



# Product manual

## IRB 6650S

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**Workspace R17-1 version a7**

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**Product manual**

**IRB 6650S - 200/3.0**

**IRB 6650S - 125/3.5**

**IRB 6650S - 90/3.9**

**M2000, M2000A, IRC5**

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Original instructions.

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# Overview of this manual

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## About this manual

This manual contains instructions for:

- mechanical and electrical installation of the robot
- maintenance of the robot
- mechanical and electrical repair of the robot.

The manual also contains reference information for all procedures detailed in the manual.

The robot described in this manual has the protection type Standard and Foundry Plus.

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## Usage

This manual should be used during:

- installation, from lifting the robot to its work site and securing it to the foundation to making it ready for operation
- maintenance work
- repair work.

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## Who should read this manual?

This manual is intended for:

- installation personnel
- maintenance personnel
- repair personnel.

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## Prerequisites

Maintenance/repair/installation personnel working with an ABB Robot must:

- be trained by ABB and have the required knowledge of mechanical and electrical installation/repair/maintenance work.

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## Organization of chapters

The manual is organized in the following chapters:

Chapter	Contents
Safety	Safety information that must be read through before performing any installation or service work on robot. Contains general safety aspects as well as more specific information about how to avoid personal injuries and damage to the product.
Installation and commissioning	Required information about lifting and installation of the robot.
Maintenance	Step-by-step procedures that describe how to perform maintenance of the robot. Based on a maintenance schedule that may be used in the work of planning periodical maintenance.
Repair	Step-by-step procedures that describe how to perform repair activities of the robot. Based on available spare parts.

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## Overview of this manual

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Chapter	Contents
Calibration	Calibration procedures and general information about calibration.
Decommissioning	Environmental information about the robot and its components.
Reference information	Useful information when performing installation, maintenance or repair work. Includes lists of necessary tools, additional documents, safety standards etc.
Spare part / Part list	Complete spare part list and complete list of robot components, shown in the exploded views.
Exploded views	Detailed illustrations of the robot with reference numbers to the part list.
Circuit diagram	Reference to the circuit diagram for the robot.

## References

Document name	Document ID	Note
<i>Product specification - IRB 6650S</i>	3HAC030822-001	
<i>Product specification - IRB 6600/6650/6650S M2000/M2000A</i>	3HAC14064-1	
<i>Product manual, spare parts - IRB 6650S</i>	3HAC049111-001	
Circuit diagram	3HAC13347-1 3HAC025744-001	
<i>Product manual - IRC5</i> IRC5 with main computer DSQC 639.	3HAC021313-001	
<i>Product manual - IRC5</i> IRC5 with main computer DSQC1000.	3HAC047136-001	
<i>Product manual - S4Cplus M2000</i>	3HAC021333-001	
<i>Product manual - S4Cplus M2000A</i>	3HAC022419-001	
<i>Operating manual - IRC5 with FlexPendant</i>	3HAC050941-001	
<i>User's guide - S4Cplus (BaseWare OS 4.0)</i>	3HAC7793-1	
<i>Operating manual - Calibration Pendulum</i>	3HAC16578-1	
<i>Operating manual - Levelmeter Calibration</i>	3HAC022907-001	M2000/M2000A
<i>Operating manual - Service Information System</i>	3HAC050944-001	M2004
<i>Technical reference manual - Lubrication in gearboxes</i>	3HAC042927-001	
<i>Technical reference manual - System parameters</i>	3HAC050948-001	
<i>Application manual - Additional axes and stand alone controller</i>	3HAC051016-001	M2004
<i>Application manual - External axes</i>	3HAC9299-1	M2000/M2000A
<i>Application manual - CalibWare Field 5.0</i>	3HAC030421-001	

## Additional document references

Document name	Document ID
CalibWare 2.0 User's guide (M2000)	3HAC16090-1

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Revisions

Revision	Description
-	First edition.
A	<ul style="list-style-type: none"> <li>Model M2004 implemented.</li> <li>Product manual divided into two parts: <i>Product manual, procedures</i> and <i>Product manual, reference information</i>.</li> <li>New foldouts: See <i>Frame - lower arm 1</i> and <i>Frame - lower arm 2</i> in <i>Product manual, spare parts - IRB 6650S</i>.</li> <li>Updated list with special tools, section <a href="#">Special tools on page 436</a>.</li> <li>Added spare part list, new section <i>Spare part list</i> in <i>Product manual, spare parts - IRB 6650S</i>.</li> </ul> <p>Various corrections and editing made in text and figures due to technical revisions etc.</p>
B	Chapter <i>Calibration</i> replaced with chapter <i>Calibration information</i> . Section <i>Document references</i> is completed with article numbers for calibration manuals.
C	New lubricating oil in the gearboxes, axes 1, 2, 3 and 6. Changes made in: <ul style="list-style-type: none"> <li>chapter <a href="#">Maintenance on page 133</a>.</li> <li>This is detailed in section <a href="#">Spare part lists on page 425</a>.</li> </ul>
D	<ul style="list-style-type: none"> <li>Article number for mechanical stop set added to section <a href="#">Mechanically restricting the working range of axis 2 on page 112</a>.</li> <li>New section added to the manual: <i>Installation of cooling fan for motors (option) on page 98</i>.</li> <li>A complete (undivided) cabling from axis 1 to axis 6 is added to the spare parts in <a href="#">Spare part lists on page 425</a>. New procedure <a href="#">Replacing cable harness, axes 1-6 on page 223</a>. Also a new circuit diagram is added to the manual, due to the new cabling.</li> <li>IRB 6650S included in section <i>Rebuilding parts</i> in <i>Product manual, spare parts - IRB 6650S</i>.</li> </ul>
E	<ul style="list-style-type: none"> <li>New variant IRB 6650S - 90/3.9 is implemented throughout the manual.</li> </ul>
F	Foundry Prime Option included.
G	Changes made in: <ul style="list-style-type: none"> <li>Prerequisites in section Overview</li> <li>Oil change in section Maintenance</li> </ul>
H	<p>This revision includes the following additions and/or changes:</p> <ul style="list-style-type: none"> <li>The product name RobotStudio Online is changed to <i>RobotStudio</i>.</li> <li>Section "<i>WARNING! - Mixed oils may cause severe damage to gearboxes</i>" in chapter Safety, has been integrated in section "<i>Type of oil in gearboxes</i>" in the Maintenance chapter.</li> <li>The oil Shell Tivela S150 in gearboxes 1, 2, 3 and 6 has been replaced by Kyodo Yushi TMO 150. Changes in chapters <i>Maintenance</i> and <i>Spare parts</i>.</li> <li>Modified maintenance intervals for oil change in gearboxes.</li> <li>Wrong illustration has been replaced by the correct one in "<i>Analysis of water content in oil, gearbox axis 6 (Foundry Prime)</i>", section <i>Inspection, oil level gearbox axis 6</i> chapter maintenance.</li> <li>The section "<i>Type of oil in gearboxes</i>" in chapter Maintenance has been updated according to changes made in oil types and intervals for oil change.</li> <li>Values for tightening torque on M24 screws in chapter Reference information, added.</li> <li>Maintenance/Cleaning of robot</li> <li><i>Maintenance/Maintenance schedule</i>: Interval for replacement of battery pack changed</li> </ul>

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## Overview of this manual

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Revision	Description
	<ul style="list-style-type: none"><li>• <i>Maintenance/Maintenance schedule</i>: Intervals for inspection activities and oilchanges has been revised.</li><li>• <i>Maintenance/Maintenance schedule</i>: Overhaul of robot is new.</li><li>• <i>Maintenance/Maintenance schedule</i>: The information about <i>Service Information System (SIS)</i> has been updated.</li><li>• <i>Maintenance/Expected component life</i>: The lifetime of certain parts has been revised.</li><li>• Section <i>What is an emergency stop?</i> added to chapter Safety.</li></ul>
J	This revision include the following addition: <ul style="list-style-type: none"><li>• New <b>WARNING!</b> added in <i>Safety chapter</i> section <i>Work inside the robot's range</i>.</li><li>• New <b>WARNING!</b> added in <i>Safety chapter</i> section <i>WARNING! - Safety risks during work with gearbox oil</i>.</li><li>• The text in the introductions to chapters <i>Installation</i>, <i>Maintenance</i> and <i>Repair</i> has been updated concerning the robot being connected to earth when power connected.</li><li>• Section <i>Expected component life</i> in chapter <i>Maintenance</i>: The lifetime of certain parts has been updated.</li><li>• Section <i>Foundry Plus,Cable guard</i> added to <i>Installation chapter</i>.</li></ul>
K	This revision includes the following additions and/or changes: <ul style="list-style-type: none"><li>• Instruction for how to inspect oil level for wrist type 2 added, see <a href="#">Inspecting the oil level in axis-6 gearbox on page 151</a>.</li><li>• Circuit diagrams are not included in this document but delivered as separate files. See <a href="#">Circuit diagram on page 441</a>.</li><li>• List of standards updated, see <a href="#">Applicable standards on page 428</a>.</li><li>• Interval changed for <i>inspection</i> and <i>lubrication</i> of balancing device (Foundry Prime). See chapter Maintenance section <a href="#">Maintenance schedule on page 135</a>.</li></ul> The chapter <i>Safety</i> updated with: <ul style="list-style-type: none"><li>• Updated safety signal graphics for the levels <i>Danger</i> and <i>Warning</i>, see <a href="#">Safety signals in the manual on page 41</a>.</li><li>• New safety labels on the manipulators, see <a href="#">Safety symbols on product labels on page 43</a>.</li><li>• Revised terminology: <i>robot</i> replaced with <i>manipulator</i>.</li></ul>
L	This revision includes the following updates: <ul style="list-style-type: none"><li>• Maximum deviation changed, see <a href="#">Securing the base plate on page 81</a>.</li><li>• New washer, see <a href="#">Replacement of upper arm on page 267</a>.</li><li>• Corrected spare part numbers.</li></ul>
M	This revision includes following additions and/or changes: <ul style="list-style-type: none"><li>• Removed information about lubricating attachment screws, section <a href="#">Inspecting the additional mechanical stops on page 169</a>.</li><li>• New safety labels on the manipulators, see <a href="#">Safety symbols on product labels on page 43</a>.</li><li>• Removed incorrect article number for fork lift, see <a href="#">Lifting robot with fork lift on page 69</a>.</li><li>• Minor adjustments made in the text concerning counters in section <a href="#">Service Information System, M2000 on page 209</a>.</li><li>• Footnote about ambient temperature in maintenance schedule is deleted, see <a href="#">Maintenance schedule on page 135</a>.</li><li>• Information about restricting and extending the working range of axis 1 is now separated, see <a href="#">Mechanically restricting the working range of axis 1 on page 109</a> and the new section <a href="#">Extended working range, axis 1 (option 561-1) on page 111</a>. Also added signal about option 561-1 in section <a href="#">Inspecting the axis-1 mechanical stop pin on page 167</a>.</li></ul>

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Revision	Description
	<ul style="list-style-type: none"> <li>Removed information about other robots than IRB 6650S from tables for oil type and amount in gearboxes, see <a href="#">Type of lubrication in gearboxes on page 178</a>.</li> </ul>
N	<p>This revision includes the following updates:</p> <ul style="list-style-type: none"> <li>A new block, about general illustrations, added in section <a href="#">How to read the product manual on page 18</a>.</li> <li>Removed all information about Foundry Prime from the manual.</li> <li>Adjusted the forces on foundation, see <a href="#">Loads on foundation, robot on page 61</a>.</li> <li>Added figures for installed position switches on axes 2 and 3 and attachment plate on axis 2, see <a href="#">Installation of position switches (option) on page 117</a>.</li> <li>Made minor corrections and improvements in the complete instruction for how to replace the axis 1 gearbox, see <a href="#">Replacing the axis 1 gearbox on page 359</a>.</li> <li>Added new mechanical structure of the lower arm attachment point for robots with protection Foundry Plus and Foundry Prime, see <a href="#">Replacement of complete lower arm on page 276</a> and <a href="#">Replacement of lower arm shaft on page 286</a>.</li> <li>Some general tightening torques have been changed/added, see updated values in <a href="#">Screw joints on page 431</a>.</li> <li>Added <a href="#">WARNING - Safety risks during handling of batteries on page 56</a>.</li> <li>The maximum allowed deviation in levelness of the base plate is changed, see <a href="#">Securing the base plate on page 81</a>.</li> <li>Corrected the article number for mechanical stops of axis 2, see <a href="#">Mechanically restricting the working range of axis 2 on page 112</a> and <a href="#">Inspecting the additional mechanical stops on page 169</a>.</li> <li>Reference to Hilti standard added to the foundation recommendation for the base plate and class designation for foundation is changed to european standard C25/C30 (previously Swedish standard K25/K30), see <a href="#">Securing the base plate on page 81</a>.</li> <li>All data about type of lubrication in gearboxes is moved from the manual to a separate lubrication manual, see <a href="#">Type and amount of oil in gearboxes on page 178</a>.</li> <li>Corrected the method of inspecting oil level in the axis-6 gearbox, see <a href="#">Inspecting the oil level in axis-6 gearbox on page 151</a>.</li> <li>Removed information about serrated lock washers from procedure <a href="#">Replacement of complete arm system on page 251</a>.</li> <li>Corrected type of screws in <i>Base incl frame ax 1</i>, see <a href="#">Product manual, spare parts - IRB 6650S</a> and <a href="#">Replacement of complete arm system on page 251</a>.</li> </ul>
P	<p>This revision includes the following updates:</p> <ul style="list-style-type: none"> <li>A new SMB unit and battery is introduced, with longer battery lifetime.</li> </ul>
Q	<p>This revision includes the following updates:</p> <ul style="list-style-type: none"> <li>Added information about risks when scrapping a decommissioned robot, see <a href="#">Scraping of robot on page 422</a>.</li> <li><i>Spare parts and exploded views</i> are not included in this document but delivered as a separate document. See <a href="#">Product manual, spare parts - IRB 6650S</a>.</li> </ul>
R	<p>This revision includes the following updates:</p> <ul style="list-style-type: none"> <li>The maximum allowed deviation in levelness of the base plate and foundation is changed, see <a href="#">Securing the base plate on page 81</a>.</li> <li>Minor corrections.</li> </ul>

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## Overview of this manual

*Continued*

Revision	Description
S	This revision includes the following updates: <ul style="list-style-type: none"><li>• New standard calibration method introduced (Axis Calibration). See <a href="#">Calibration on page 393</a>.</li><li>• Tightening torque for securing screw in piston shaft front eye changed, see <a href="#">Replacing the balancing device on page 309</a>.</li><li>• Turning disk fixture is removed from special tools for Levelmeter calibration.</li></ul>
T	This revision includes the following updates: <ul style="list-style-type: none"><li>• Edited information regarding deciding calibration routine in each repair section.</li><li>• Added information about inspection of calibration tool prior to usage, see <a href="#">Examining the calibration tool on page 408</a>.</li><li>• Added a warning that calibration pin must be inserted in the calibration bushing until it snaps, see <a href="#">Description of Axis Calibration on page 406</a>.</li><li>• Added warning regarding risk of pinching, in <a href="#">Description of Axis Calibration on page 406</a>.</li><li>• Added information about Axis Calibration when SafeMove is installed, see <a href="#">Axis Calibration with SafeMove option on page 414</a>.</li><li>• Added information about the calibration procedure, see <a href="#">Overview of the calibration procedure on the FlexPendant on page 411</a>, <a href="#">Restarting an interrupted calibration procedure on page 413</a>.</li></ul>
U	Published in release R16.2. The following updates are done in this revision: <ul style="list-style-type: none"><li>• Drawing of base plate is not available for purchase, faulty information removed in <a href="#">Securing the base plate on page 81</a>.</li><li>• Drawing of tool flange for LeanID added.</li><li>• Added spare part number for protection cover and plug set (Axis Calibration).</li></ul>
V	Published in release R17.1. The following updates are made in this revision: <ul style="list-style-type: none"><li>• Removed article number for press fixture (for pressing the pinion of the axis-5 motor). The fixture is not sold by ABB.</li></ul>

# Product documentation, M2000/M2000A

## General

The complete product documentation kit for the M2000 robot system, including controller, robot and any hardware option, consists of the manuals listed below:

## Product manuals

Manipulators, controllers, DressPack/SpotPack, and most other hardware will be delivered with a **Product manual** that generally contains:

- Safety information.
- Installation and commissioning (descriptions of mechanical installation or electrical connections).
- Maintenance (descriptions of all required preventive maintenance procedures including intervals and expected life time of parts).
- Repair (descriptions of all recommended repair procedures including spare parts).
- Calibration.
- Decommissioning.
- Reference information (safety standards, unit conversions, screw joints, lists of tools ).
- Spare parts list with exploded views (or references to separate spare parts lists).
- Circuit diagrams (or references to circuit diagrams).

## Software manuals

The software documentation consists of a wide range of manuals, ranging from manuals for basic understanding of the operating system to manuals for entering parameters during operation.

A complete listing of all available software manuals is available from ABB.

## Controller hardware option manual

Each hardware option for the controller is supplied with its own documentation.

Each document set contains the types of information specified below:

- Installation information
- Repair information
- Maintenance information

In addition, spare part information is supplied for the entire option.

# Product documentation, IRC5

### Categories for user documentation from ABB Robotics

The user documentation from ABB Robotics is divided into a number of categories. This listing is based on the type of information in the documents, regardless of whether the products are standard or optional.

All documents listed can be ordered from ABB on a DVD. The documents listed are valid for IRC5 robot systems.

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### Product manuals

Manipulators, controllers, DressPack/SpotPack, and most other hardware is delivered with a **Product manual** that generally contains:

- Safety information.
- Installation and commissioning (descriptions of mechanical installation or electrical connections).
- Maintenance (descriptions of all required preventive maintenance procedures including intervals and expected life time of parts).
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- Calibration.
- Decommissioning.
- Reference information (safety standards, unit conversions, screw joints, lists of tools).
- Spare parts list with exploded views (or references to separate spare parts lists).
- Circuit diagrams (or references to circuit diagrams).

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### Technical reference manuals

The technical reference manuals describe reference information for robotics products.

- *Technical reference manual - Lubrication in gearboxes*: Description of types and volumes of lubrication for the manipulator gearboxes.
- *Technical reference manual - RAPID overview*: An overview of the RAPID programming language.
- *Technical reference manual - RAPID Instructions, Functions and Data types*: Description and syntax for all RAPID instructions, functions, and data types.
- *Technical reference manual - RAPID kernel*: A formal description of the RAPID programming language.
- *Technical reference manual - System parameters*: Description of system parameters and configuration workflows.

*Continues on next page*

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## Application manuals

Specific applications (for example software or hardware options) are described in **Application manuals**. An application manual can describe one or several applications.

An application manual generally contains information about:

- The purpose of the application (what it does and when it is useful).
- What is included (for example cables, I/O boards, RAPID instructions, system parameters, DVD with PC software).
- How to install included or required hardware.
- How to use the application.
- Examples of how to use the application.

