drives are deactivated immediately and the brakes are applied. The manipulator is stopped with path-oriented braking. <strong>Note:</strong> This stop category is called STOP 0 in this document.</td>
</tr>
</tbody>
</table>
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 instruction at defined intervals and pass on information concerning possible dangers in the workplace.

The user is responsible for preparing technical and organizational protective measures conforming to 2014/34/EC and setting them out in writing, e.g. a risk analysis and risk assessment.

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

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
- Affixing the CE marks
- 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 event of a stop, the manipulator is braked and comes to a stop within the danger zone.

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

5.3.1 Determining stopping distances

The system integrator’s risk assessment may indicate that the stopping distances must be determined for an application. In order to determine the stopping distances, the system integrator must identify the safety-relevant points on the programmed path.

When determining the stopping distances, the robot must be moved with the tool and loads which are also used in the application. The robot must be at operating temperature. This is the case after approx. 1 h in normal operation.

During execution of the application, the robot must be stopped at the point from which the stopping distance is to be calculated. This process must be repeated several times with a safety stop 0 and a safety stop 1. The least favorable stopping distance is decisive.

A safety stop 0 can be triggered by a safe operational stop via the safety interface, for example. If a safety option is installed, it can be triggered, for instance, by a space violation (e.g. the robot exceeds the limit of an activated workspace in Automatic mode).

A safety stop 1 can be triggered by pressing the EMERGENCY STOP device on the smartPAD, for example.
5.4 Potentially explosive area, zone 1

Following certification by a notified body, the robot can be used in combination with the pressure monitoring system and KR C4 EU EX 2G in potentially explosive areas of category 2G according to ATEX Directive 2014/34/EU. The robot then receives the following marking:

<table>
<thead>
<tr>
<th>Ex symbol</th>
<th>Symbol for prevention of explosions according to 2014/34/EU. Device approved for potentially explosive areas according to marking.</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>Device group II specifies that the robot can be used for all areas (except underground).</td>
</tr>
<tr>
<td>2</td>
<td>ATEX category: In category 2, potentially explosive gases are occasionally present (&lt;1,000 h/year). Devices of category 2 are required for operation in explosion protection zone 1.</td>
</tr>
<tr>
<td>G</td>
<td>The explosion protection refers to explosive gases and vapors, not to dust.</td>
</tr>
<tr>
<td>Ex pxb</td>
<td>Type of protection: pressurized enclosure with increased protection</td>
</tr>
<tr>
<td>IIC</td>
<td>Explosion class</td>
</tr>
<tr>
<td>T4</td>
<td>Temperature class (&lt;135° C)</td>
</tr>
<tr>
<td>Gb</td>
<td>EPL Zone 2 (flammable gases/vapors)</td>
</tr>
<tr>
<td>CE mark</td>
<td>Refers here exclusively to compliance with the ATEX guidelines.</td>
</tr>
</tbody>
</table>

Hazards in Ex zones

Ex zones are marked to indicate that there is a potentially explosive atmosphere. A mixture of air and flammable substances is thus present under atmospheric conditions in which, after ignition has occurred, combustion spreads to the entire unburned mixture.

Flammable substances include:
- Vapors released from deposits
- Solvent vapors
- Cleaning fluids

⚠️ **DANGER** In the event of failure of the technical ventilation, the concentration of flammable substances is liable to increase rapidly. The Ex zone must be evacuated immediately.

⚠️ **DANGER** In the event of failure of the power supply, the concentration of flammable substances is liable to increase rapidly. The Ex zone must be evacuated immediately.

Use of tools in Ex zones

Only accessories authorized for use in Ex zone 1 environments may be used in an Ex zone.

Tools and devices which do not correspond to the device category for the relevant Ex zone may only be used in compliance with the following instruction.

The smartPAD and the robot controller are not designed for use in an Ex zone 1 environment and may only be taken into the Ex zone if there is no longer an explosive atmosphere.
5.5 Triggers for stop reactions

Stop reactions of the industrial robot are triggered in response to operator actions or as a reaction to monitoring functions and error messages. The following table shows the different stop reactions according to the operating mode that has been set.

<table>
<thead>
<tr>
<th>Trigger</th>
<th>T1, T2</th>
<th>AUT, AUT EXT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start key released</td>
<td>STOP 2</td>
<td>-</td>
</tr>
<tr>
<td>STOP key pressed</td>
<td>STOP 2</td>
<td></td>
</tr>
<tr>
<td>Drives OFF</td>
<td>STOP 1</td>
<td></td>
</tr>
<tr>
<td>&quot;Motion enable&quot; input drops out</td>
<td>STOP 2</td>
<td></td>
</tr>
<tr>
<td>Power switched off via main switch or power failure</td>
<td>STOP 0</td>
<td></td>
</tr>
<tr>
<td>Internal error in non-safety-oriented part of the robot controller</td>
<td>STOP 0 or STOP 1 (dependent on the cause of the error)</td>
<td></td>
</tr>
<tr>
<td>Operating mode changed during operation</td>
<td>Safety stop 2</td>
<td></td>
</tr>
<tr>
<td>Safety gate opened (operator safety)</td>
<td>-</td>
<td>Safety stop 1</td>
</tr>
<tr>
<td>Enabling switch released</td>
<td>Safety stop 2</td>
<td>-</td>
</tr>
<tr>
<td>Enabling switch pressed fully down or error</td>
<td>Safety stop 1</td>
<td>-</td>
</tr>
<tr>
<td>E-STOP pressed</td>
<td>Safety stop 1</td>
<td></td>
</tr>
<tr>
<td>Error in safety controller or periphery of the safety controller</td>
<td>Safety stop 0</td>
<td></td>
</tr>
<tr>
<td>Safe shutdown</td>
<td>Safety stop 1</td>
<td></td>
</tr>
</tbody>
</table>