---

## Operating manuals

The operating manuals describe hands-on handling of the products. The manuals are aimed at those having first-hand operational contact with the product, that is production cell operators, programmers, and trouble shooters.

The group of manuals includes (among others):

- *Operating manual - Emergency safety information*
- *Operating manual - General safety information*
- *Operating manual - Getting started, IRC5 and RobotStudio*
- *Operating manual - IRC5 Integrator's guide*
- *Operating manual - IRC5 with FlexPendant*
- *Operating manual - RobotStudio*
- *Operating manual - Trouble shooting IRC5*

# How to read the product manual

### Reading the procedures

The procedures contain references to figures, tools, material, and so on. The references are read as described below.

### References to figures

The procedures often include references to components or attachment points located on the manipulator/controller. The components or attachment points are marked with *italic text* in the procedures and completed with a reference to the figure where the current component or attachment point is shown.

The denomination in the procedure for the component or attachment point corresponds to the denomination in the referenced figure.

The table below shows an example of a reference to a figure from a step in a procedure.

	Action	Note/Illustration
8.	Remove the <i>rear attachment screws</i> , gearbox.	Shown in the figure <a href="#">Location of gearbox on page xx</a> .

### References to required equipment

The procedures often include references to equipment (spare parts, tools, etc.) required for the different actions in the procedure. The equipment is marked with *italic text* in the procedures and completed with a reference to the section where the equipment is listed with further information, that is article number and dimensions.

The designation in the procedure for the component or attachment point corresponds to the designation in the referenced list.

The table below shows an example of a reference to a list of required equipment from a step in a procedure.

	Action	Note/Illustration
3.	Fit a new <i>sealing</i> , axis 2 to the gearbox.	Art. no. is specified in <a href="#">Required equipment on page xx</a> .

---

### Safety information

The manual includes a separate safety chapter that must be read through before proceeding with any service or installation procedures. All procedures also include specific safety information when dangerous steps are to be performed.

Read more in the chapter [Safety on page 19](#).

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### Illustrations

The robot is illustrated with general figures that does not take painting or protection type in consideration.

Likewise, certain work methods or general information that is valid for several robot models, can be illustrated with illustrations that show a different robot model than the one that is described in the current manual.

# 1 Safety

## 1.1 Introduction to safety information

---

### Overview

The safety information in this manual is divided into the following categories:

- General safety aspects, important to attend to before performing any service work on the robot. These are applicable for all service work and are found in [General safety information on page 20](#).
- Safety signals and symbols shown in the manual and on the robot, warning for different types of dangers, are found in [Safety signals and symbols on page 41](#).
- Specific safety information, pointed out in the procedures. How to avoid and eliminate the danger is either described directly in the procedure, or in specific instructions in the section [Safety related instructions on page 49](#).

# 1 Safety

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## 1.2.1 Introduction to general safety information

## 1.2 General safety information

### 1.2.1 Introduction to general safety information

---

#### Definitions

This section details general safety information for personnel performing installation, repair and maintenance work.

---

#### Sections

The general safety information is divided into the following sections.

Section	Examples of content
<a href="#"><i>Safety in the manipulator system on page 21</i></a>	This section describes the following: <ul style="list-style-type: none"><li>• safety, service</li><li>• limitation of liability</li><li>• related information</li></ul>
<a href="#"><i>Protective stop and emergency stop on page 23</i></a>	This section describes protective stop and emergency stop.
<a href="#"><i>Safety risks on page 24</i></a>	This section lists dangers relevant when working with the product. The dangers are split into different categories. <ul style="list-style-type: none"><li>• safety risks during installation or service</li><li>• risks associated with live electrical parts</li></ul>
<a href="#"><i>Safety actions on page 33</i></a>	This section describes actions which may be taken to remedy or avoid dangers. <ul style="list-style-type: none"><li>• fire extinguishing</li><li>• safe use of the teach pendant or jogging device</li></ul>

## 1.2.2 Safety in the manipulator system

### Validity and responsibility

The information does not cover how to design, install and operate a complete system, nor does it cover all peripheral equipment that can influence the safety of the entire system. To protect personnel, the complete system must be designed and installed in accordance with the safety requirements set forth in the standards and regulations of the country where the robot is installed.

The users of ABB industrial robots are responsible for ensuring that the applicable safety laws and regulations in the country concerned are observed and that the safety devices necessary to protect people working with the robot system are designed and installed correctly. Personnel working with robot must be familiar with the operation and handling of the industrial robot as described in the applicable documents, for example:

- *Operating manual - IRC5 with FlexPendant*
- *Operating manual - General safety information*<sup>1</sup>
- *Product manual*

<sup>1</sup> This manual contains all safety instructions from the product manuals for the robots and the controllers.

The robot system shall be designed and constructed in such a way as to allow safe access to all areas where intervention is necessary during operation, adjustment, and maintenance.

Where it is necessary to perform tasks within the safeguarded space there shall be safe and adequate access to the task locations.

Users shall not be exposed to hazards, including slipping, tripping, and falling hazards.

### Connection of external safety devices

Apart from the built-in safety functions, the robot is also supplied with an interface for the connection of external safety devices. An external safety function can interact with other machines and peripheral equipment via this interface. This means that control signals can act on safety signals received from the peripheral equipment as well as from the robot.

### Limitation of liability

Any information given in this manual regarding safety must not be construed as a warranty by ABB that the industrial robot will not cause injury or damage even if all safety instructions are complied with.

### Related information

Type of information	Detailed in document	Section
Installation of safety devices	<i>Product manual for the robot</i>	Installation and commissioning
Changing operating modes	<i>Operating manual - IRC5 with FlexPendant</i> <i>Operator's Manual - IRC5P</i>	Operating modes

*Continues on next page*

## 1 Safety

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### 1.2.2 Safety in the manipulator system

*Continued*

Type of information	Detailed in document	Section
Restricting the working space	<i>Product manual for the robot</i>	Installation and commissioning

### **1.2.3 Protective stop and emergency stop**

---

#### **Overview**

The protective stops and emergency stops are described in the product manual for the controller.

# 1 Safety

---

## 1.2.4.1 Safety risks during installation and service work on robots

### 1.2.4 Safety risks

#### 1.2.4.1 Safety risks during installation and service work on robots

---

##### Overview

This section includes information on general safety risks to be considered when performing installation and service work on the robot.

These safety instructions have to be read and followed by any person who deals with the installation and maintenance of the robot. Only persons who know the robot and are trained in the operation and handling of the robot are allowed to maintain the robot. Persons who are under the influence of alcohol, drugs or any other intoxicating substances are not allowed to maintain, repair, or use the robot.

---

##### General risks during installation and service

- The instructions in the product manual in the chapters *Installation and commissioning*, and *Repair* must always be followed.
- Emergency stop buttons must be positioned in easily accessible places so that the robot can be stopped quickly.
- Those in charge of operations must make sure that safety instructions are available for the installation in question.
- Those who install or service/maintain the robot must have the appropriate training for the equipment in question and in any safety matters associated with it.

---

##### Spare parts and special equipment

ABB does not supply spare parts and special equipment which have not been tested and approved by ABB. The installation and/or use of such products could negatively affect the structural properties of the robot and as a result of that affect the active or passive safety operation. ABB is not liable for damages caused by the use of non-original spare parts and special equipment. ABB is not liable for damages or injuries caused by unauthorized modifications to the robot system.

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##### Personal protective equipment

Always use suitable personal protective equipment, based on the risk assessment for the robot installation.

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##### Nation/region specific regulations

To prevent injuries and damages during the installation of the robot, the regulations applicable in the country concerned and the instructions of ABB Robotics must be complied with.

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##### Non-voltage related risks

- Make sure that no one else can turn on the power to the controller and robot while you are working with the system. A good method is to always lock the main switch on the controller cabinet with a safety lock.

*Continues on next page*

## 1.2.4.1 Safety risks during installation and service work on robots

*Continued*

- Safety zones, which must be crossed before admittance, must be set up in front of the robot's working space. Light beams or sensitive mats are suitable devices.
- Turntables or the like should be used to keep the operator out of the robot's working space.
- If the robot is installed at a height, hanging, or other than standing directly on the floor, there may be additional risks than those for a robot standing directly on the floor.
- The axes are affected by the force of gravity when the brakes are released. In addition to the risk of being hit by moving robot parts, there is a risk of being crushed by the parallel arm (if there is one).
- Energy stored in the robot for the purpose of counterbalancing certain axes may be released if the robot, or parts thereof, are dismantled.
- When dismantling/assembling mechanical units, watch out for falling objects.
- Be aware of stored heat energy in the controller.
- Never use the robot as a ladder, which means, do not climb on the robot motors or other parts during service work. There is a serious risk of slipping because of the high temperature of the motors and oil spills that can occur on the robot.
- Never use the robot as a ladder, which means, do not climb on the manipulator motors or other parts during service work. There is a risk of the robot being damaged.

**To be observed by the supplier of the complete system**

When integrating the robot with external devices and machines:

- The supplier of the complete system must ensure that all circuits used in the safety function are interlocked in accordance with the applicable standards for that function.
- The supplier of the complete system must ensure that all circuits used in the emergency stop function are interlocked in a safe manner, in accordance with the applicable standards for the emergency stop function.

**Complete robot**

Safety risk	Description
Hot components!	 <b>CAUTION</b> Motors and gearboxes are HOT after running the robot! Touching motors and gearboxes may result in burns! With a higher environment temperature, more surfaces on the manipulator will get HOT and may also result in burns.

*Continues on next page*

# 1 Safety

## 1.2.4.1 Safety risks during installation and service work on robots

*Continued*

Safety risk	Description
Removed parts may result in collapse of the robot!	 <b>WARNING</b> Take any necessary measures to ensure that the robot does not collapse as parts are removed. For example, secure the lower arm according to the repair instruction if removing the axis-2 motor.
Removed cables to the measurement system	 <b>WARNING</b> If the internal cables for the measurement system have been disconnected during repair or maintenance, then the revolution counters must be updated.

## Cabling

Safety risk	Description
Cable packages are sensitive to mechanical damage!	 <b>CAUTION</b> The cable packages are sensitive to mechanical damage. Handle the cable packages and the connectors with care in order to avoid damage.

## Gearboxes and motors

Safety risk	Description
Gears may be damaged if excessive force is used!	 <b>CAUTION</b> Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!

## Balancing device

Safety risk	Description
Dangerous balancing device!	 <b>WARNING</b> <i>Do not</i> , under any circumstances, deal with the balancing device in any other way than that described in the product documentation! For example, attempting to open the balancing device is potentially lethal!

## 1.2.4.2 CAUTION - Hot parts may cause burns!

**1.2.4.2 CAUTION - Hot parts may cause burns!****Description**

During normal operation, many robot parts become hot, especially the drive motors and gearboxes. Sometimes areas around these parts also become hot. Touching these may cause burns of various severity.

Because of a higher environment temperature, more surfaces on the robot get hot and may result in burns.

**Elimination**

The following instructions describe how to avoid the dangers specified above:

	Action	Information
1	Always use your hand, at some distance, to feel if heat is radiating from the potentially hot component before actually touching it.	
2	Wait until the potentially hot component has cooled if it is to be removed or handled in any other way.	

# 1 Safety

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## 1.2.4.3 Safety risks related to tools/work pieces

### 1.2.4.3 Safety risks related to tools/work pieces

#### Safe handling

It must be possible to safely turn off tools, such as milling cutters, etc. Make sure that guards remain closed until the cutters stop rotating.

It should be possible to release parts by manual operation (valves).

#### Safe design

Grippers/end effectors must be designed so that they retain work pieces in the event of a power failure or a disturbance to the controller.

Unauthorized modifications of the originally delivered robot are prohibited. Without the consent of ABB it is forbidden to attach additional parts through welding, riveting, or drilling of new holes into the castings. The strength could be affected.



#### CAUTION

Ensure that a gripper is prevented from dropping a work piece, if such is used.

#### 1.2.4.4 Safety risks related to pneumatic/hydraulic systems

---

##### General

Special safety regulations apply to pneumatic and hydraulic systems.



##### Note

All components that remain pressurized after separating the machine from the power supply must be provided with clearly visible drain facilities and a warning sign that indicates the need for pressure relief before adjustments or performing any maintenance on the robot system.

---

##### Residual energy

- Residual energy can be present in these systems. After shutdown, particular care must be taken.
- The pressure must be released in the complete pneumatic or hydraulic systems before starting to repair them.
- Work on hydraulic equipment may only be performed by persons with special knowledge and experience of hydraulics.
- All pipes, hoses, and connections have to be inspected regularly for leaks and damage. Damage must be repaired immediately.
- Splashed oil may cause injury or fire.

---

##### Safe design

- Gravity may cause any parts or objects held by these systems to drop.
- Dump valves should be used in case of emergency.
- Shot bolts should be used to prevent tools, etc., from falling due to gravity.

# **1 Safety**

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## **1.2.4.5 Safety risks during operational disturbances**

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### **General**

- The industrial robot is a flexible tool that can be used in many different industrial applications.
- All work must be carried out professionally and in accordance with the applicable safety regulations.
- Care must be taken at all times.

---

### **Qualified personnel**

Corrective maintenance must only be carried out by qualified personnel who are familiar with the entire installation as well as the special risks associated with its different parts.

---

### **Extraordinary risks**

If the working process is interrupted, extra care must be taken due to risks other than those associated with regular operation. Such an interruption may have to be rectified manually.

## 1.2.4.6 Risks associated with live electric parts

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### Voltage related risks, general

Work on the electrical equipment of the robot must be performed by a qualified electrician in accordance with electrical regulations.

- Although troubleshooting may, on occasion, need to be carried out while the power supply is turned on, the robot must be turned off (by setting the main switch to OFF) when repairing faults, disconnecting electric leads and disconnecting or connecting units.
- The main supply to the robot must be connected in such a way that it can be turned off from outside the working space of the robot.
- Make sure that no one else can turn on the power to the controller and robot while you are working with the system. A good method is to always lock the main switch on the controller cabinet with a safety lock.

The necessary protection for the electrical equipment and robot system during construction, commissioning, and maintenance is guaranteed if the valid regulations are followed.

All work must be performed:

- by qualified personnel
- on machine/robot system in deadlock
- in an isolated state, disconnected from power supply, and protected against reconnection.

---

### Voltage related risks, IRC5 controller

A danger of high voltage is associated with, for example, the following parts:

- Be aware of stored electrical energy (DC link, Ultracapacitor bank unit) in the controller.
- Units such as I/O modules, can be supplied with power from an external source.
- The main supply/main switch
- The transformers
- The power unit
- The control power supply (230 VAC)
- The rectifier unit (262/400-480 VAC and 400/700 VDC. Note: capacitors!)
- The drive unit (400/700 VDC)
- The drive system power supply (230 VAC)
- The service outlets (115/230 VAC)
- The customer power supply (230 VAC)
- The power supply unit for additional tools, or special power supply units for the machining process.
- The external voltage connected to the controller remains live even when the robot is disconnected from the mains.
- Additional connections.

*Continues on next page*

## **1 Safety**

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### **1.2.4.6 Risks associated with live electric parts**

*Continued*

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#### **Voltage related risks, robot**

A danger of high voltage is associated with the robot in:

- The power supply for the motors (up to 800 VDC).
  - The user connections for tools or other parts of the installation (max. 230 VAC).
- 

#### **Voltage related risks, tools, material handling devices, etc.**

Tools, material handling devices, etc., may be live even if the robot system is in the OFF position. Power supply cables which are in motion during the working process may be damaged.

### 1.2.5 Safety actions

#### 1.2.5.1 Safety fence dimensions

---

##### General

Install a safety cell around the robot to ensure safe robot installation and operation.

---

##### Dimensioning

The fence or enclosure must be dimensioned to withstand the force created if the load being handled by the robot is dropped or released at maximum speed.

Determine the maximum speed from the maximum velocities of the robot axes and from the position at which the robot is working in the work cell (see the section *Robot motion* in the *Product specification*).

Also consider the maximum possible impact caused by a breaking or malfunctioning rotating tool or other device fitted to the robot.

## **1 Safety**

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### **1.2.5.2 Fire extinguishing**



#### **Note**

**Use a CARBON DIOXIDE (CO<sub>2</sub>) extinguisher in the event of a fire in the robot or controller!**

### 1.2.5.3 Emergency release of the robot arm

#### Description

In an emergency situation, the brakes on a robot axis can be released manually by pushing a brake release button.

How to release the brakes is detailed in the section:

- [Manually releasing the brakes on page 78.](#)

The robot arm may be moved manually on smaller robot models, but larger models may require using an overhead crane or similar equipment.

#### Increased injury

Before releasing the brakes, make sure that the weight of the arms does not increase the pressure on the trapped person, further increasing any injury!



#### DANGER

When releasing the holding brakes, the robot axes may move very quickly and sometimes in unexpected ways.

Make sure no personnel is near or beneath the robot arm.

# 1 Safety

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## 1.2.5.4 Brake testing

### 1.2.5.4 Brake testing

---

#### When to test

During operation, the holding brake of each axis normally wears down. A test can be performed to determine whether the brake can still perform its function.

---

#### How to test

The function of the holding brake of each axis motor may be verified as described below:

- 1 Run each robot axis to a position where the combined weight of the robot arm and any load is maximized (maximum static load).
- 2 Switch the motor to the MOTORS OFF.
- 3 Inspect and verify that the axis maintains its position.

If the robot does not change position as the motors are switched off, then the brake function is adequate.

## 1.2.5.5 Risk of disabling function "Reduced speed 250 mm/s"



### Note

Do not change *Transm gear ratio* or other kinematic system parameters from the FlexPendant or a PC. This will affect the safety function "Reduced speed 250 mm/s".

# 1 Safety

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## 1.2.5.6 Safe use of the jogging device

### 1.2.5.6 Safe use of the jogging device

#### Three-position enabling device

The three-position enabling device is a manually operated, constant pressure push-button which, when continuously activated in one position only, allows potentially hazardous functions but does not initiate them. In any other position, hazardous functions are stopped safely.

The three-position enabling device is of a specific type where you must press the push-button only half-way to activate it. In the fully in and fully out positions, operating the robot is impossible.



#### Note

The three-position enabling device is a push-button located on the jogging device which, when pressed halfway in, switches the system to MOTORS ON. When the enabling device is released or pushed all the way in, the manipulator switches to the MOTORS OFF state.

To ensure safe use of the jogging device, the following must be implemented:

- The enabling device must never be rendered inoperational in any way.
- During programming and testing, the enabling device must be released as soon as there is no need for the robot to move.
- Anyone entering the working space of the robot must always bring the jogging device with him/her. This is to prevent anyone else from taking control of the robot without his/her knowledge.

---

#### Hold-to-run function

The hold-to-run function allows movement when a button connected to the function is actuated manually and immediately stops any movement when released. The hold-to-run function can only be used in manual mode.

How to operate the hold-to-run function for IRC5 is described in *Operating manual - IRC5 with FlexPendant*.

### 1.2.5.7 Work inside the working range of the robot



#### WARNING

If work must be carried out within the work area of the robot, then the following points must be observed:

- The operating mode selector on the controller must be in the manual mode position to render the three-position enabling device operational and to block operation from a computer link or remote control panel.
- The maximum speed of the robot is limited to 250 mm/s when the operating mode selector is in the position *Manual mode with reduced speed*. This should be the normal position when entering the working space.  
The position *Manual mode with full speed (100%)* may only be used by trained personnel who are aware of the risks that this entails. *Manual mode with full speed (100%)* is not available in USA or Canada.
- Pay attention to the rotating axes of the robot. Keep away from axes to not get entangled with hair or clothing. Also, be aware of any danger that may be caused by rotating tools or other devices mounted on the robot or inside the cell.
- Test the motor brake on each axis, according to the section [Brake testing on page 36](#).
- To prevent anyone else from taking control of the robot, always put a safety lock on the cell door and bring the three-position enabling device with you when entering the working space.



#### WARNING

**NEVER**, under any circumstances, stay beneath any of the robot's axes! There is always a risk that the robot will move unexpectedly when robot axes are moved using the three-position enabling device or during other work inside the working range of the robot.

## **1 Safety**

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### **1.2.5.8 Signal lamp (optional)**

#### **1.2.5.8 Signal lamp (optional)**

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##### **Description**

A signal lamp with a yellow fixed light can be mounted on the robot, as a safety device.

---

##### **Function**

The lamp is active in MOTORS ON mode.

---

##### **Further information**

Further information about the MOTORS ON/MOTORS OFF mode may be found in the product manual for the controller.

## 1.3 Safety signals and symbols

### 1.3.1 Safety signals in the manual

#### Introduction to safety signals

This section specifies all dangers that can arise when doing the work described in the user manuals. Each danger consists of:

- A caption specifying the danger level (DANGER, WARNING, or CAUTION) and the type of danger.
- A brief description of what will happen if the operator/service personnel do not eliminate the danger.
- Instruction about how to eliminate danger to simplify doing the work.

#### Danger levels

The table below defines the captions specifying the danger levels used throughout this manual.

Symbol	Designation	Significance
 xx0200000022	DANGER	Warns that an accident <i>will</i> occur if the instructions are not followed, resulting in a serious or fatal injury and/or severe damage to the product. It applies to warnings that apply to danger with, for example, contact with high voltage electrical units, explosion or fire risk, risk of poisonous gases, risk of crushing, impact, fall from height, and so on.
 xx0100000002	WARNING	Warns that an accident <i>may</i> occur if the instructions are not followed that can lead to serious injury, possibly fatal, and/or great damage to the product. It applies to warnings that apply to danger with, for example, contact with high voltage electrical units, explosion or fire risk, risk of poisonous gases, risk of crushing, impact, fall from height, etc.
 xx0200000024	ELECTRICAL SHOCK	Warns for electrical hazards which could result in severe personal injury or death.
 xx0100000003	CAUTION	Warns that an accident <i>may</i> occur if the instructions are not followed that can result in injury and/or damage to the product. It also applies to warnings of risks that include burns, eye injury, skin injury, hearing damage, crushing or slipping, tripping, impact, fall from height, etc. Furthermore, it applies to warnings that include function requirements when fitting and removing equipment where there is a risk of damaging the product or causing a breakdown.
 xx0200000023	ELECTROSTATIC DISCHARGE (ESD)	Warns for electrostatic hazards which could result in severe damage to the product.

*Continues on next page*

# 1 Safety

## 1.3.1 Safety signals in the manual

*Continued*

Symbol	Designation	Significance
 xx010000004	NOTE	Describes important facts and conditions.
 xx0100000098	TIP	Describes where to find additional information or how to do an operation in an easier way.

## 1.3.2 Safety symbols on product labels

### Introduction to labels

This section describes safety symbols used on labels (stickers) on the product.

Symbols are used in combinations on the labels, describing each specific warning. The descriptions in this section are generic, the labels can contain additional information such as values.



#### Note

The safety and health symbols on the labels on the product must be observed. Additional safety information given by the system builder or integrator must also be observed.

### Types of labels

Both the robot and the controller are marked with several safety and information labels, containing important information about the product. The information is useful for all personnel handling the robot system, for example during installation, service, or operation.

The safety labels are language independent, they only use graphics. See [Symbols on safety labels on page 43](#).

The information labels can contain information in text (English, German, and French).

The labels are identified and located on the product as shown in the section:

- [on page ?](#)

### Symbols on safety labels

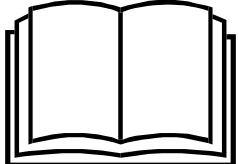
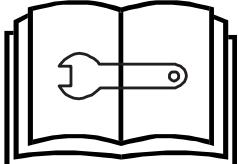
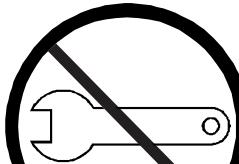
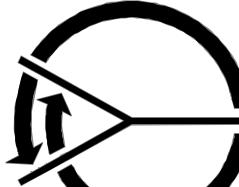
Symbol	Description
xx0900000812	<b>Warning!</b> Warns that an accident <i>may</i> occur if the instructions are not followed that can lead to serious injury, possibly fatal, and/or great damage to the product. It applies to warnings that apply to danger with, for example, contact with high voltage electrical units, explosion or fire risk, risk of poisonous gases, risk of crushing, impact, fall from height, etc.
xx0900000811	<b>Caution!</b> Warns that an accident may occur if the instructions are not followed that can result in injury and/or damage to the product. It also applies to warnings of risks that include burns, eye injury, skin injury, hearing damage, crushing or slipping, tripping, impact, fall from height, etc. Furthermore, it applies to warnings that include function requirements when fitting and removing equipment where there is a risk of damaging the product or causing a breakdown.

*Continues on next page*

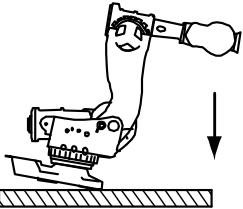
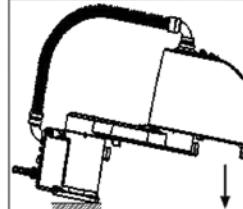
# 1 Safety

## 1.3.2 Safety symbols on product labels

*Continued*

Symbol	Description
 xx0900000839	<b>Prohibition</b> Used in combinations with other symbols.
 xx0900000813	<b>See user documentation</b> Read user documentation for details. Which manual to read is defined by the symbol: <ul style="list-style-type: none"><li>• No text: <i>Product manual</i>.</li><li>• EPS: <i>Application manual - Electronic Position Switches</i>.</li></ul>
 xx0900000816	<b>Before disassemble, see product manual</b>
 xx0900000815	<b>Do not disassemble</b> Disassembling this part can cause injury.
 xx0900000814	<b>Extended rotation</b> This axis has extended rotation (working area) compared to standard.
 xx0900000808	<b>Brake release</b> Pressing this button will release the brakes. This means that the robot arm can fall down.

*Continues on next page*

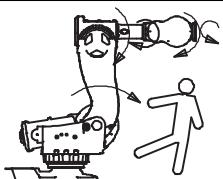
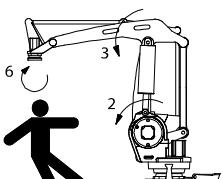
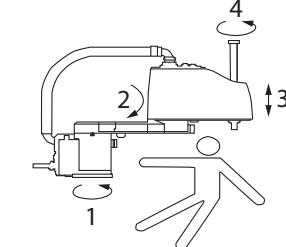
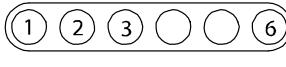
Symbol	Description
 xx0900000810	<b>Tip risk when loosening bolts</b> The robot can tip over if the bolts are not securely fastened.
  3HAC 057068-001	
  xx0900000817	<b>Crush</b> Risk of crush injuries.
 xx0900000818	<b>Heat</b> Risk of heat that can cause burns.

*Continues on next page*

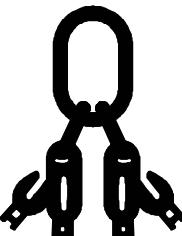
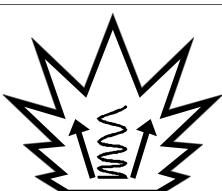
# 1 Safety

## 1.3.2 Safety symbols on product labels

*Continued*

Symbol	Description
 xx0900000819	<b>Moving robot</b> The robot can move unexpectedly.
 xx1000001141	
 xx1500002616	
 xx0900000820	<b>Brake release buttons</b>
 xx1000001140	
 xx0900000821	<b>Lifting bolt</b>

*Continues on next page*

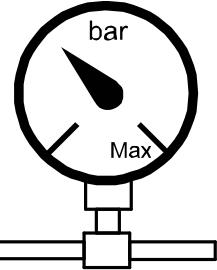
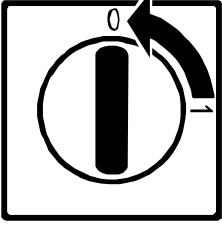
Symbol	Description
 xx1000001242	Chain sling with shortener
 xx0900000822	Lifting of robot
 xx0900000823	<b>Oil</b> Can be used in combination with prohibition if oil is not allowed.
 xx0900000824	Mechanical stop
 xx1000001144	No mechanical stop
 xx0900000825	<b>Stored energy</b> Warns that this part contains stored energy. Used in combination with <i>Do not disassemble</i> symbol.

Continues on next page

# 1 Safety

## 1.3.2 Safety symbols on product labels

*Continued*

Symbol	Description
 xx0900000826	<b>Pressure</b> Warns that this part is pressurized. Usually contains additional text with the pressure level.
 xx0900000827	<b>Shut off with handle</b> Use the power switch on the controller.
 xx1400002648	<b>Do not step</b> Warns that stepping on these parts can cause damage to the parts.

## 1.4.1 DANGER - Moving robots are potentially lethal!

## 1.4 Safety related instructions

### 1.4.1 DANGER - Moving robots are potentially lethal!

#### Description

Any moving robot is a potentially lethal machine.

When running, the robot may perform unexpected and sometimes irrational movements. Moreover, all movements are performed with great force and may seriously injure any personnel and/or damage any piece of equipment located within the working range of the robot.

#### Elimination

	Action	Note
1	Before attempting to run the robot, make sure all emergency stop equipment is correctly installed and connected.	Emergency stop equipment such as gates, tread mats, light curtains, etc.
2	Usually the hold-to-run function is active only in manual full speed mode. To increase safety it is also possible to activate hold-to-run for manual reduced speed with a system parameter. The hold-to-run function is used in manual mode, not in automatic mode.	How to use the hold-to-run function is described in section <i>How to use the hold-to-run function</i> in the <i>Operating manual - IRC5 with FlexPendant</i> .
3	Make sure no personnel are present within the working range of the robot before pressing the start button.	

## 1 Safety

---

### 1.4.2 DANGER - First test run may cause injury or damage!

#### Description

Since performing a service activity often requires disassembly of the robot, there are several safety risks to take into consideration before the first test run.

#### Elimination

Follow the procedure below when performing the first test run after a service activity, such as repair, installation, or maintenance.



#### DANGER

Running the robot without fulfilling the following aspects, may cause severe damage to the robot.

	Action
1	Remove all service tools and foreign objects from the robot and its working area.
2	Verify that the robot is secured to its position, see installation section in the product manual for the robot.
3	Verify that any safety equipment installed to secure the robot arm position or restrict the robot arm motion during service activity is removed.
4	Verify that the fixture and work piece are well secured, if applicable.
5	Install all safety equipment properly.
6	Make sure all personnel are standing at a safe distance from the robot, that is out of its reach behind safety fences, and so on.
7	Pay special attention to the function of the part that previously was serviced.

#### Collision risks



#### CAUTION

When programming the movements of the robot, always identify potential collision risks before the first test run.

## 1.4.3 WARNING - The brake release buttons may be jammed after service work

**1.4.3 WARNING - The brake release buttons may be jammed after service work****Description**

The brake release unit has push-buttons for the brake release of each axis motor. When service work is performed inside the SMB recess that includes removal and refitting of the brake release unit, the brake release buttons may be jammed after refitting.

**DANGER**

If the power is turned on while a brake release button is jammed in depressed position, the affected motor brake is released! This may cause serious personal injuries and damage to the robot.

**Elimination**

To eliminate the danger after service work has been performed inside the SMB recess, follow the procedure below.

	Action
1	Make sure the power is turned off.
2	Remove the push-button guard, if necessary.
3	Verify that the push-buttons of the brake release unit are working by pressing them down, one by one. Make sure none of the buttons are jammed in the tube.
4	If a button gets jammed in the depressed position, the alignment of the brake release unit must be adjusted so that the buttons can move freely in their tubes!

## 1 Safety

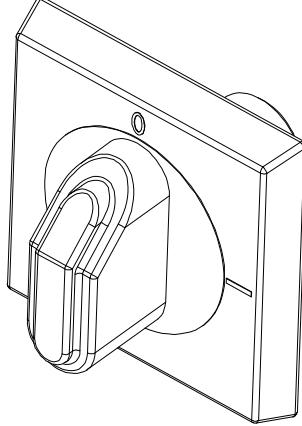
1.4.4 DANGER - Make sure that the main power has been switched off!

### 1.4.4 DANGER - Make sure that the main power has been switched off!

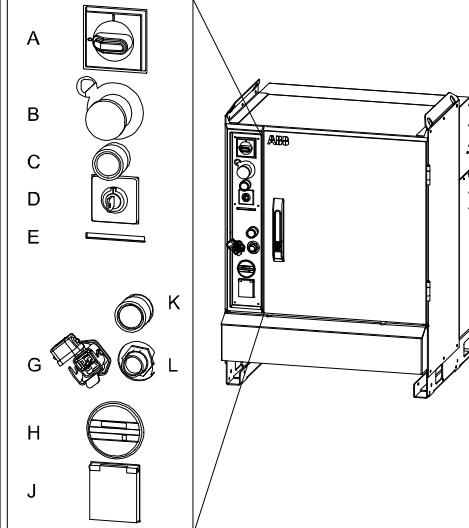
#### Description

Working with high voltage is potentially lethal. Persons subjected to high voltage may suffer cardiac arrest, burn injuries, or other severe injuries. To avoid these dangers, do not proceed working before eliminating the danger as detailed below.

#### Elimination, IRC5 Panel Mounted Controller

	Action	Note/illustration
1	Switch off the main switch for the controller.	 xx0600003255

#### Elimination, IRC5 Single Cabinet Controller

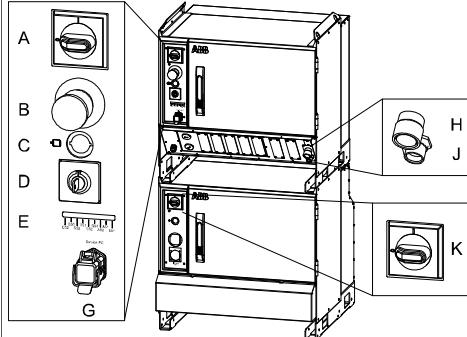
	Action	Note/illustration
1	Switch off the main switch on the controller cabinet.	 xx0600002782 A: Main switch

*Continues on next page*

## 1.4.4 DANGER - Make sure that the main power has been switched off!

*Continued*

### Elimination, IRC5 Dual Cabinet Controller

	Action	Note/illustration
1	Switch off the main switch on the Drive Module.	 <p>xx0600002783</p> <p>K: Main switch, Drive Module</p>
2	Switch off the main switch on the Control Module.	A: Main switch, Control Module

## 1 Safety

### 1.4.5 WARNING - The unit is sensitive to ESD!

#### Description

ESD (electrostatic discharge) is the transfer of electrical static charge between two bodies at different potentials, either through direct contact or through an induced electrical field. When handling parts or their containers, personnel not grounded may potentially transfer high static charges. This discharge may destroy sensitive electronics.

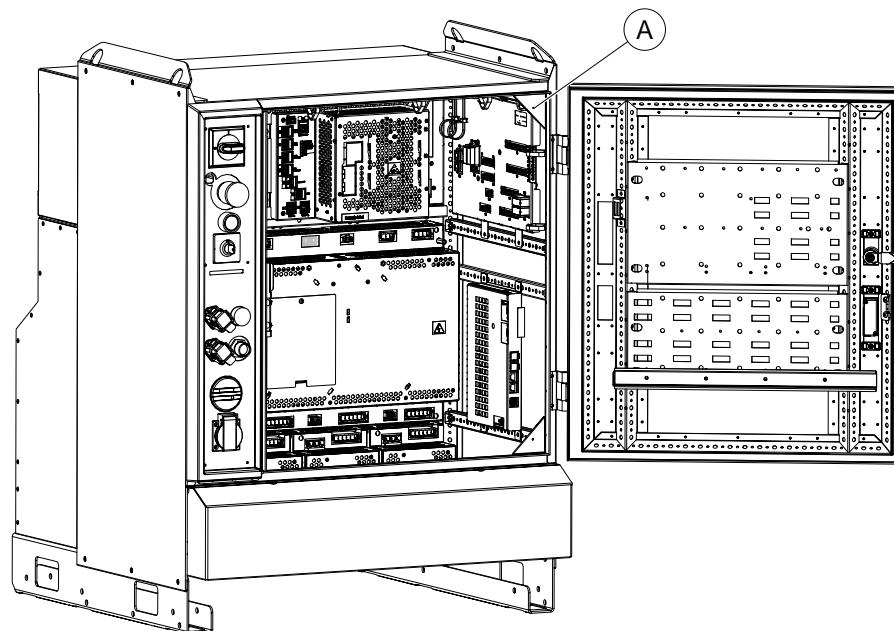
#### Elimination

	Action	Note
1	Use a wrist strap.	Wrist straps must be tested frequently to ensure that they are not damaged and are operating correctly.
2	Use an ESD protective floor mat.	The mat must be grounded through a current-limiting resistor.
3	Use a dissipative table mat.	The mat should provide a controlled discharge of static voltages and must be grounded.

#### Location of wrist strap button

The location of the wrist strap button is shown in the following illustration.