5.6 Safety functions

5.6.1 Overview of the safety functions

The following safety functions are present in the industrial robot:

- Selecting the operating mode
- Operator safety (= connection for the monitoring of physical safeguards)
- EMERGENCY STOP device
- EMERGENCY STOP fire protection
- Enabling device
- External safe operational stop
- External safety stop 1
- External safety stop 2
- Velocity monitoring in T1

Before entering the Ex zone, the user must ensure that there is no longer an explosive atmosphere present in the Ex zone. It is important to be aware of an uneven distribution of the concentration. The appropriate procedure must be selected in accordance with the operating conditions at the user’s plant.
The safety functions of the industrial robot meet the following requirements:

- **Category 3** and **Performance Level d** in accordance with EN ISO 13849-1

The requirements are only met on the following condition, however:

- The EMERGENCY STOP device is pressed at least once every 12 months.

The following components are involved in the safety functions:

- Safety controller in the control PC
- KUKA smartPAD
- Cabinet Control Unit (CCU)
- Resolver Digital Converter (RDC)
- KUKA Power Pack (KPP)
- KUKA Servo Pack (KSP)
- Safety Interface Board (SIB) (if used)
- Pressure monitoring consisting of compressed air sensor, compressed air controller and safe data cable

There are also interfaces to components outside the industrial robot and to other robot controllers.

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**5.6.2 Safety controller**

The safety controller is a unit inside the control PC. It links safety-relevant signals and safety-relevant monitoring functions.

Safety controller tasks:

- Switching off the drives; applying the brakes
- Monitoring the braking ramp
- Standstill monitoring (after the stop)
- Velocity monitoring in T1
- Evaluation of safety-relevant signals
- Setting of safety-oriented outputs

---

**5.6.3 Selecting the operating mode**

**Operating modes** The industrial robot can be operated in the following modes:

- Manual Reduced Velocity (T1)
- Manual High Velocity (T2)
- Automatic (AUT)
- Automatic External (AUT EXT)
The user can change the operating mode via the connection manager. The connection manager is a view that is called by means of the mode selector switch on the smartPAD.

The mode selector switch may be one of the following variants:

- **With key**
  It is only possible to change operating mode if the key is inserted.

- **Without key**

**WARNING** If the smartPAD is fitted with a switch without a key:
  An additional device must be present to ensure that the relevant functions cannot be executed by all users, but only by a restricted group of people.
  The device itself must not trigger motions of the industrial robot or other hazards. If this device is missing, death or severe injuries may result.

The system integrator is responsible for ensuring that such a device is implemented.

### 5.6.4 “Operator safety” signal

The “operator safety” signal is used for monitoring physical safeguards, e.g. safety gates. Automatic operation is not possible without this signal. In the event of a loss of signal during automatic operation (e.g. safety gate is opened), the manipulator stops with a safety stop 1.

Operator safety is not active in modes T1 (Manual Reduced Velocity) and T2 (Manual High Velocity).
5.6.5 EMERGENCY STOP device

The EMERGENCY STOP device for the industrial robot is the EMERGENCY STOP device on the smartPAD and the EMERGENCY STOP device on the technology cabinet. The device must be pressed in the event of a hazardous situation or emergency.

Reactions of the industrial robot if the EMERGENCY STOP device is pressed:

- The manipulator stops with a safety stop 1.

Before operation can be resumed, the EMERGENCY STOP device must be turned to release it.

Tools and other equipment connected to the robot must be integrated into the EMERGENCY STOP circuit on the system side if they could constitute a potential hazard. Failure to observe this precaution may result in death, severe injuries or considerable damage to property.

5.6.6 Logging off from the higher-level safety controller

If the robot controller is connected to a higher-level safety controller, this connection will inevitably be terminated in the following cases:

- Switching off the voltage via the main switch of the robot
  Or power failure
- Shutdown of the robot controller via the smartHMI
- Activation of a WorkVisual project in WorkVisual or directly on the robot controller
- Changes to Start-up > Network configuration
- Changes to Configuration > Safety configuration
- I/O drivers > Reconfigure
- Restoration of an archive

Effect of the interruption:

- If a discrete safety interface is used, this triggers an EMERGENCY STOP for the overall system.
5.6.7 External EMERGENCY STOP device

Every operator station that can initiate a robot motion or other potentially hazardous situation must be equipped with an EMERGENCY STOP device. The system integrator is responsible for ensuring this.

There must always be at least one external EMERGENCY STOP device installed. An external EMERGENCY STOP device for fire protection must also be installed. This ensures that an EMERGENCY STOP device is available even when the smartPAD is disconnected.

External EMERGENCY STOP devices are connected via the customer interfaces. External EMERGENCY STOP devices are not included in the scope of supply of the industrial robot.

5.6.8 Enabling device

The enabling devices of the industrial robot are the enabling switches on the smartPAD.

There are 3 enabling switches installed on the smartPAD. The enabling switches have 3 positions:

- Not pressed
- Center position
- Panic position

In the test modes, the manipulator can only be moved if one of the enabling switches is held in the central position.

- Releasing the enabling switch triggers a safety stop 2.
- Pressing the enabling switch down fully (panic position) triggers a safety stop 1.
- It is possible to hold 2 enabling switches in the center position simultaneously for up to 15 seconds. This makes it possible to adjust grip from one enabling switch to another one. If 2 enabling switches are held simultaneously in the center position for longer than 15 seconds, this triggers a safety stop 1.

If an enabling switch malfunctions (e.g. jams in the central position), the industrial robot can be stopped using the following methods:

- Press the enabling switch down fully.
- Actuate the EMERGENCY STOP device.
- Release the Start key.

The enabling switches must not be held down by adhesive tape or other means or tampered with in any other way. Death, injuries or damage to property may result.
### 5.6.9 External enabling device

External enabling devices are required if it is necessary for more than one person to be in the danger zone of the industrial robot.

External enabling devices are not included in the scope of supply of the industrial robot.

---

**Which interface can be used for connecting external enabling devices is described in the “Planning” chapter of the robot controller operating instructions and assembly instructions.**

### 5.6.10 External safe operational stop

The safe operational stop can be triggered via an input on the customer interface. The state is maintained as long as the external signal is FALSE. If the external signal is TRUE, the manipulator can be moved again. No acknowledgement is required.

### 5.6.11 External safety stop 1 and external safety stop 2

Safety stop 1 and safety stop 2 can be triggered via an input on the customer interface. The state is maintained as long as the external signal is FALSE. If the external signal is TRUE, the manipulator can be moved again. No acknowledgement is required.

If interface X11 is selected as the customer interface, only the signal **Safety stop 2** is available.

### 5.6.12 Velocity monitoring in T1

The velocity at the mounting flange is monitored in T1 mode. If the velocity exceeds 250 mm/s, a safety stop 0 is triggered.

### 5.6.13 Safety shutdown of motors

All motors of the robot are protected from mechanical and thermal overloading:

- In the event of mechanical overloading, the corresponding electric current limitation triggers a safety cut-out of the robot.
- In the event of thermal overloading, the corresponding temperature monitor or temperature limiter triggers a safety cut-out of the robot.

### 5.7 Additional protective equipment

#### 5.7.1 Jog mode

In the operating modes T1 (Manual Reduced Velocity) and T2 (Manual High Velocity), the robot controller can only execute programs in jog mode. This means that it is necessary to hold down an enabling switch and the Start key in order to execute a program.

- Releasing the enabling switch triggers a safety stop 2.
- Pressing the enabling switch down fully (panic position) triggers a safety stop 1.
- Releasing the Start key triggers a STOP 2.
### 5.7.2 Software limit switches

The axis ranges of all manipulator and positioner axes are limited by means of adjustable software limit switches. These software limit switches only serve as machine protection and must be adjusted in such a way that the manipulator/positioner cannot hit the mechanical end stops.

The software limit switches are set during commissioning of an industrial robot.

Further information is contained in the operating and programming instructions.

### 5.7.3 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.

**WARNING** If the manipulator hits an obstruction or a mechanical end stop, 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.

### 5.7.4 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**

In order to move the manipulator after an accident or malfunction without drive energy, a brake release device is available which can open axes A1 to A3 or axes A4 to A6.

**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.

### 5.7.5 Labeling on the industrial robot

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

Labeling on the industrial robot consists of:

- Identification plates
- Warning signs
- Safety symbols
- Designation labels
- Cable markings
- Rating plates
5.7.6 External safeguards

The access of persons to the danger zone of the industrial robot must be prevented by means of safeguards. It is the responsibility of the system integrator to ensure this.

Physical safeguards must meet the following requirements:

- They meet the requirements of EN ISO 14120.
- They prevent access of persons to the danger zone and cannot be easily circumvented.
- They are sufficiently fastened and can withstand all forces that are likely to occur in the course of operation, whether from inside or outside the enclosure.
- They do not, themselves, represent a hazard or potential hazard.
- Prescribed clearances, e.g. to danger zones, are adhered to.

Safety gates (maintenance gates) must meet the following requirements:

- They are reduced to an absolute minimum.
- The interlocks (e.g. safety gate switches) are linked to the operator safety input of the robot controller via safety gate switching devices or safety PLC.
- Switching devices, switches and the type of switching conform to the requirements of Performance Level d and category 3 according to EN ISO 13849-1.
- Depending on the risk situation: the safety gate is additionally safeguarded by means of a locking mechanism that only allows the gate to be opened if the manipulator is safely at a standstill.
- The button for acknowledging the safety gate is located outside the space limited by the safeguards.

Other safety equipment

Other safety equipment must be integrated into the system in accordance with the corresponding standards and regulations.

5.8 Overview of operating modes and safety functions

The following table indicates the operating modes in which the safety functions are active.