IRC5



xx1300000856

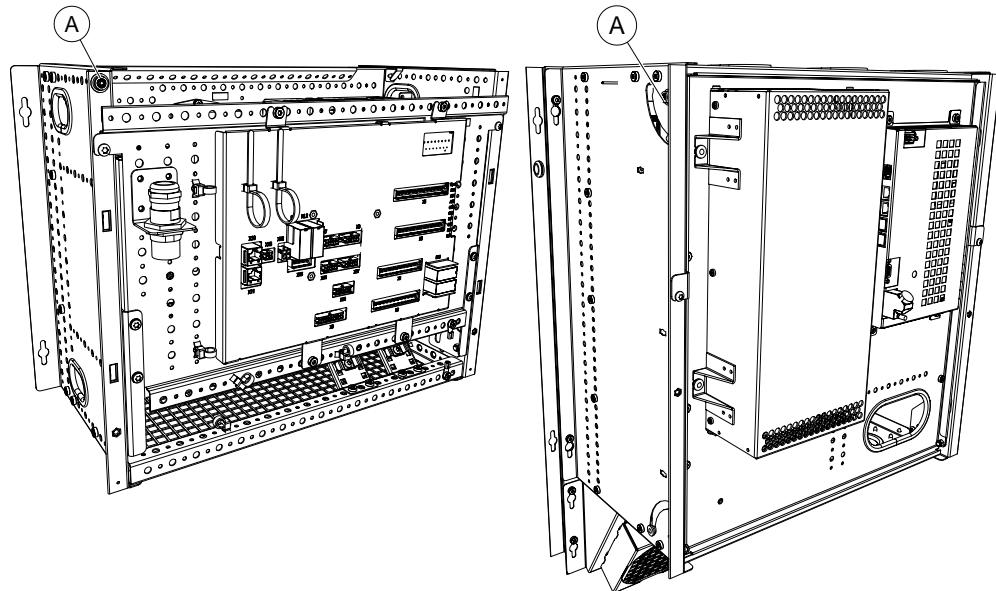
A	Wrist strap button
---	--------------------

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## 1.4.5 WARNING - The unit is sensitive to ESD!

*Continued*

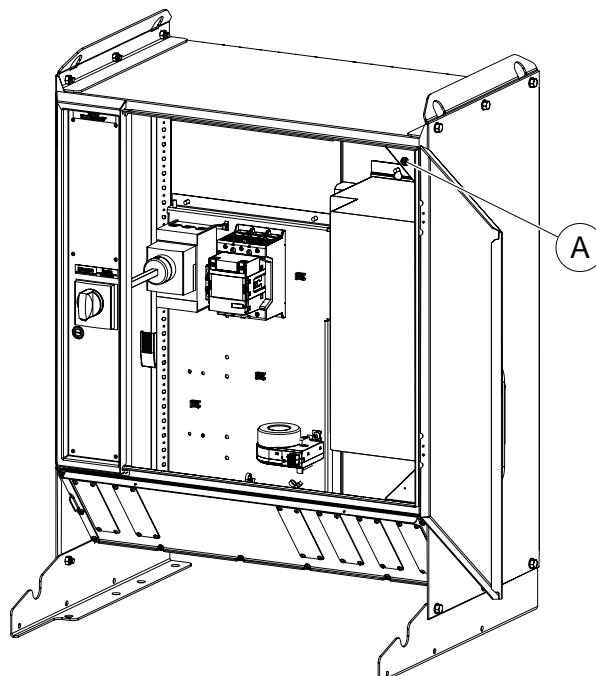
Panel Mounted Controller



xx1300001960

A	Wrist strap button
---	--------------------

Spot welding cabinet



xx1600000253

# 1 Safety

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## 1.4.6 WARNING - Safety risks during handling of batteries

### Description

Under normal conditions of use, the electrode materials and liquid electrolyte in the batteries are not exposed to the outside, provided the battery integrity is maintained and seals remain intact.

There is a risk of exposure only in case of abuse (mechanical, thermal, electrical) which leads to the activation of safety valves and/or the rupture of the battery container. Electrolyte leakage, electrode materials reaction with moisture/water or battery vent/explosion/fire may follow, depending upon the circumstances.



#### Note

Appropriate disposal regulations must be observed.

### Elimination

	Action	Note
1	Do not short circuit, recharge, puncture, incinerate, crush, immerse, force discharge or expose to temperatures above the declared operating temperature range of the product. Risk of fire or explosion.	Operating temperatures are listed in <a href="#">Pre-installation procedure on page 60</a> .
2	Use safety glasses when handling the batteries.	
3	In the event of leakage, wear gloves and chemical apron.	
4	In the event of fire, use self-contained breathing apparatus.	

## 1.4.7 WARNING - Safety risks during work with gearbox lubricants (oil or grease)

**1.4.7 WARNING - Safety risks during work with gearbox lubricants (oil or grease)****Description**

When handling gearbox lubricants, there is a risk of both personal injury and product damage occurring. The following safety information must be regarded before performing any work with lubricants in the gearboxes.

**Note**

When handling oil, grease, or other chemical substances the safety information of the manufacturer must be observed.

**Note**

When aggressive media is handled, an appropriate skin protection must be provided. Gloves and goggles are recommended.

**Note**

Appropriate disposal regulations must be observed.

**Note**

Take special care when handling hot lubricants.

**Warnings and elimination**

Warning	Description	Elimination/Action
 xx0100000002 <b>Hot oil or grease</b>	Changing and draining gearbox oil or grease may require handling hot lubricant heated up to 90 °C.	Make sure that protective gear like goggles and gloves are always worn during this activity.
 xx0100000002 <b>Allergic reaction</b>	When working with gearbox lubricant there is a risk of an allergic reaction.	Make sure that protective gear like goggles and gloves are always worn.
 xx0100000002 <b>Possible pressure build-up in gearbox</b>	When opening the oil or grease plug, there may be pressure present in the gearbox, causing lubricant to spray from the opening.	Open the plug carefully and keep away from the opening. Do not overfill the gearbox when filling.

*Continues on next page*

# 1 Safety

## 1.4.7 WARNING - Safety risks during work with gearbox lubricants (oil or grease)

*Continued*

Warning	Description	Elimination/Action
 xx010000002 <b>Do not overfill</b>	Overfilling of gearbox lubricant can lead to internal over-pressure inside the gearbox which in turn may: <ul style="list-style-type: none"><li>• damage seals and gaskets</li><li>• completely press out seals and gaskets</li><li>• prevent the robot from moving freely.</li></ul>	Make sure not to overfill the gearbox when filling it with oil or grease! After filling, verify that the level is correct.
 xx010000002 <b>Do not mix types of oil</b>	Mixing types of oil may cause severe damage to the gearbox.	When filling gearbox oil, do not mix different types of oil unless specified in the instructions. Always use the type of oil specified by the manufacturer!
 xx010000008 <b>Heat up the oil</b>	Warm oil drains quicker than cold oil.	When changing gearbox oil, first run the robot for a time to heat up the oil.
 xx010000004 <b>Specified amount depends on drained volume</b>	The specified amount of oil or grease is based on the total volume of the gearbox. When changing the lubricant, the amount refilled may differ from the specified amount, depending on how much has previously been drained from the gearbox.	After filling, verify that the level is correct.
 xx010000003 <b>Contaminated oil in gear boxes</b>	When draining the oil make sure that as much oil as possible is drained from the gearbox. The reason for this is to drain as much oil sludge and metal chips as possible from the gearbox. The magnetic oil plugs will take care of any remaining metal chips.	

# 2 Installation and commissioning

## 2.1 Introduction

### General

This chapter contains assembly instructions and information for installing the IRB 6650S at the working site.

More detailed technical data can be found in the *Product specification* for the IRB 6650S, such as:

- Load diagram
- Permitted extra loads (equipment), if any
- Location of extra loads (equipment), if any.

### Safety information

Before any installation work is commenced, it is extremely important that all safety information is observed!

There are general safety aspects that must be read through, as well as more specific safety information that describes the danger and safety risks when performing the procedures. Read the chapter [Safety on page 19](#) before performing any installation work.



#### Note

If the IRB 6650S is connected to power, always make sure that the robot is connected to *protective earth* before starting any installation work!

For more information see:

- *Product manual - IRC5*

## 2 Installation and commissioning

### 2.2.1 Pre-installation procedure

## 2.2 Unpacking

### 2.2.1 Pre-installation procedure

#### Introduction

This section is intended for use when unpacking and installing the robot for the first time. It also contains information useful during later re-installation of the robot.

#### Prerequisites for installation personnel

Installation personnel working with an ABB product must:

- be trained by ABB and have the required knowledge of mechanical and electrical installation/maintenance/repair work
- conform to all national and local codes.

#### Checking the pre-requisites for installation

	Action
1	Make a visual inspection of the packaging and make sure that nothing is damaged.
2	Remove the packaging.
3	Check for any visible transport damage.   <b>Note</b> Stop unpacking and contact ABB if transport damages are found.
4	Clean the unit with a lint-free cloth, if necessary.
5	Make sure that the lifting accessory used is suitable to handle the weight of the robot as specified in: <a href="#">Weight, robot on page 61</a>
6	If the robot is not installed directly, it must be stored as described in: <a href="#">Storage conditions, robot on page 62</a>
7	Make sure that the expected operating environment of the robot conforms to the specifications as described in: <a href="#">Operating conditions, robot on page 62</a>
8	Before taking the robot to its installation site, make sure that the site conforms to: <ul style="list-style-type: none"><li>• <a href="#">Loads on foundation, robot on page 61</a></li><li>• <a href="#">Protection classes, robot on page 63</a></li><li>• <a href="#">Requirements, foundation on page 62</a></li></ul>
9	Before moving the robot, please observe the stability of the robot: <a href="#">Risk of tipping/stability on page 68</a>
10	When these prerequisites are met, the robot can be taken to its installation site as described in section: <a href="#">On-site installation on page 69</a>
11	Install required equipment, if any. <ul style="list-style-type: none"><li>• <a href="#">Installation of signal lamp (option) on page 95</a></li></ul>

Continues on next page

**Weight, robot**

The table shows the weight of the robot.

The weight does not include the weight of the DressPack.

Robot model	Weight
IRB 6650S	2275 kg

**Note**

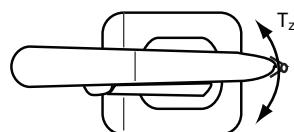
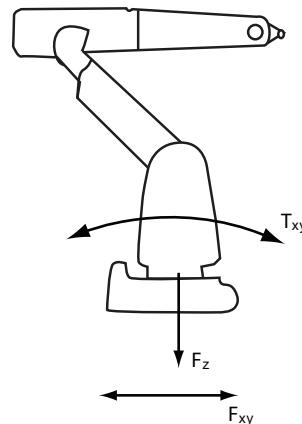
The weight does not include tools and other equipment fitted on the robot!

The weight does not include the weight of the DressPack.

**Loads on foundation, robot**

The illustration shows the directions of the robots stress forces.

The directions are valid for all floor mounted, suspended and inverted robots.



xx1100000521

$F_{xy}$	Force in any direction in the XY plane
$F_z$	Force in the Z plane
$T_{xy}$	Bending torque in any direction in the XY plane
$T_z$	Bending torque in the Z plane

The table shows the various forces and torques working on the robot during different kinds of operation.

**Note**

These forces and torques are extreme values that are rarely encountered during operation. The values also never reach their maximum at the same time!

*Continues on next page*

## 2 Installation and commissioning

### 2.2.1 Pre-installation procedure

*Continued*

Floor mounted

Force	Endurance load (in operation)	Max. load (emergency stop)
Force xy	$\pm 10.6 \text{ kN}$	$\pm 20.9 \text{ kN}$
Force z	$28.2 \pm 7.7 \text{ kN}$	$28.2 \pm 16.4 \text{ kN}$
Torque xy	$\pm 28.2 \text{ kNm}$ $\pm 31 \text{ kNm}^*$	$\pm 50.5 \text{ kNm}$ $\pm 55.6 \text{ kNm}^*$
Torque z	$\pm 7.9 \text{ kNm}$	$\pm 13.6 \text{ kNm}$

### Requirements, foundation

The table shows the requirements for the foundation where the weight of the installed robot is included:

Requirement	Value	Note
Flatness of foundation surface	0.3 mm	Flat foundations give better repeatability of the resolver calibration compared to original settings on delivery from ABB. The value for levelness aims at the circumstance of the anchoring points in the robot base. In order to compensate for an uneven surface, the robot can be recalibrated during installation. If resolver/encoder calibration is changed this will influence the absolute accuracy.
Maximum tilt	5°	
Minimum resonance frequency	22 Hz	

### Storage conditions, robot

The table shows the allowed storage conditions for the robot:

Parameter	Value
Minimum ambient temperature	-25° C
Maximum ambient temperature	+55° C
Maximum ambient temperature (less than 24 hrs)	+70° C
Maximum ambient humidity	95% at constant temperature (gaseous only)

### Operating conditions, robot

The table shows the allowed operating conditions for the robot:

Parameter	Value
Minimum ambient temperature	+5°
Maximum ambient temperature	+50°
Maximum ambient humidity	Max. 95% at constant temperature.

*Continues on next page*

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#### **Protection classes, robot**

The table shows the available protection types of the robot, with the corresponding protection class.

<b>Protection type</b>	<b>Protection class</b>
Manipulator, protection type Standard	IP 67
Manipulator, protection type Foundry Plus	IP 67

## 2 Installation and commissioning

### 2.2.2 Working range and type of motion

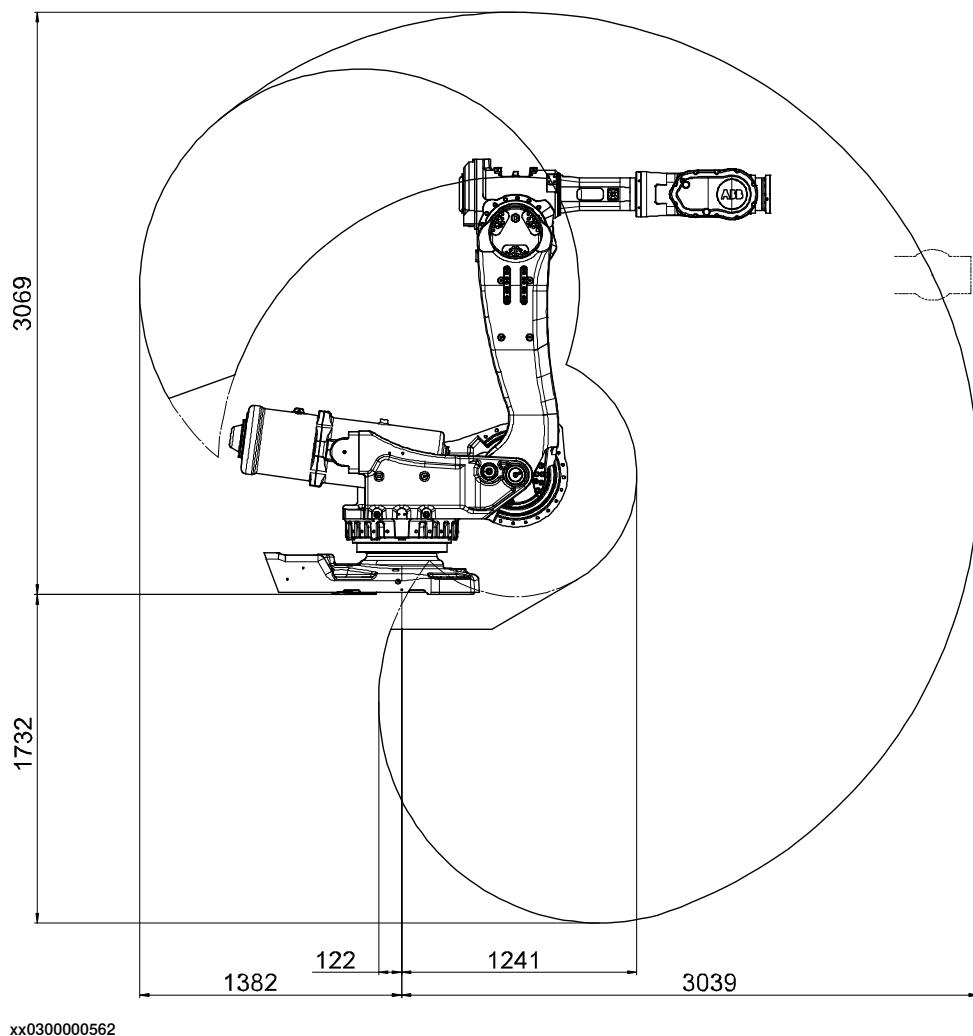
#### 2.2.2 Working range and type of motion

##### Working range

The following figures show the working ranges of the robot variants. The extreme positions of the robot arm are specified at the wrist center (dimensions in mm).

##### IRB 6650S - 200/3.0

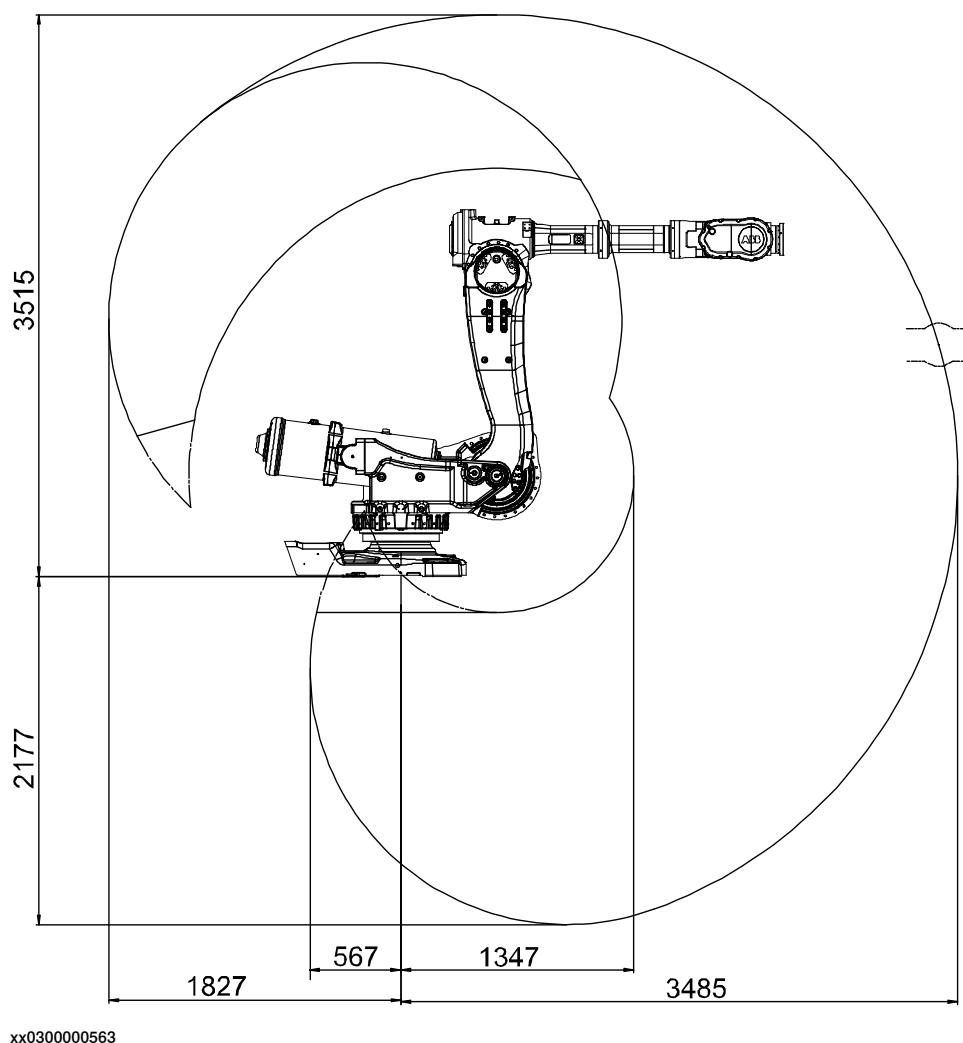
The illustration below shows the unrestricted working range of IRB 6650S - 200/3.0:



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#### IRB 6650S - 125/3.5

The illustration below shows the unrestricted working range of IRB 6650S - 125/3.5:



*Continues on next page*

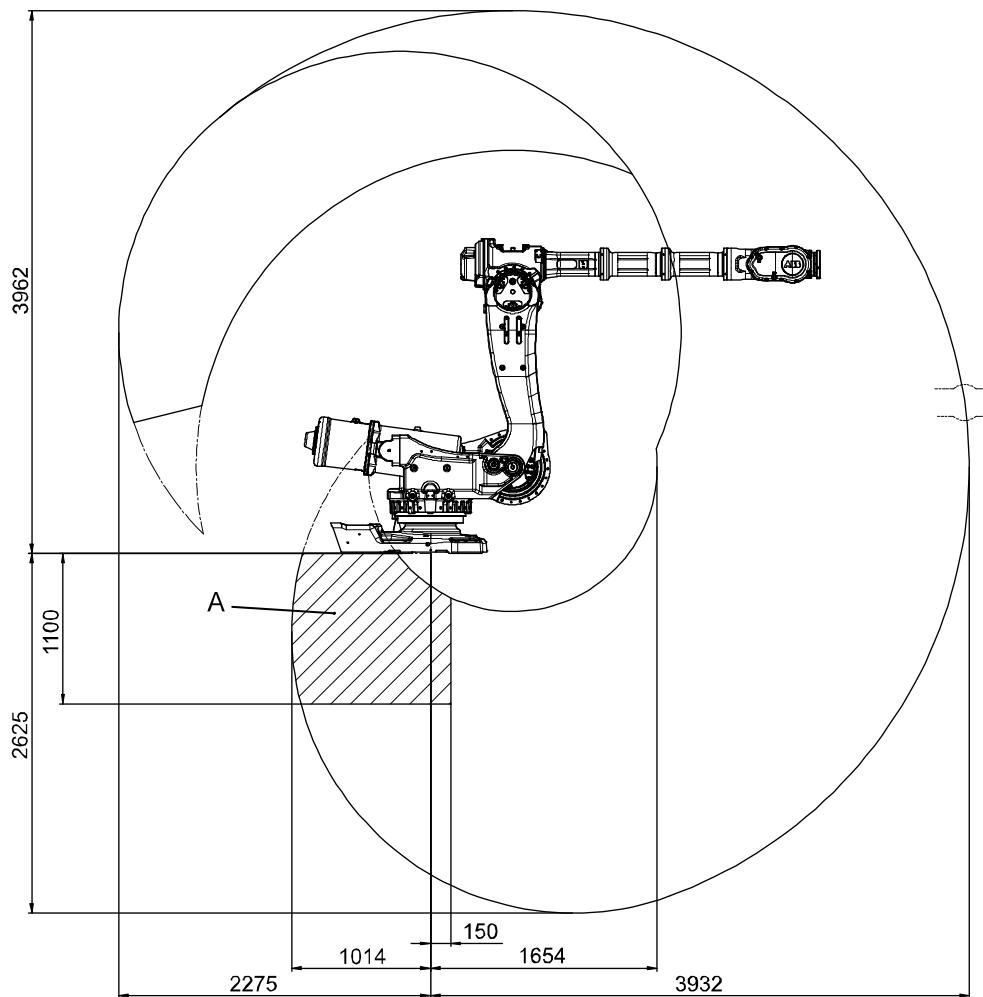
## 2 Installation and commissioning

### 2.2.2 Working range and type of motion

*Continued*

#### IRB 6650S - 90/3.9

The illustration below shows the unrestricted working range of IRB 6650S - 90/3.9:



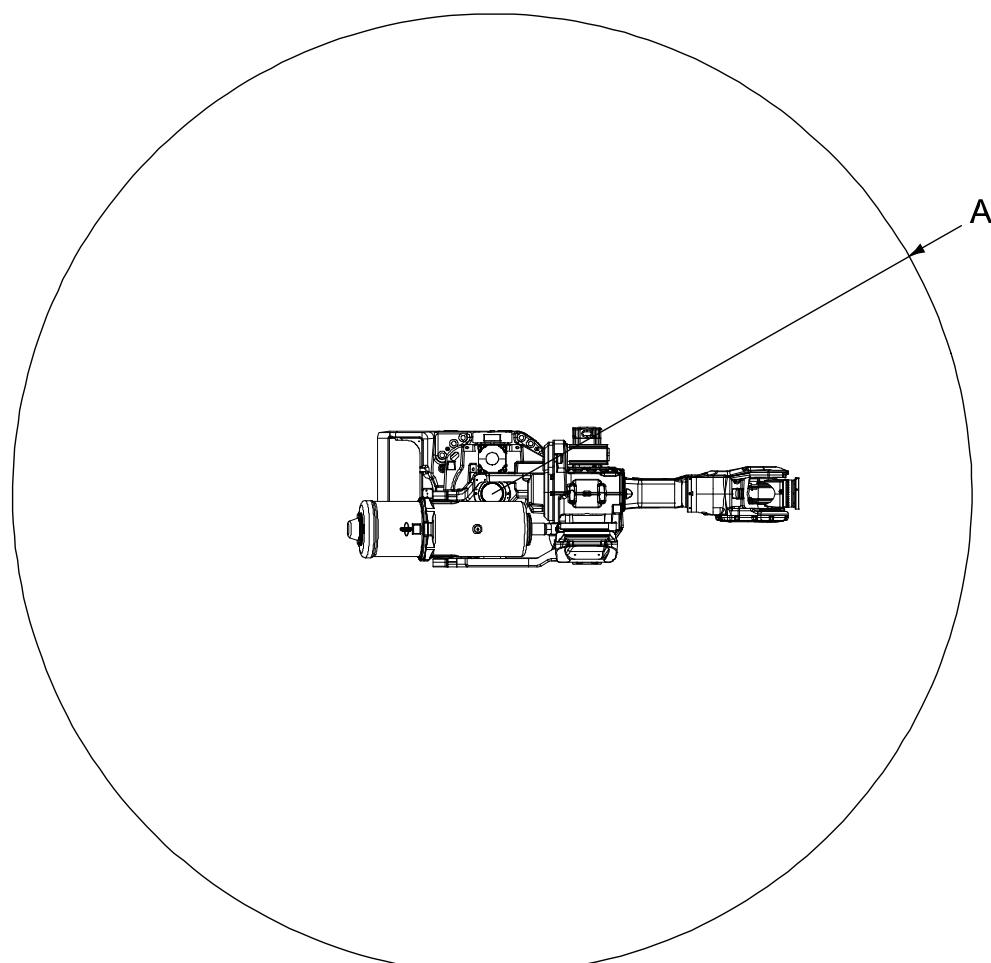
A

Marked area: max. payload 50 kg

*Continues on next page*

#### Turning radius

The turning radius, shown as A in the figure below, is specified for the different robot variants below the figure.



xx0600002740

IRB 6650S - 200/3.0	3039 mm
IRB 6650S - 125/3.5	3485 mm
IRB 6650S - 90/3.9	3932 mm

#### Type of motion

Axis	Type of motion	Range of movement	Note
1	Rotation motion	+180° to -180°	+220° to -220° (option 561-1)
2	Arm motion	+160° to -40°	
3	Arm motion	+70° to -180°	
4	Wrist motion	+300° to -300°	
5	Bend motion	+120° to -120°	
6	Turn motion	+300° to -300°	

## 2 Installation and commissioning

### 2.2.3 Risk of tipping/stability

#### 2.2.3 Risk of tipping/stability

##### Risk of tipping

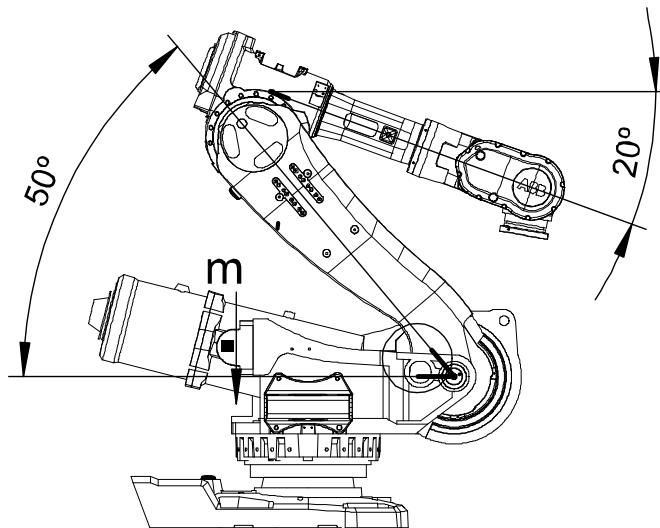
If the robot is not fastened to the foundation while moving the arm, the robot is not stable in the whole working area. Moving the arm will displace the center of gravity, which may cause the robot to tip over.

The shipping position is the most stable position.

**Do not change the robot position before securing it to the foundation!**

##### Shipping and transportation position

This figure shows the robot in its shipping position and transportation position.



xx0300000632



##### WARNING

The robot is likely to be mechanically unstable if not secured to the foundation.

## 2.3 On-site installation

### 2.3.1 Lifting robot with fork lift

#### General

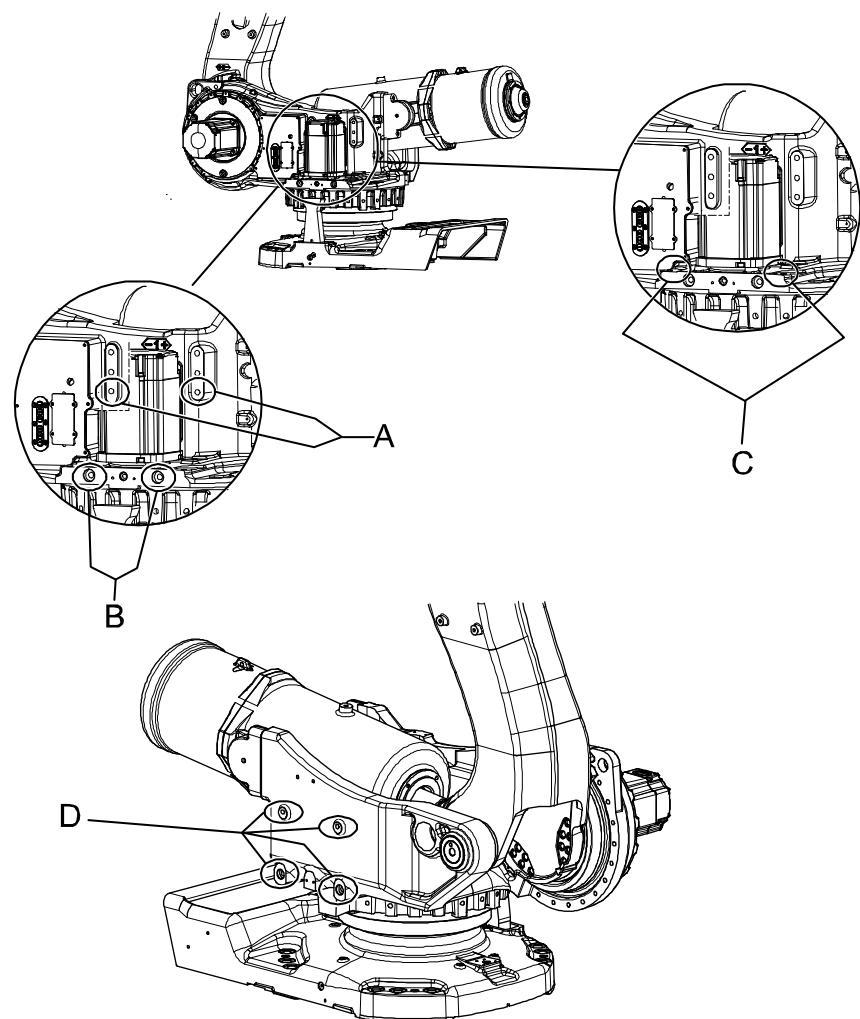
The robot may be moved using a fork lift, provided that available special aids are used.

This section describes how to attach the fork lift equipment to the robot.

#### Attachment points on robot

The attachment points for the fork lift equipment are shown in this figure.

Notice the length of the IRB 6650S balancing device when planning to lift with a fork lift, shown in the figure below.



xx0300000463

A	Attachment points, spacer and horizontal attachment screws
B	Attachment points, horizontal attachment screws
C	Attachment points, vertical attachment screws

*Continues on next page*

## 2 Installation and commissioning

### 2.3.1 Lifting robot with fork lift

*Continued*

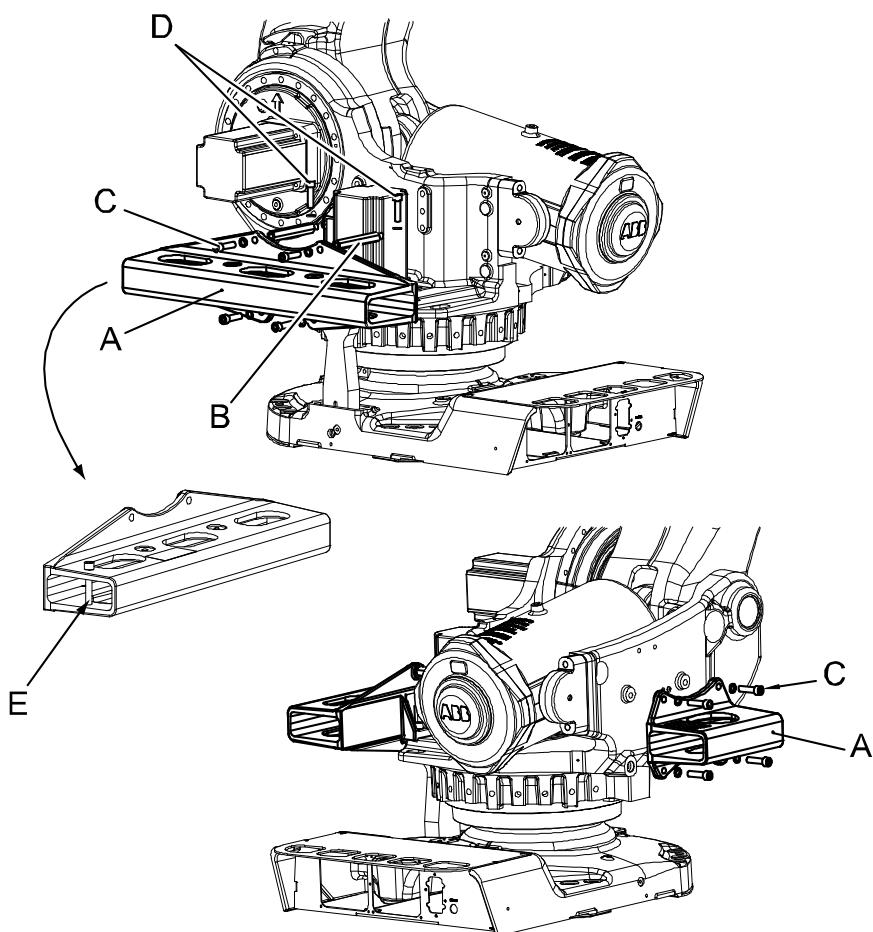
D	Attachment points, horizontal attachment screws
---	---

#### Required equipment

Equipment, etc.	Art. no.	Note
Fork lift accessory, incl. all required hardware	3HAC0604-2	
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .

#### Fork lift accessory, 3HAC0604-2

The Fork lift accessory, 3HAC0604-2, is fitted to the robot as shown in the figure below.



xx0200000379

A	Fork lift pocket (2 pcs, 3HAC15766-1 , 3HAC11264-1)
B	Spacer (2 pcs)
C	Horizontal attachment screws (4 pcs/ fork lift pocket)
D	Vertical attachment screws (2 pcs)

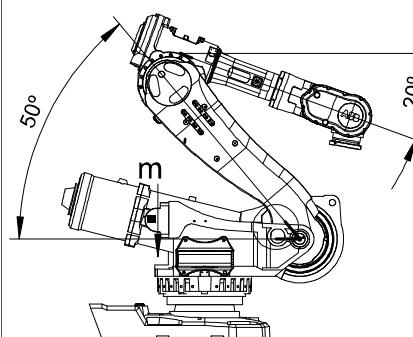
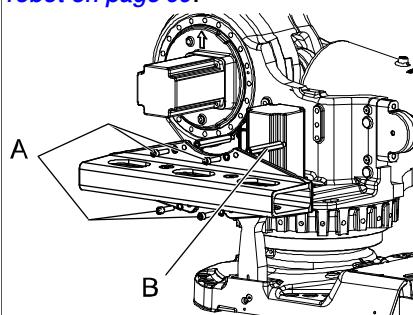
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### 2.3.1 Lifting robot with fork lift

*Continued*

#### Lifting robot with fork lift

This section details how to secure the fork lift set to the robot in order to lift and move the robot using the fork lift ONLY!

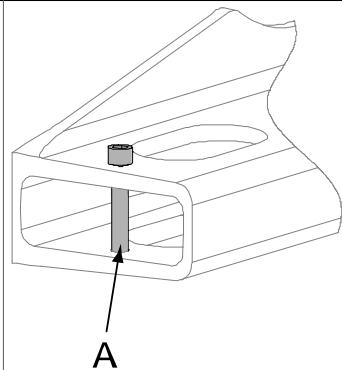
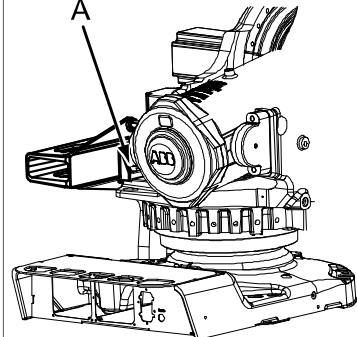
Action	Note
1 If a cooling fan for the axis 1 motor is used, it must be removed in order to use the fork lift device!	
2 Position the robot as shown in the figure to the right!	Release the brakes if required as detailed in section <a href="#">Manually releasing the brakes on page 78</a> .  
3 Fit the two spacers to the robot and secure.	Attachment points are shown in figure <a href="#">Attachment points on robot on page 69</a> .
4  <b>CAUTION</b> The fork lift pocket weighs 60 kg!	
5 Secure the longer <i>fork lift pocket</i> to the spacers with four of the <i>horizontal attachment screws</i> and washers.   <b>Note</b>  The screws, which are attached horizontally and vertically, are identical. However, they are tightened with different torque!	Always use original screws (or replacements of equivalent quality: M16, quality 12.9)! Attachment points on the robot are shown in figure <a href="#">Attachment points on robot on page 69</a> .    A Horizontal attachment screws, 4 pcs, M16 x 60. Tightening torque: 60 Nm. B Spacers, 2 pcs.