<table>
<thead>
<tr>
<th>Safety functions</th>
<th>T1</th>
<th>T2</th>
<th>AUT</th>
<th>AUT EXT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator safety</td>
<td>-</td>
<td>-</td>
<td>Active</td>
<td>Active</td>
</tr>
<tr>
<td>EMERGENCY STOP device</td>
<td>Active</td>
<td>Active</td>
<td>Active</td>
<td>Active</td>
</tr>
<tr>
<td>Enabling device</td>
<td>Active</td>
<td>Active</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Reduced velocity during program verification</td>
<td>Active</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Jog mode</td>
<td>Active</td>
<td>Active</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Software limit switches</td>
<td>Active</td>
<td>Active</td>
<td>Active</td>
<td>Active</td>
</tr>
</tbody>
</table>
5.9  Safety measures

5.9.1  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. Flushing with purge gas safeguards the manipulator's properties of explosion protection. Operator errors can result in personal injury and damage to property.

When operating the robot in a potentially explosive atmosphere, safety-relevant requirements conforming to 2014/34/EU must be observed along with the technical documentation. First and foremost, the probability of an explosive atmosphere developing or existing at the place of operation must be kept to a minimum or, if possible, eliminated entirely. There must be no active ignition sources in the explosion zones that cannot be avoided. Before installation and start-up, it must be assured that the planned operation procedures are permissible or acceptable.

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 to sag. If work is to be carried out on a switched-off industrial robot, it must first be moved into a position in which it is unable to move on its own, whether the payload is mounted or not. If this is not possible, the manipulator must be secured by appropriate means.

Work on the manipulator (e.g. cleaning, maintenance or repair) may only be carried out if there is no risk of explosion.

The system integrator must ensure that the manipulator is only energized if the pre-purge phase has been completed and the interior is permanently pressurized against the atmosphere. Before removal/installation, the overpressure monitoring system must be completely deenergized.

---

**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.

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**Protective function**

As part of the primary protective measures, the size of the potentially explosive area must be limited as far as possible at the place of operation through suitable technical ventilation.

As part of the secondary protective measures, possible ignition sources within the potentially explosive area must be avoided or deactivated.

The power supply and the associated controller, including the smartPAD, must be installed and operated outside of the danger zone (explosion zones).

Releasing, disconnecting and/or replacing electrical cables as well as pressing the enabling device (for example) is strictly prohibited under the operating conditions.
2014/34/EU is a mandatory directive for achieving or guaranteeing an acceptable minimum level of explosion protection for the persons employed on the business premises.

In the event of unusual process conditions and a significantly higher potential for danger, additional safety measures may be necessary, such as:

- Monitoring of the concentration of combustible substances in the direct vicinity of the technical system, combined with automatic deactivation of the process and all potential ignition sources if the maximum acceptable concentration is exceeded.
- Installation of an automatic system for suppressing explosions in the event that not all protective measures against ignition can be implemented with sufficient reliability.

smartPAD

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

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

![CAUTION]

The smartPAD is not designed for use in an Ex zone 1 environment and may only be taken into the Ex zone if there is no longer an explosive atmosphere.

![WARNING]

The operator must ensure that decoupled 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.

Compressed air

The system integrator/user must ensure that the manipulator is operated with the KR C4 EU EX (2G) controller and with the supplied connecting cable set. The pressure monitoring system must be functioning correctly.

![NOTICE]

The robot may only be operated with a correctly adjusted pressure regulator and with the compressed air supply connected. Incorrectly adjusted pressure regulators or operation with no pressure regulator may result in damage to the robot.

Modifications

After modifications to the industrial robot, checks must be carried out to ensure the required safety level and the robot’s properties of explosion protection. 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

Faults are reduced through proper operation of the industrial robot and through the use of preventative safety measures.

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 if the robot's properties of explosion protection are not affected.

**DANGER** The robot's properties of explosion protection are no longer assured if there is a kinematic fault. In such a case, it is no longer permissible to operate the robot in an explosion protection zone. Elimination of the fault requires consultation with KUKA Deutschland GmbH.

### 5.9.2 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.

### 5.9.3 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 functions must also be tested.

**WARNING** The robot controller is preconfigured for the specific industrial robot. If cables are interchanged, the manipulator 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.
Function test

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

**General test:**

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. Examples: Dents or abrasion that could be caused by an impact or collision.
- There are no foreign bodies or loose parts on the industrial robot.
- All required safety equipment is correctly installed and operational.
- The pre-purge phase was completed correctly.
- 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.

**Test of the safety functions:**

A function test must be carried out for the following safety functions to ensure that they are functioning correctly:

- Local EMERGENCY STOP device
- External EMERGENCY STOP device (input and output)
- Enabling device (in the test modes)
- Pressure monitoring
- Operator safety
- All other safety-relevant inputs and outputs used
- Other external safety functions

### 5.9.3.1 Checking machine data and safety configuration

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

Following the start-up procedure, the practical tests for the machine data must be carried out. The tool must be calibrated (either via an actual calibration or through numerical entry of the data).
Following modifications to the machine data, the safety configuration must be checked.

After activation of a WorkVisual project on the robot controller, the safety configuration must be checked.

If machine data are adopted when checking the safety configuration (regardless of the reason for the safety configuration check), the practical tests for the machine data must be carried out.

System Software 8.3 or higher: If the checksum of the safety configuration has changed, the safe axis monitoring functions must be checked.

If the practical tests are not successfully completed in the initial start-up, KUKA Deutschland GmbH must be contacted.

If the practical tests are not successfully completed during a different procedure, the machine data and the safety-relevant controller configuration must be checked and corrected.

General practical test

If practical tests are required for the machine data, this test must always be carried out.

For 6-axis robots:
The following methods are available for performing the practical test:

- TCP calibration with the XYZ 4-point method
  The practical test is passed if the TCP has been successfully calibrated.

  Or:

  1. Align the TCP with a freely selected point. The point serves as a reference point.
     - The point must be located so that reorientation is possible.
     - The point must not be located on the Z axis of the FLANGE coordinate system.

  2. Move the TCP manually at least 45° once in each of the A, B and C directions.
     The movements do not have to be accumulative, i.e. after motion in one direction it is possible to return to the original position before moving in the next direction.
     The practical test is passed if the TCP does not deviate from the reference point by more than 2 cm in total.

For palletizing robots:
Palletizing robots, in this case, are either robots that can be used only as palletizers from the start or robots operated in palletizing mode. The latter must also be in palletizing mode during the practical test.

First part:

1. Mark the starting position of the TCP.
   Also read and note the starting position from the Actual position — Cartesian display on the smartHMI.

2. Jog the TCP in the X direction. The distance must be at least 20% of the robot’s maximum reach. Determine the exact length via the Actual position display.

3. Measure the distance covered and compare it with the distance value displayed on the smartHMI. The deviation must be < 5%.

4. Repeat steps 1 and 2 for the Y direction and Z direction.
The first part of the practical test is passed if the deviation is < 5% in every direction.

Second part:

- Rotate the tool manually about A by 45°: once in the plus direction, once in the minus direction. At the same time, observe the TCP.

The second part of the practical test is passed if the position of the TCP in space is not altered during the rotations.

### Practical test for axes that are not mathematically coupled

If practical tests are required for the machine data, this test must be carried out when axes are present that are not mathematically coupled.

1. Mark the starting position of the axis that is not mathematically coupled.
   
   Also read and note the start position from the Actual position display on the smartHMI.

2. Move the axis manually by a freely selected path length. Determine the path length from the Actual position display.
   
   - Move linear axes a specific distance.
   - Move rotational axes through a specific angle.

3. Measure the length of the path covered and compare it with the value displayed on the smartHMI.
   
   The practical test is passed if the values differ by no more than 5%.

4. Repeat the test for each axis that is not mathematically coupled.

### Practical test for robot on KUKA linear unit

If practical tests are required for the machine data, this test must be carried out if the robot and KL are mathematically coupled.

- Move the KL manually in Cartesian mode.

The practical test is passed if the TCP does not move at the same time.

### Practical test for couplable axes

If practical tests are required for the machine data, this test must be carried out when axes are present that can be physically coupled and uncoupled, e.g. a servo gun.

1. Physically uncouple the couplable axis.

2. Move all the remaining axes individually.

The practical test is passed if it has been possible to move all the remaining axes.

#### 5.9.3.2 Start-up mode

**Description**

The industrial robot can be set to Start-up mode via the smartHMI user interface. In this mode, the manipulator can be moved in T1 without the external safeguards being put into operation.

The safety interface used affects “Start-up” mode:

**Discrete safety interface**

- System Software 8.2 or earlier:

  Start-up mode is always possible if all input signals at the discrete safety interface have the state “logic zero”. If this is not the case, the robot controller prevents or terminates Start-up mode.

  If an additional discrete safety interface for safety options is used, the inputs there must also have the state “logic zero”.

---
System Software 8.3 or higher:
Start-up mode is always possible. This also means that it is independent
of the state of the inputs at the discrete safety interface.
If an additional discrete safety interface is used for safety options: The
states of these inputs are also irrelevant.

**Ethernet safety interface**
The robot controller prevents or terminates Start-up mode if a connection to a
higher-level safety system exists or is established.

**Effect**
When the Start-up mode is activated, all outputs are automatically set to the
state “logic zero”.

If the robot controller has a peripheral contactor (US2), and if the safety con-
figuration specifies for this to switch in accordance with the motion enable,
then the same also applies in Start-up mode. This means that if motion enable
is present, the US2 voltage is switched on – even in Start-up mode.

---

**NOTICE**
The maximum number of switching cycles of the peripheral contactors is 175 per day.

**Hazards**
Possible hazards and risks involved in using Start-up mode:

- A person walks into the manipulator’s danger zone.
- In a hazardous situation, a disabled external EMERGENCY STOP device
  is actuated and the manipulator is not shut down.

Additional measures for avoiding risks in Start-up mode:

- Cover disabled EMERGENCY STOP devices or attach a warning sign in-
 dicating that the EMERGENCY STOP device is out of operation.
- If there is no safety fence, other measures must be taken to prevent per-
  sons from entering the manipulator’s danger zone, e.g. use of warning
tape.

**Use**
Intended use of Start-up mode:

- Start-up in T1 mode when the external safeguards have not yet been in-
  stalled or put into operation. The danger zone must be delimited at least
  by means of warning tape.
- Fault localization (periphery fault).
- Use of Start-up mode must be minimized as much as possible.