*Continues on next page*

## 2 Installation and commissioning

### 2.3.1 Lifting robot with fork lift

*Continued*

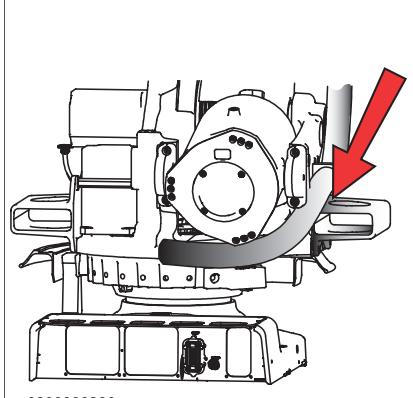
Action	Note
6 Make sure the securing screw is fitted to the longer fork lift pocket. It prevents the fork of the fork lift to be inserted too far into the pocket and thereby damaging the motor of axis 2.	 <b>A Securing screw</b>
7 Secure fork lift pocket to robot with two <i>vertical attachment screws</i> and washers.   <b>Note</b>  Vertical and the horizontally attached screws are identical, but tightened with different torques!	 <b>A Vertical attachment screws, 2 pcs, M16x60. Tightening torque: 270 Nm.</b> Always use original screws (or replacements of equivalent quality: M16, quality 12.9)! Attachment points on robot are shown in figure <a href="#">Attachment points on robot on page 69</a> .
8  <b>CAUTION</b>  The fork lift pocket weighs 22 kg!	
9 Secure the shorter fork lift pocket on the other side of the robot with the four remaining <i>horizontal attachment screws</i> .	4 pcs, M16x60. Tightening torque: 60 Nm. Always use original screws (or replacements of equivalent quality: M16, quality 12.9)! Attachment points on robot are shown in figure <a href="#">Attachment points on robot on page 69</a> .

*Continues on next page*

## 2 Installation and commissioning

### 2.3.1 Lifting robot with fork lift

*Continued*

Action	Note
10 Double-check that pockets are properly secured to the robot! Insert fork lift forks into the pockets.	 xx0200000380 Reposition harness, if any, before using a fork lift!
11  <b>CAUTION</b> The IRB 6650S robot weighs 2275 kg. All lifting accessories used must be sized accordingly!	
12 Carefully lift the robot and move it to its installation site.	
13  <b>WARNING</b> Personnel must not, under any circumstances, be present under the suspended load!	
14 Refit the cooling fan to the motor, if any.	

## 2 Installation and commissioning

### 2.3.2 Lifting robot with roundslings

#### 2.3.2 Lifting robot with roundslings

##### General

The robot can be lifted with roundslings according to this section.

##### Sling specification

Sling type	Qty	Lifting capacity	Length / Note
Chain sling with shortener	4 pcs	4 000 kg	0.43 m 0.605 m 0.75 m 0.785 m
Roundsling, robot	4 pcs	2 000 kg	2 m

##### Lifting with roundslings

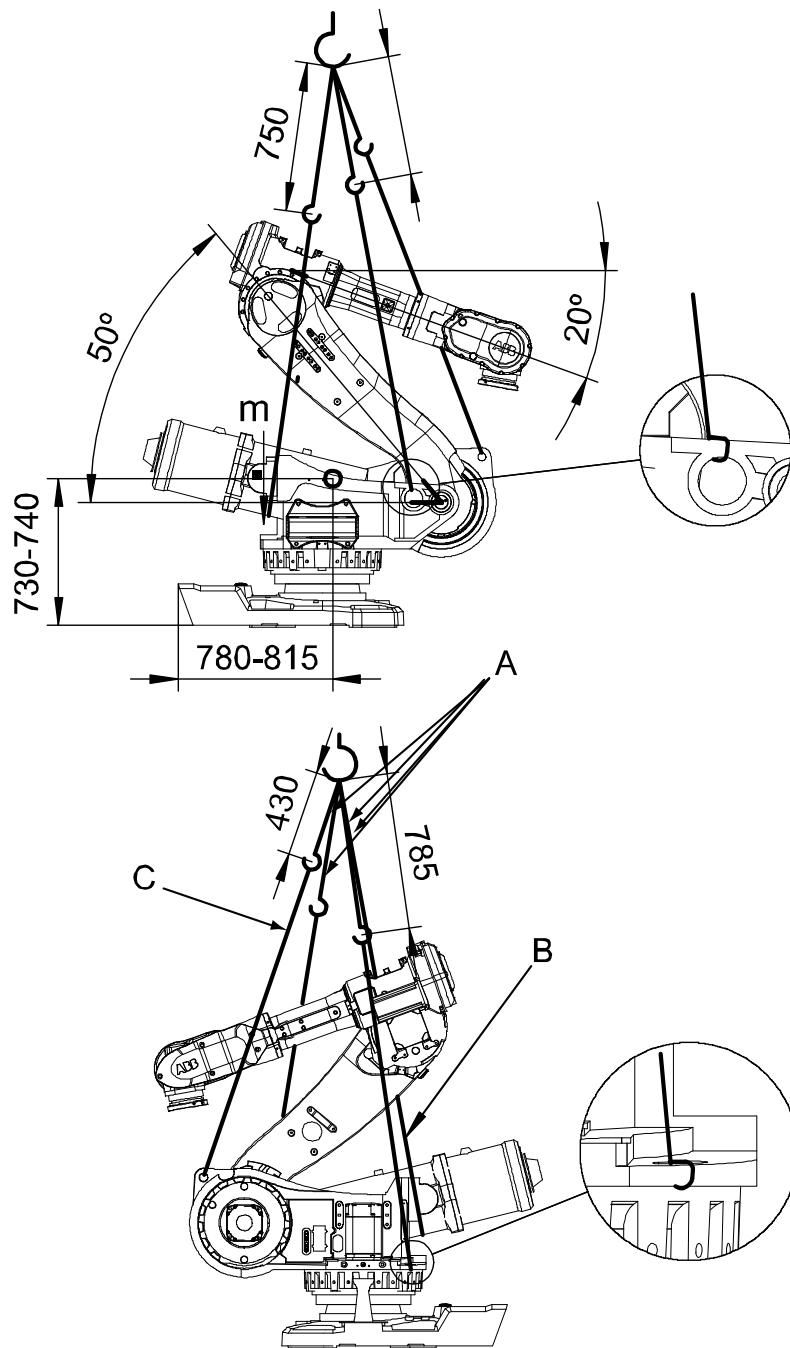
	Action	Note
1	Position robot in a secure transport position.	
2	Attach roundslings to robot according to figure <a href="#">Attachment points on page 75</a> .	
3	 <b>CAUTION</b>  The IRB 6650S robot weighs 2275 kg. All lifting accessories used must be sized accordingly!	
4	 <b>WARNING</b>  Personnel must not, under any circumstances, be present under the suspended load!	

*Continues on next page*

#### Attachment points

This figure shows how to attach the roundslings to the robot.

The illustration is similar with the label attached to the robot's lower arm.



xx0400000679

A	Chain sling with shortener
B	Roundsling, robot
C	Roundsling, used to secure against rotation

## 2 Installation and commissioning

### 2.3.3 Lifting robot with lifting slings

#### General

This section contains a general overview of how to lift the complete robot using special lifting equipment. More detailed instructions are included with the equipment.



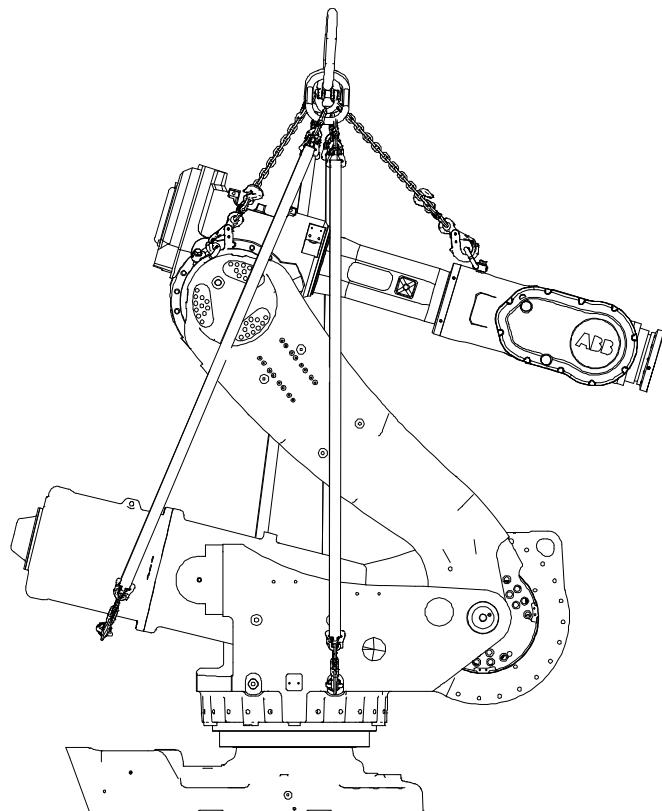
#### Note

Move the robot to the recommended position shown in the figure and in the instruction!

Attempting to lift a robot in any other position may result in the robot tipping over, causing severe damage or injury!

#### Illustration, lifting slings

The figure below shows how to lift the complete robot with lifting slings.



xx0400000722

#### Required equipment

Equipment	Article number	Note
Lifting accessory, robot	3HAC15607-1	Includes user instructions 3HAC15971-2

*Continues on next page*

#### Slings attached directly onto robot

This section details how to lift and move the robot using lifting slings when these are attached directly onto the robot frame.

Action	Note
1 Run the overhead crane to a position above the robot.	
2 Position the robot as detailed in enclosed instruction!	Art. no. is specified in <a href="#">Required equipment on page 76</a> . Release the brakes if required as detailed in section <a href="#">Manually releasing the brakes on page 78</a> .
3 Fit the <i>lifting accessory</i> to the robot as described in the enclosed instruction!	Art. no. is specified in <a href="#">Required equipment on page 76</a> .
4  CAUTION  The IRB 6650S robot weighs 2275 kg. All lifting accessories used must be sized accordingly!	
5  WARNING  Personnel must not, under any circumstances, be present under the suspended load!	
6 Raise overhead crane to lift the robot.	Make sure all hooks and attachments maintain their correct positions while lifting the robot! Always move the robot at very low speeds, making sure it does not tip.

## 2 Installation and commissioning

### 2.3.4 Manually releasing the brakes

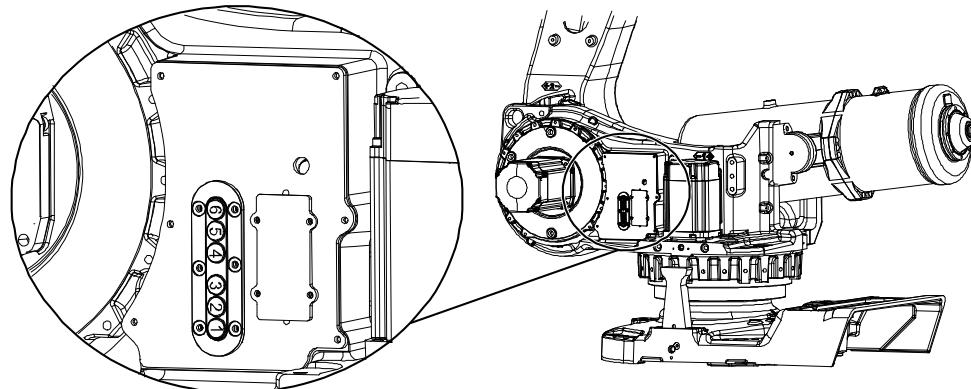
#### 2.3.4 Manually releasing the brakes

##### Introduction to manually releasing the brakes

This section describes how to release the holding brakes for the motors of each axis.

##### Location of brake release unit

The internal brake release unit is located as shown in the figure.



##### Releasing the brakes

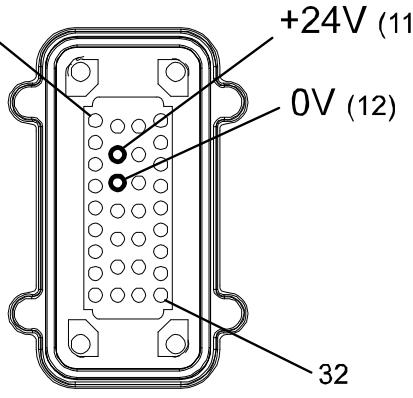
This procedure details how to release the holding brakes when the robot is equipped with an internal brake release unit.

Action	Note
1 The internal brake release unit is equipped with buttons for controlling the axes brakes. The buttons are numbered according to the numbers of the axes. If the robot is not connected to the controller, power must be supplied to the connector R1.MP according to the section <a href="#">Supplying power to connector R1.MP on page 79</a> .	Buttons are shown in figure <a href="#">Location of brake release unit on page 78</a> .
2  <b>DANGER</b> When releasing the holding brakes, the robot axes may move very quickly and sometimes in unexpected ways. Make sure no personnel is near or beneath the robot arm.	
3 Release the holding brake on a particular robot axis by pressing the corresponding button on the internal brake release unit. The brake will function again as soon as the button is released.	

*Continues on next page*

#### Supplying power to connector R1.MP

If the robot is not connected to the controller, power must be supplied to connector R1.MP on the robot, in order to enable the brake release buttons.

Action	Note
1  <b>DANGER</b> Incorrect connections, such as supplying power to the wrong pin, may cause all brakes to be released simultaneously!	
2 Supply 0V on pin 12 and 24V on pin 11.	 xx0600002937

## 2 Installation and commissioning

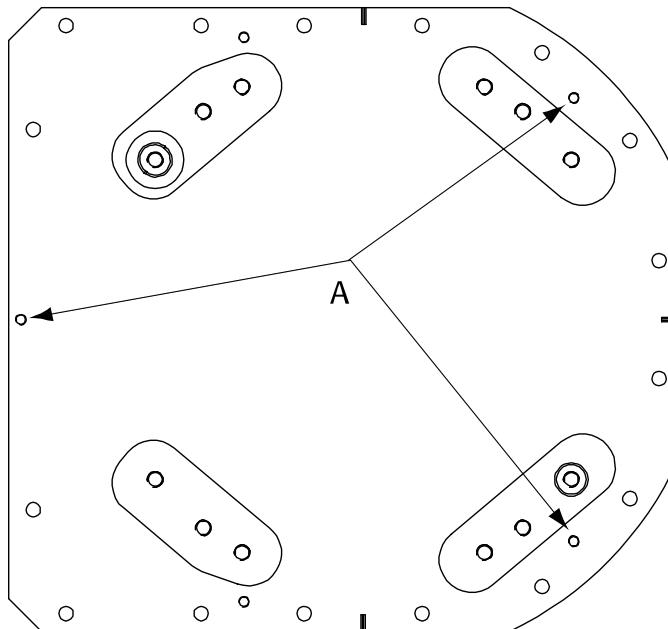
### 2.3.5 Lifting the base plate

#### 2.3.5 Lifting the base plate

##### Required equipment

Equipment	Article number	Note
Lifting eye, M16	3HAC14457-4	3 pcs
Lifting slings		Length: approx. 2 m

##### Hole configuration



xx0200000096

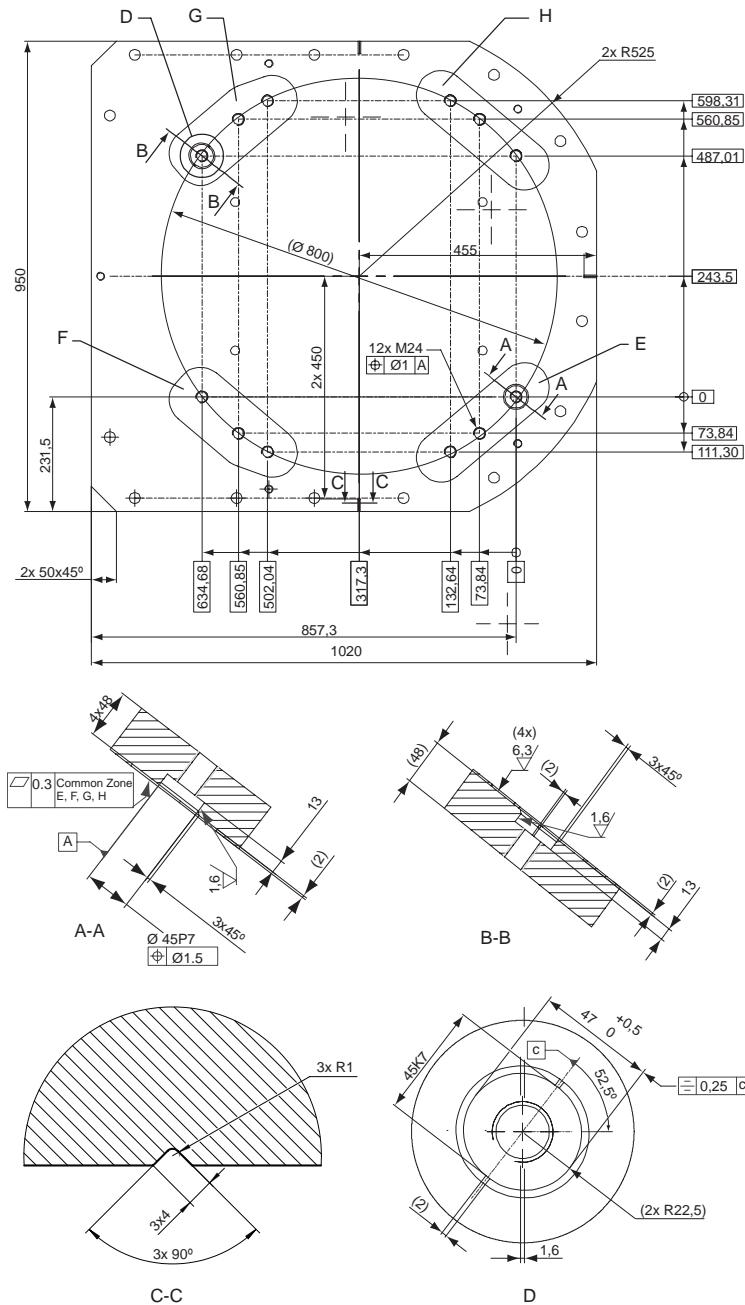
A	Attachment holes for lifting eyes (x3)
---	--

##### Lifting, base plate

	Action	Note
1	 <b>CAUTION</b> The base plate weighs 353 kg. All lifting accessories used must be sized accordingly.	
2	Fit lifting eyes in specified holes.	Shown in figure <a href="#">Hole configuration on page 80</a> .
3	 <b>CAUTION</b> Lift and move the base plate very slowly. If the base plate starts to swing it is a risk for injuries or damage.	