---

**WARNING**
Use of Start-up mode disables all external safeguards. The service personnel are responsible for ensuring that there is no-one in or near the danger zone of the manipulator as long as the safeguards are disabled. Failure to observe this precaution may result in death, injuries or damage to property.

**Misuse**
Any use or application deviating from the intended use is deemed to be misuse
and is not allowed. KUKA Deutschland GmbH is not liable for any damage re-
sulting from such misuse. The risk lies entirely with the user.

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**5.9.4 Manual mode**

**General**
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:

- New or modified programs must always be tested first in Manual Reduced Velocity mode (T1).
- The manipulator or its tooling 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.

Setup work in T1

If it is necessary to carry out setup work from inside the safeguarded area, the following must be taken into consideration in the operating mode Manual Reduced Velocity (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.
- Unexpected motions of the manipulator cannot be ruled out, e.g. in the event of a fault. For this reason, an appropriate clearance must be maintained between persons and the manipulator (including tool). Guide value: 50 cm.
  
  The minimum clearance may vary depending on local circumstances, the motion program and other factors. The minimum clearance that is to apply for the specific application must be decided by the user on the basis of a risk assessment.

Setup work in T2

If it is necessary to carry out setup work from inside the safeguarded area, the following must be taken into consideration in the operating mode Manual High Velocity (T2):

- This mode may only be used if the application requires a test at a velocity higher than that 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.

5.9.5 Simulation

Simulation programs do not correspond exactly to reality. Robot programs created in simulation programs must be tested in the system in Manual Reduced Velocity mode (T1). It may be necessary to modify the program.
5.9.6 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 comes to a standstill for no apparent reason, the danger zone must not be entered until an EMERGENCY STOP has been triggered.

5.9.7 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.

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.

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

Voltages in excess of 50 V (up to 480 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.

### 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.

### 5.9.8 Decommissioning, storage and disposal

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

### 5.9.9 Safety measures for “single point of control”

#### Overview

If certain components in the industrial robot are operated, safety measures must be taken to ensure complete implementation of the principle of “single point of control” (SPOC).

The relevant components are:

- Submit interpreter
- PLC
- OPC server
- Remote control tools
- Tools for configuration of bus systems with online functionality
- KUKA.RobotSensorInterface

The implementation of additional safety measures may be required. This must be clarified for each specific application; this is the responsibility of the system integrator, programmer or user of the system.

Since only the system integrator knows the safe states of actuators in the periphery of the robot controller, it is his task to set these actuators to a safe state, e.g. in the event of an EMERGENCY STOP.

#### T1, T2

In modes T1 and T2, the components referred to above may only access the industrial robot if the following signals have the following states:

<table>
<thead>
<tr>
<th>Signal</th>
<th>State required for SPOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>$USER_SAF</td>
<td>TRUE</td>
</tr>
<tr>
<td>$SPOC_MOTION_ENABLE</td>
<td>TRUE</td>
</tr>
</tbody>
</table>

Submit interpreter, PLC

If motions, (e.g. drives or grippers) are controlled with the submit interpreter or the PLC via the I/O system, and if they are not safeguarded by other means, then this control will take effect even in T1 and T2 modes or while an EMERGENCY STOP is active.
If variables that affect the robot motion (e.g. override) are modified with the submit interpreter or the PLC, this takes effect even in T1 and T2 modes or while an EMERGENCY STOP is active.

Safety measures:

- In T1 and T2, the system variable $OV_PRO must not be written to by the submit interpreter or the PLC.
- Do not modify safety-relevant signals and variables (e.g. operating mode, EMERGENCY STOP, safety gate contact) via the submit interpreter or PLC.

If modifications are nonetheless required, all safety-relevant signals and variables must be linked in such a way that they cannot be set to a dangerous state by the submit interpreter or PLC. This is the responsibility of the system integrator.

**OPC server, remote control tools**

These components can be used with write access to modify programs, outputs or other parameters of the robot controller, without this being noticed by any persons located inside the system.

Safety measure:

If these components are used, outputs that could cause a hazard must be determined in a risk assessment. These outputs must be designed in such a way that they cannot be set without being enabled. This can be done using an external enabling device, for example.

**Tools for configuration of bus systems**

If these components have an online functionality, they can be used with write access to modify programs, outputs or other parameters of the robot controller, without this being noticed by any persons located inside the system.

- WorkVisual from KUKA
- Tools from other manufacturers

Safety measure:

In the test modes, programs, outputs or other parameters of the robot controller must not be modified using these components.

### 5.10 Applied norms and regulations

<table>
<thead>
<tr>
<th>Name/Edition</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>EN ISO 13850:2015</td>
<td>Safety of machinery: Emergency stop - Principles for design</td>
</tr>
<tr>
<td>EN ISO 13849-1:2015</td>
<td>Safety of machinery: Safety-related parts of control systems - Part 1: General principles of design</td>
</tr>
<tr>
<td>EN ISO 12100:2010</td>
<td>Safety of machinery: General principles of design, risk assessment and risk reduction</td>
</tr>
<tr>
<td>Note:</td>
<td>Content equivalent to ANSI/RIA R.15.06-2012, Part 1</td>
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<tr>
<td>EN 61000-6-2:2005</td>
<td>Electromagnetic compatibility (EMC): Part 6-2: Generic standards; Immunity for industrial environments</td>
</tr>
<tr>
<td>EN 50176:2009</td>
<td>Stationary electrostatic application equipment for ignitable liquid coating material Safety requirements</td>
</tr>
<tr>
<td>EN 1127-1:2011</td>
<td>Explosive atmospheres - Explosion prevention and protection: Part 1: Basic concepts and methodology</td>
</tr>
<tr>
<td>EN ISO 80079-36:2016</td>
<td>Explosive atmospheres: Part 36: Non-electrical equipment for explosive atmospheres - Basic method and requirements</td>
</tr>
<tr>
<td>Standard Number</td>
<td>Standard Name</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------------------------------------------------</td>
</tr>
<tr>
<td>EN 60079-0:2012+A11:2013</td>
<td>Explosive atmospheres:</td>
</tr>
<tr>
<td>EN 60079-14:2014</td>
<td>Explosive atmospheres</td>
</tr>
</tbody>
</table>
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 operating parameters specified in the technical data must be taken into account during planning.

- Continuous operation near temperature limits or in abrasive environments
- Continuous operation in wet and abrasive environments
- Operation in aggressive chemical environments
- Operation in the immediate vicinity of cooling lubricant spray, waterjets or compressed air
- Continuous operation close to the performance limits, e.g. high rpm of an axis
- High duty cycle of individual axes
- Monotonous motion profiles, e.g. short, frequently recurring axis motions
- Static axis positions, e.g. continuous vertical position of a wrist axis

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

6.2 Robot planning

Operating modes

The following operating modes do not correspond to normal operation and are not permissible in a potentially explosive atmosphere:

- Mastering with MEMD
- Manual mode
- Re-programming and testing

Normal operation corresponds to Automatic mode.

Pre-purge phase

Before the robot is energized, a pre-purge phase of the following duration must be carried out.

<table>
<thead>
<tr>
<th>Robot</th>
<th>Duration of pre-purge phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>KR 10 R1100 EX 2G</td>
<td>approx. 100 seconds</td>
</tr>
</tbody>
</table>

The purging process is indicated by the flashing yellow LED. When the purging process is completed, the LED is continuously lit up green. Further information can be found in the assembly and operating instructions of the KR C4 EU EX 2G controller.

Pressure monitoring

The connection between the pressure sensor and the compressed air controller is established via the following lines:

- Safe data cable: CON-EX cable, 7 m
- Pneumatic line: PUN-6x1-BL, 7 m

<table>
<thead>
<tr>
<th>Inside diameter</th>
<th>Min. purge volume</th>
<th>Min. air pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 mm</td>
<td>140 l</td>
<td>1.5 mbar</td>
</tr>
</tbody>
</table>

Issued: 22.05.2018 Version: Spez KR 10 R1100 EX 2G V2
### Accessories

Only authorized accessories may be used. These devices and accessory components must possess the appropriate EC declarations of conformity.

### Connections

All open connections on the robot have sealed gas-tight covers.

### 6.3 Mounting base

**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:

- Bedplate
- 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 bedplate and the concrete foundation.

The minimum dimensions must be observed.

---

**Fig. 6-1: Mounting base**

1. Robot base frame
2. Locating pin, cylindrical
3. Resin-bonded anchor
4. Hexagon bolt
5. Bedplate
6. Locating pin, flat-sided

---

**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 bedplate/bedplates and the concrete foundation. The quality of the concrete must meet the requirements of the following standard:


**Dimensioned drawing**

The following illustration (Fig. 6-2) provides all the necessary information on the mounting base, together with the required foundation data. The specified foundation dimensions refer to the safe transmission of the foundation loads into the foundation and not to the stability of the 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).

**Fig. 6-2: Mounting base, dimensioned drawing**

The dimensions specified for the distance to the edge are valid for non-reinforced or normally reinforced concrete without verification of concrete edge failure. For safety against concrete edge failure in accordance with ETAG 001 Annex C, the concrete foundation must be provided with an appropriate edge reinforcement.
6.4 Machine frame mounting

Description

The machine frame mounting assembly is used when the robot is fastened on a steel structure or booster frame (pedestal). This assembly is also used if the robot is installed on the wall or 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:

- Locating pin
- Hexagon bolts with conical spring washers
6.5 Connecting cables and interfaces

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:

1 Hexagon bolt (4x)
2 Cylindrical locating pin
3 Mounting surface
4 Flat-sided locating pin
5 Steel structure
- Motor cable
- Data cable
- Air line
- Safe data cable CON-EX
- Ground conductor

The standard cable length is 7 m. The maximum length of the connecting cables must not exceed 7 m.

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 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:

- For all cables, the bending radius for fixed installation is 3x the cable diameter.
- 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).

**Interface A1**

Interface A1 is located at the rear of the base frame. In order to have access to the interface, the cover of interface cover A1 must first be removed. For this, unscrew 3 Allen screws and remove the cover.

![Fig. 6-6: Interface A1](image-url)
1  Connection MEMD X32
2  Motor cable connection X30
3  Data cable connection X31
4  Purging air input connection AIR2
5  Purging air output connection PURGE
6  Sensor block
7  Safe data cable connection X71
7 Transportation

7.1 Transporting the manipulator

**Description**
Move the robot into its transport position each time it is transported. It must be ensured that the robot is stable while it is being transported. The robot must remain in its transport position until it has been fastened to the foundation. 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 corrosion or glue on contact surfaces.