#### 2.3.6 Securing the base plate

##### Base plate, dimensions



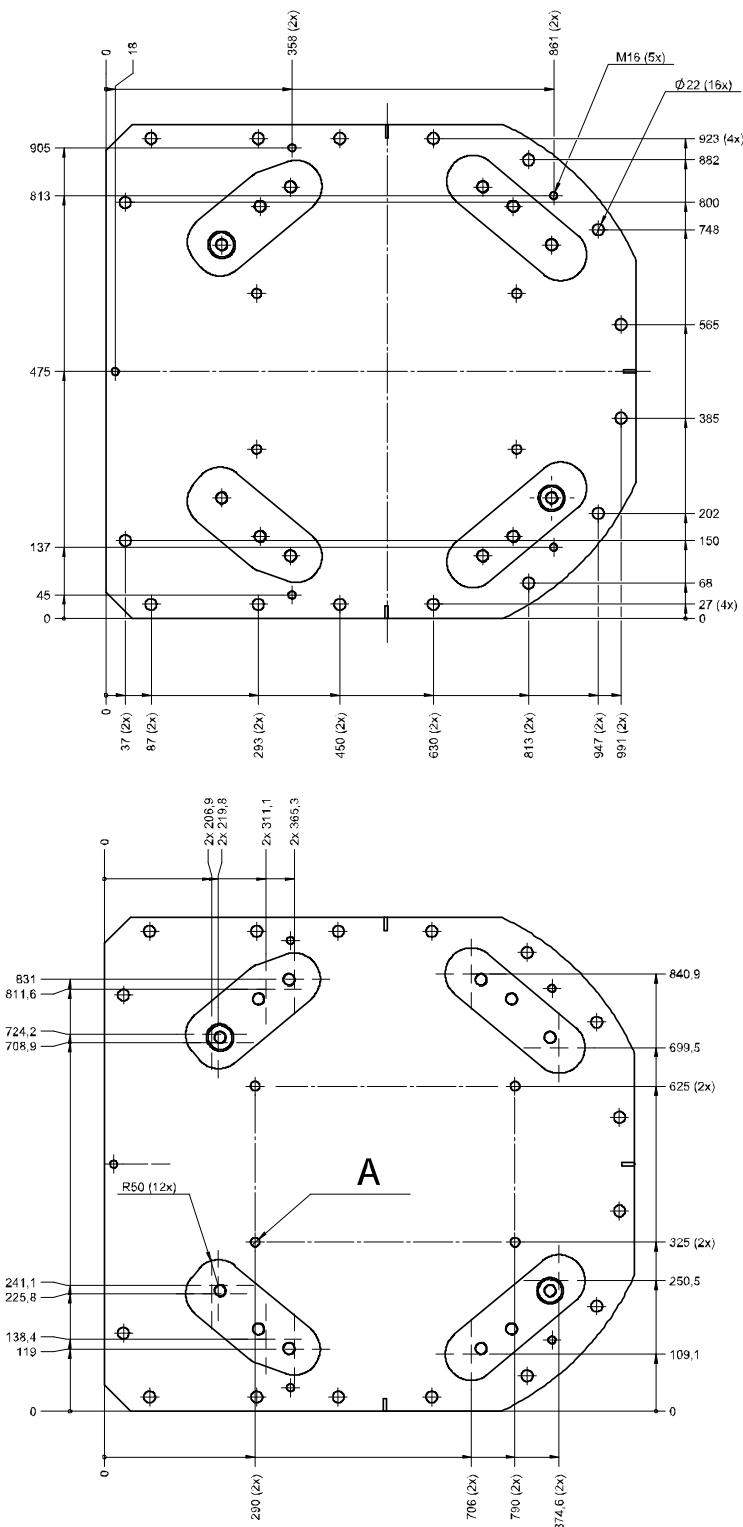
E, F, G, H	Common tolerance zone (accuracy all over the base plate from one contact surface to the other)
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## 2 Installation and commissioning

### 2.3.6 Securing the base plate

Continued



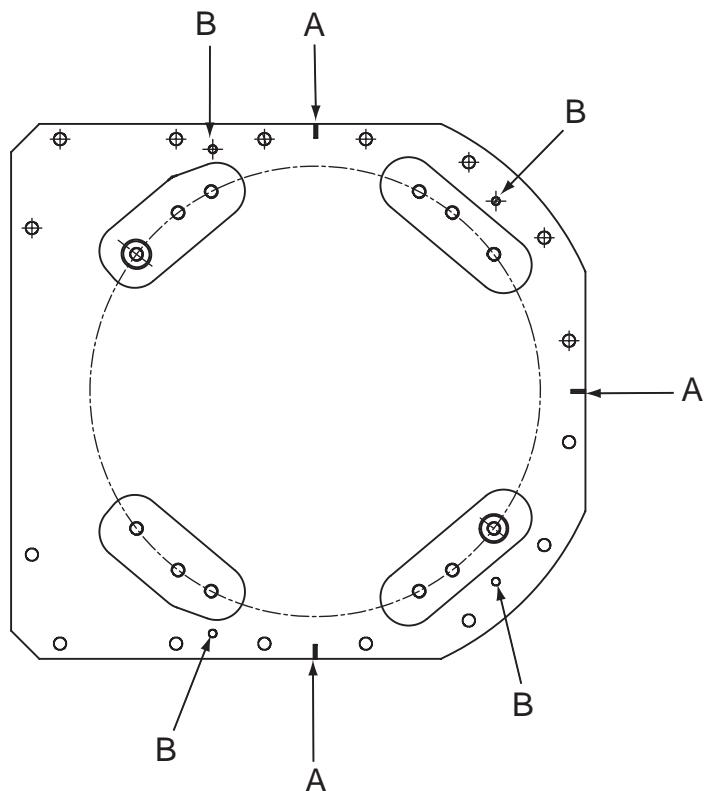
xx0400000715

A	Four holes for alternative clamping, 4x Ø18
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#### Base plate, orienting grooves and leveling bolts

The illustration below shows the orienting grooves and attachment holes for leveling bolts in the base plate.



xx1500000312

A	Orienting grooves (3 pcs)
B	Levelling bolts, attachment holes (4 pcs)

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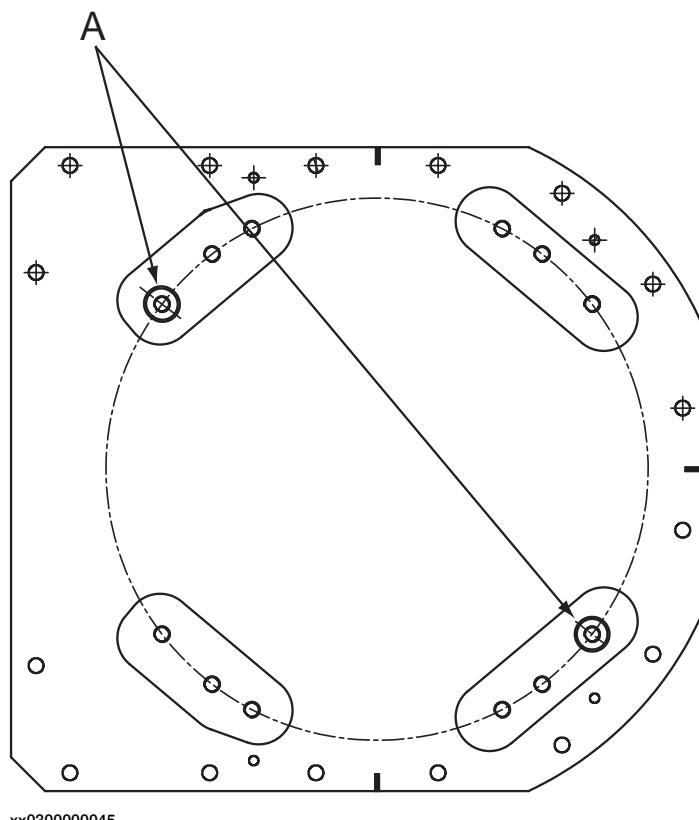
## 2 Installation and commissioning

### 2.3.6 Securing the base plate

*Continued*

#### Base plate, guide sleeve holes

The illustration below shows the orienting grooves and guide sleeve holes in the base plate.



xx030000045

A      Guide sleeve holes (2 pcs)

#### Required equipment

Equipment	Article number	Note
Base plate	3HAC12937-8	Includes <ul style="list-style-type: none"><li>• guide sleeves, 3HAC12937-3</li><li>• levelling screws, 9ADA120-79</li><li>• attachment screws and washers for securing the robot to the base plate.</li></ul>
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

#### Base plate

This section details how to secure the base plate to the foundation.

	Action	Note
1	Make sure the foundation is levelled.	

*Continues on next page*

Action	Note
2  <b>CAUTION</b> The base plate weighs 353 kg! All lifting equipment used must be sized accordingly!	
3 Position base plate in relation to the robot work location using the grooves in the base plate.	Shown in figure <a href="#">Base plate, orienting grooves and leveling bolts on page 83</a> .
4 Lift the base plate to its mounting position.	Detailed in section <a href="#">Lifting the base plate on page 80</a> .
5 Use the base plate as a template and drill attachment holes as required by the selected bolt dimension.	Attachment holes: 16 pcs.
6 Fit the base plate and use the levelling bolts to level the base plate.	Shown in figure <a href="#">Base plate, orienting grooves and leveling bolts on page 83</a> .
7 If required, fit strips of sheet metal underneath the base plate to fill any gaps.	
8 Secure the base plate to the foundation with screws and sleeves.	
9 Recheck the four contact surfaces on the base plate to make sure the base plate is levelled and flat. If it is not, use pieces of sheet metal or similar to bring the base plate to a levelled position.	Maximum allowed deviation all over the base plate, from one contact surface to the other: 0.3 mm.

## 2 Installation and commissioning

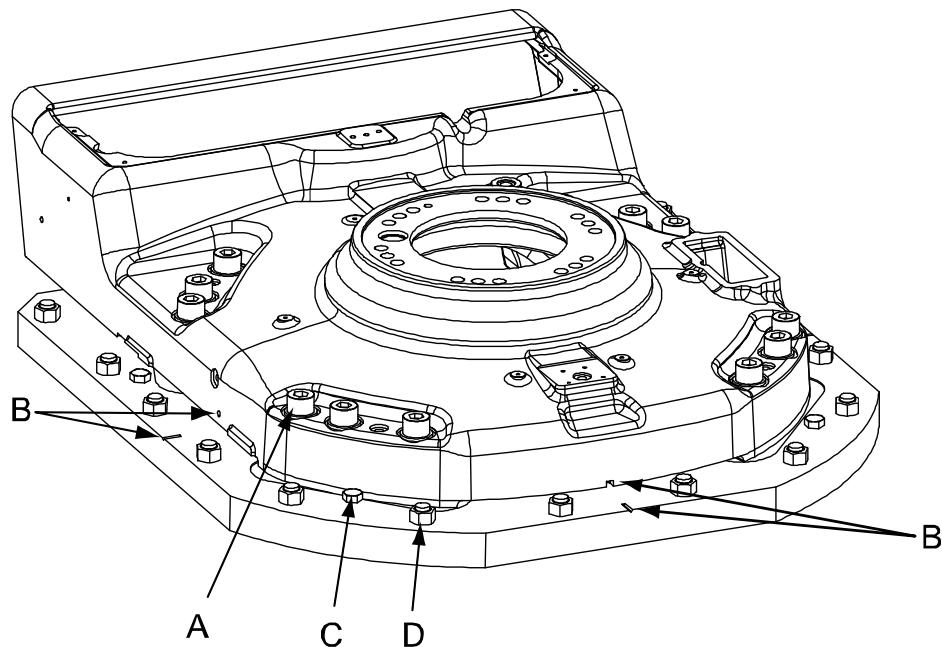
### 2.3.7 Orienting and securing the robot

#### General

This section details how to orient and secure the robot to the base plate in order to run the robot safely.

#### Illustration, robot fitted to base plate

This illustration shows the robot base fitted to the base plate.



xx0100000107

A	Robot attachment bolts and washers, 12 pcs (M24 x 140)
B	Orienting grooves in the robot base and in the base plate
C	Levelling screws
D	Base plate attachment screws

#### Attachment screws

The table below specifies the type of securing screws and washers to be used for securing the robot to the base plate/foundation.

Suitable screws, lightly lubricated:	M24 x 140
Quality:	Quality 8.8
Suitable washer:	Thickness: 4 mm Outer diameter: 44 mm Inner diameter: 25 mm
Tightening torque:	725 Nm

*Continues on next page*

#### Securing the robot

Use this procedure to secure robot to base plate after fitting plate to the foundation.

	Action	Note
1	Lift the robot.	See section <a href="#">Lifting robot with lifting slings on page 76</a> . See section <a href="#">Lifting robot with round-slings on page 74</a> .
2	Move robot to the vicinity of its installation location.	
3	Fit two guide sleeves to the <i>guide sleeve holes</i> in the base plate.	Shown in figure <a href="#">Base plate, guide sleeve holes on page 84</a> .   <b>Note</b> One of the guide sleeve holes is elongated!
4	Guide the robot gently using two M24 screws while lowering it into its mounting position.	Make sure the robot base is correctly fitted onto the guide sleeves!
5	Fit the <i>bolts and washers</i> in the base attachment holes.	Specified in <a href="#">Attachment screws on page 86</a> . Shown in figure <a href="#">Illustration, robot fitted to base plate on page 86</a> .   <b>Note</b> Lightly lubricate screws before assembly!
6	Tighten bolts in a criss-cross pattern to ensure that the base is not distorted.	

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## 2 Installation and commissioning

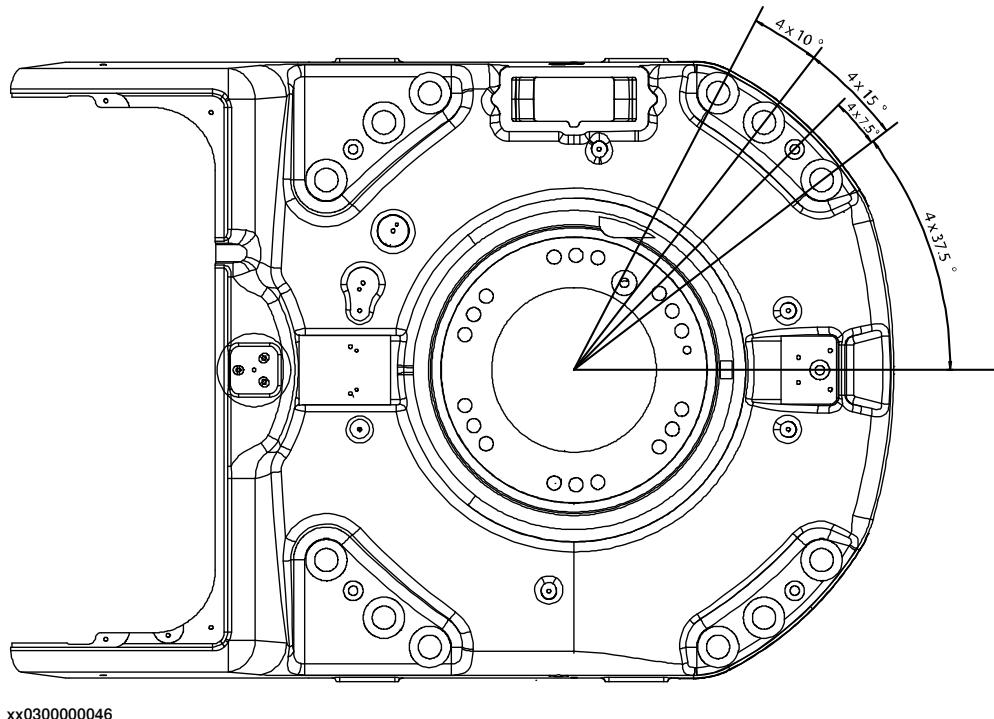
### 2.3.7 Orienting and securing the robot

*Continued*

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#### Hole configuration, base

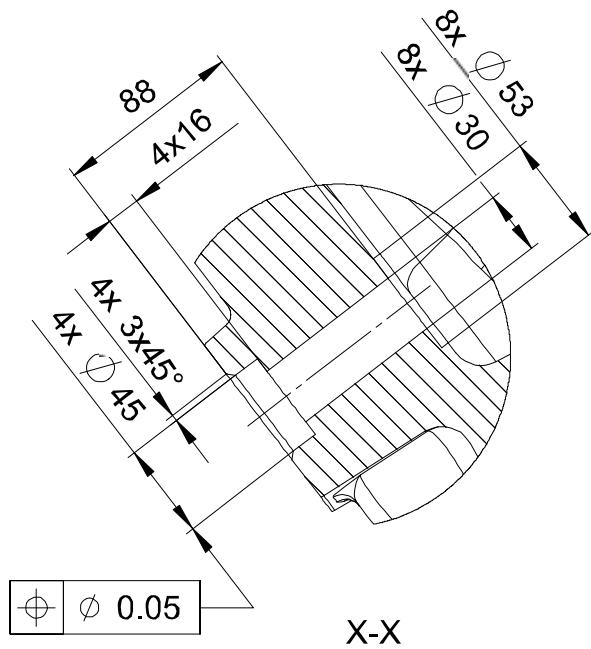
This illustration shows the hole configuration used when securing the robot.



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#### Cross section, guide sleeve hole

This illustration shows the cross section of the guide sleeve holes.



## 2.3.8 Fitting equipment on robot

### General

The robot features mounting holes for additional equipment.

Access to any of the following mounting holes may be obstructed by any additional cabling, equipment, etc., fitted by the robot user. Make sure the required mounting holes are accessible when planning the robot cell.



#### Note

All equipment and cables used on the robot, must be designed and fitted not to damage the robot and/or its parts.



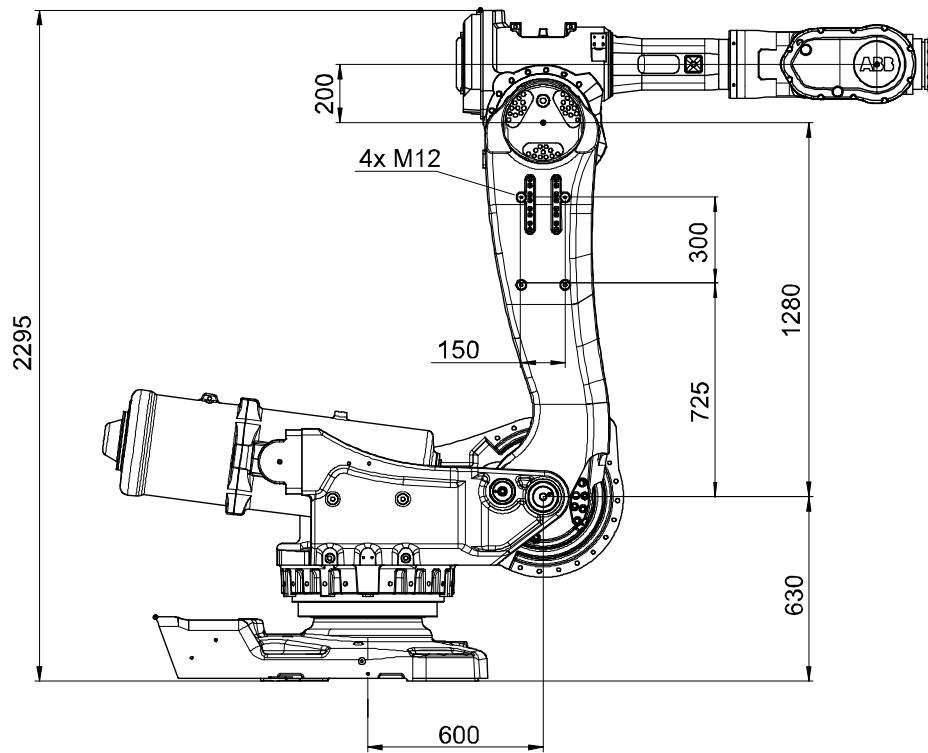
#### Note

The robot IRB 6600ID, IRB 6650ID and IRB 6650ID is delivered with DressPack and there may not be any additional equipment fitted to the robot, except at the turning disk and the frame.