**Transport position**
The robot must be in the transport position before it can be transported. The robot is in the transport position when the axes are in the following positions:

<table>
<thead>
<tr>
<th>Axis</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle</td>
<td>0°</td>
<td>-105°</td>
<td>+156°</td>
<td>0°</td>
<td>+120°</td>
<td>0°</td>
</tr>
</tbody>
</table>

Fig. 7-1: Transport position

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

The robot is transported using lifting tackle. For this, it must be in the transport position. The loops of the lifting tackle are passed around the link arm and rotating column. All ropes must be long enough and must be routed in such a way that the robot is not damaged. Installed tools and items of equipment can cause undesirable shifts in the center of gravity.

**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.

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. 7-2: Transport dimensions**

1 Robot  
2 Center of gravity
Fig. 7-3: Transportation using lifting tackle

1  Crane
2  Lifting tackle
3  Link arm
4  Rotating column
8 Appendix

8.1 Tightening torques

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

The specified values apply to lightly oiled black (e.g. phosphated) and coated (e.g. mech. galv., zinc flake plating) screws and nuts.

<table>
<thead>
<tr>
<th>Thread</th>
<th>8.8</th>
<th>10.9</th>
<th>12.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1.6</td>
<td>0.17 Nm</td>
<td>0.24 Nm</td>
<td>0.28 Nm</td>
</tr>
<tr>
<td>M2.5</td>
<td>0.35 Nm</td>
<td>0.48 Nm</td>
<td>0.56 Nm</td>
</tr>
<tr>
<td>M3</td>
<td>0.88 Nm</td>
<td>0.93 Nm</td>
<td>1.10 Nm</td>
</tr>
<tr>
<td>M4</td>
<td>2.8 Nm</td>
<td>3.8 Nm</td>
<td>4.4 Nm</td>
</tr>
<tr>
<td>M5</td>
<td>5.6 Nm</td>
<td>7.5 Nm</td>
<td>9.0 Nm</td>
</tr>
<tr>
<td>M6</td>
<td>9.5 Nm</td>
<td>12.5 Nm</td>
<td>15.0 Nm</td>
</tr>
<tr>
<td>M8</td>
<td>23.0 Nm</td>
<td>31.0 Nm</td>
<td>36.0 Nm</td>
</tr>
<tr>
<td>M10</td>
<td>45.0 Nm</td>
<td>60.0 Nm</td>
<td>70.0 Nm</td>
</tr>
<tr>
<td>M12</td>
<td>78.0 Nm</td>
<td>104.0 Nm</td>
<td>125.0 Nm</td>
</tr>
<tr>
<td>M14</td>
<td>125.0 Nm</td>
<td>165.0 Nm</td>
<td>195.0 Nm</td>
</tr>
<tr>
<td>M16</td>
<td>195.0 Nm</td>
<td>250.0 Nm</td>
<td>305.0 Nm</td>
</tr>
<tr>
<td>M20</td>
<td>370.0 Nm</td>
<td>500.0 Nm</td>
<td>600.0 Nm</td>
</tr>
<tr>
<td>M24</td>
<td>640.0 Nm</td>
<td>860.0 Nm</td>
<td>1030.0 Nm</td>
</tr>
<tr>
<td>M30</td>
<td>1330.0 Nm</td>
<td>1700.0 Nm</td>
<td>2000.0 Nm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thread</th>
<th>8.8 ISO7991 Allen screw</th>
<th>10.9 ISO7380, ISO07381 Fillister head screw</th>
</tr>
</thead>
<tbody>
<tr>
<td>M3</td>
<td>0.8 Nm</td>
<td>0.8 Nm</td>
</tr>
<tr>
<td>M4</td>
<td>1.9 Nm</td>
<td>1.9 Nm</td>
</tr>
<tr>
<td>M5</td>
<td>3.8 Nm</td>
<td>3.8 Nm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thread</th>
<th>10.9 DIN7984 pan head screws</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4</td>
<td>2.8 Nm</td>
</tr>
</tbody>
</table>

Tighten M5 domed cap nuts with a torque of 4.2 Nm.
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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<table>
<thead>
<tr>
<th>Country</th>
<th>Address</th>
</tr>
</thead>
</table>
| Poland    | KUKA Roboter CEE GmbH Poland  
Spółka z ograniczoną odpowiedzialnością  
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<thead>
<tr>
<th>Country</th>
<th>Address</th>
<th>Phone</th>
<th>Fax</th>
<th>Email</th>
</tr>
</thead>
<tbody>
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<td><a href="mailto:comercial@kukarob.es">comercial@kukarob.es</a></td>
<td></td>
</tr>
<tr>
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<td>+27 41 391 4700</td>
<td>+27 41 373 3869</td>
<td><a href="http://www.jendamark.co.za">www.jendamark.co.za</a></td>
</tr>
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<td>+886 2 8978 1188</td>
<td>+886 2 8797 5118</td>
<td><a href="mailto:info@kuka.com.tw">info@kuka.com.tw</a></td>
</tr>
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