### Illustration, fitting of extra equipment on lower arm

The illustration below shows the mounting holes available for fitting extra equipment on the lower arm.

Make sure not to damage the robot cabling on the inside of the lower arm when fitting extra equipment. Always use appropriate attachment screws!



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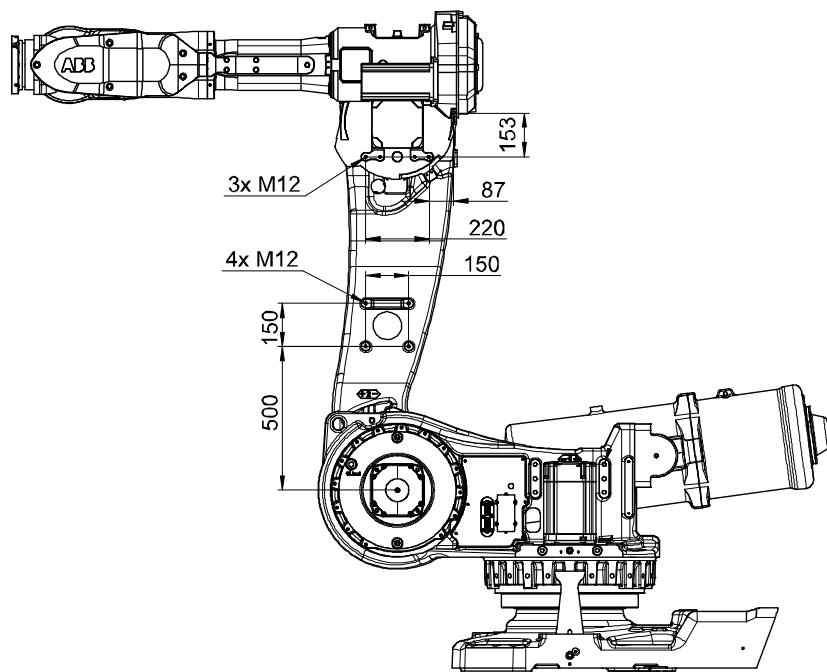
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## 2 Installation and commissioning

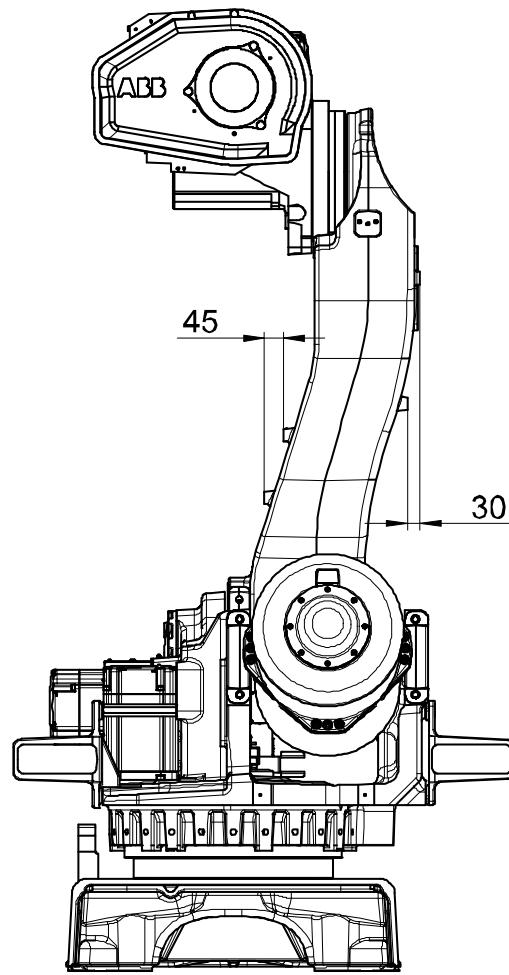
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### 2.3.8 Fitting equipment on robot

*Continued*



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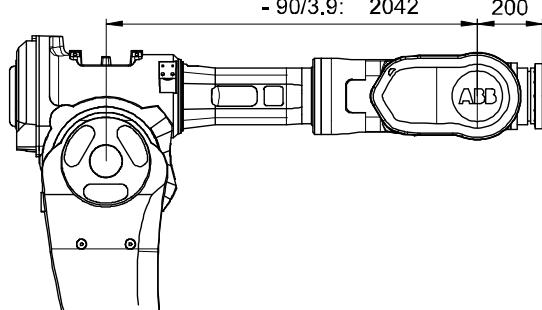
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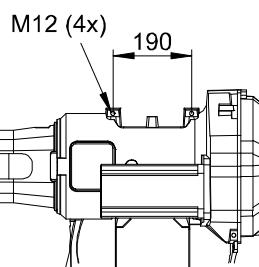
#### Illustration, fitting of extra equipment on upper arm

The illustration below shows the mounting holes available for fitting extra equipment on the upper arm.

IRB 6650S - 200/3.0: 1142  
- 125/3.5: 1592  
- 90/3.9: 2042



xx0300000574



xx0200000196

-	Only valid for IRB 6600 and IRB 6650
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## 2 Installation and commissioning

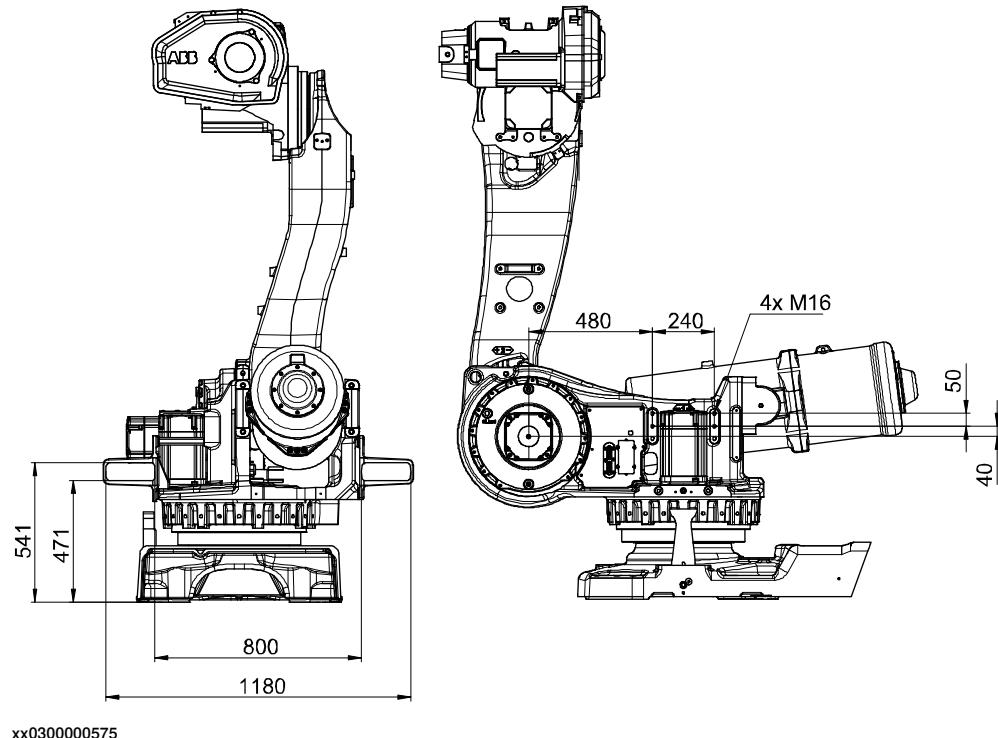
### 2.3.8 Fitting equipment on robot

*Continued*

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#### Illustration, fitting of extra equipment on frame

The mounting holes available for fitting extra equipment on the frame are shown below.

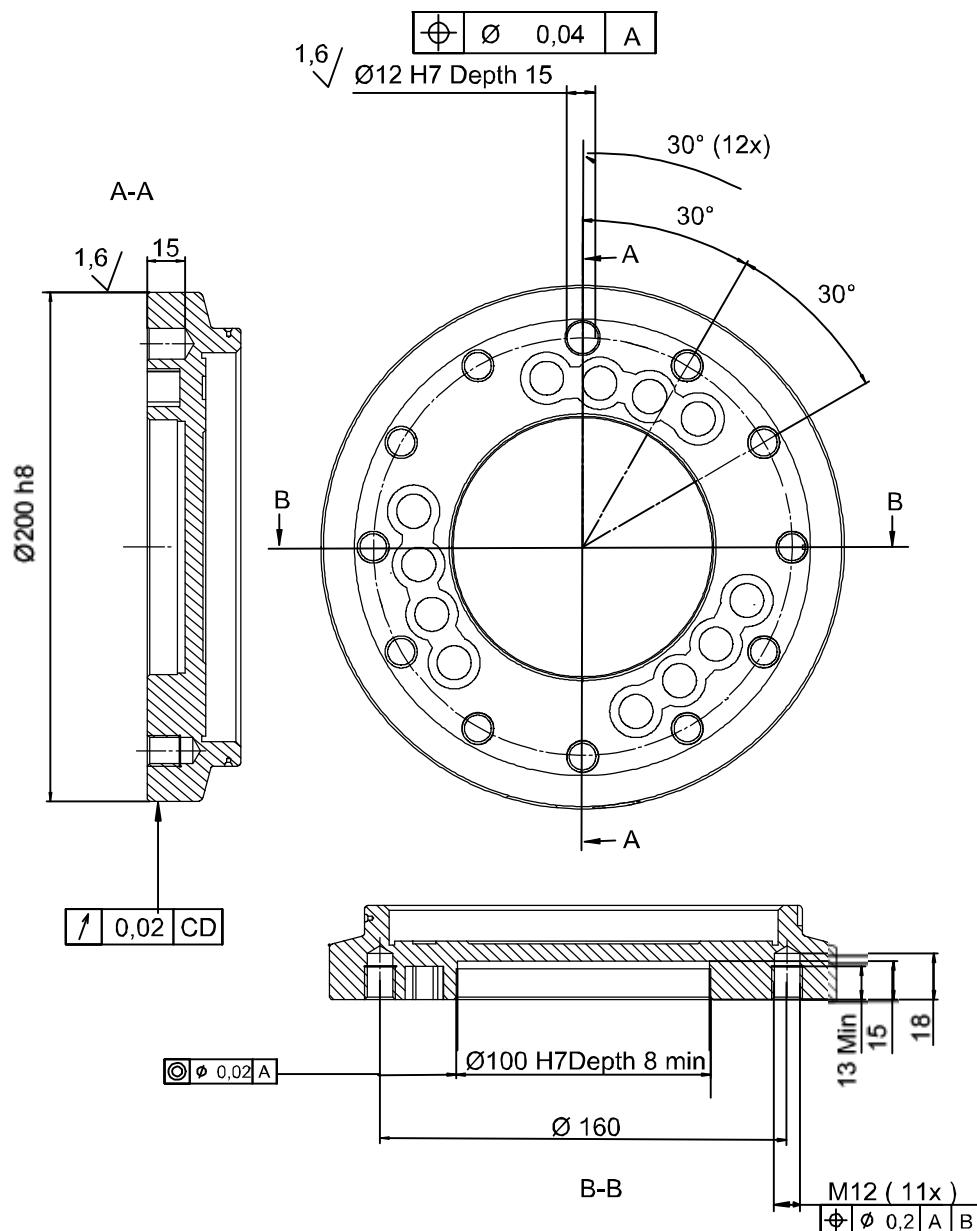


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#### Tool flange, standard

The illustration below shows the mounting holes available for fitting equipment on the turning disc.



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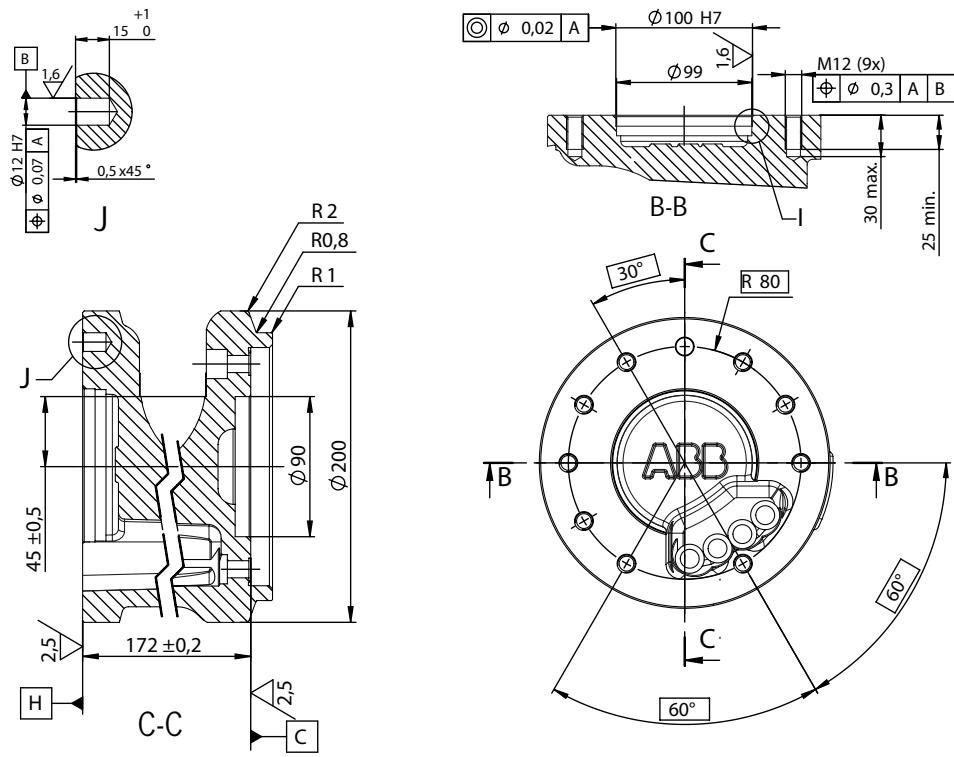
## 2 Installation and commissioning

### 2.3.8 Fitting equipment on robot

*Continued*

#### Tool flange, LeanID

The illustration below shows the tool flange for option 780-4 LeanID.



xx1600000979

#### Fastener quality

When fitting tools on the turning disk (see the figures above), only use screws with quality 12.9.

Standard screws with quality 8.8 may be used when fitting other equipment to the mounting holes.

#### **2.3.9 Installation of signal lamp (option)**

---

##### **Signal lamp**

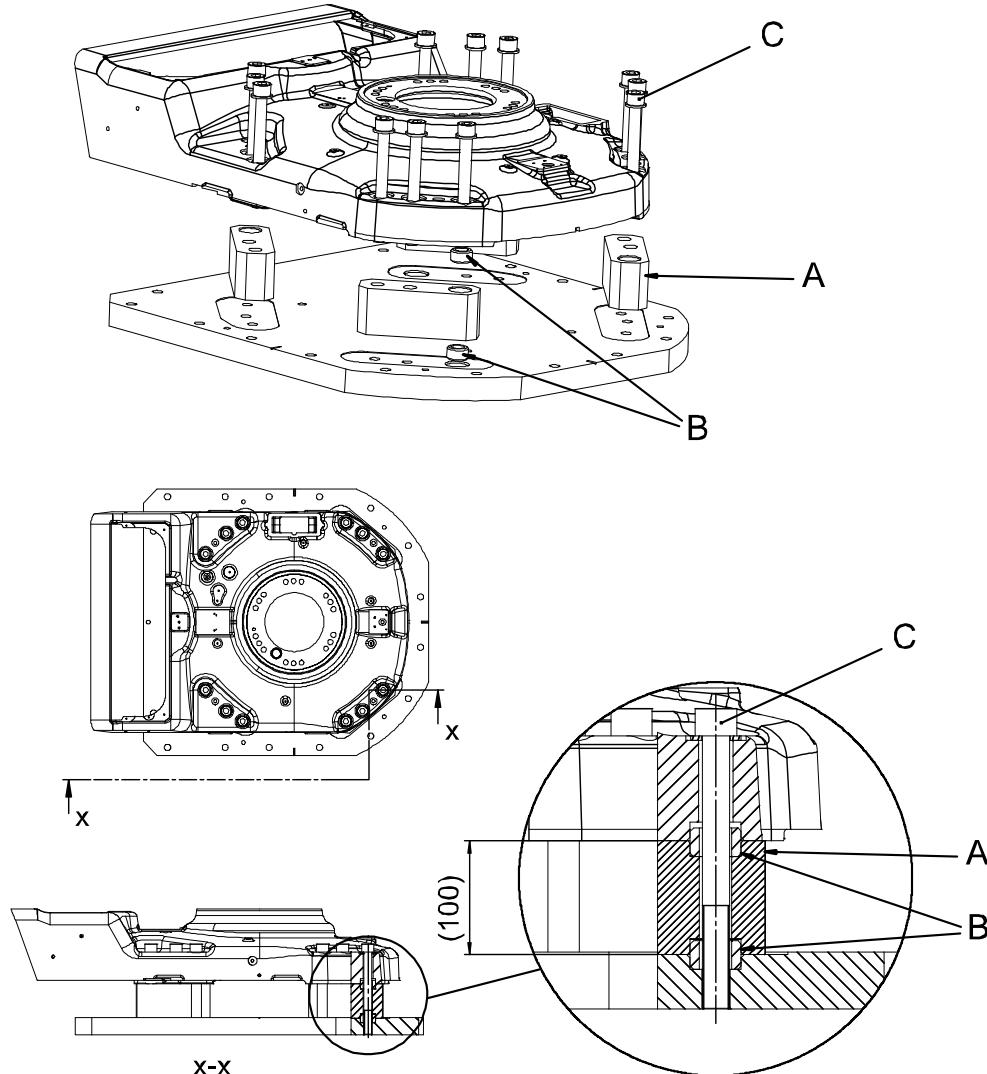
See the assembly instruction delivered with the signal lamp.

## 2 Installation and commissioning

### 2.3.10 Installation of base spacers (option)

#### 2.3.10 Installation of base spacers (option)

Illustration, installation of base spacers



xx0500001570

A	Base spacer (4 pcs)
B	Guide sleeve (4 pcs)
C	Attachment screws and washers (8 pcs)

#### Required equipment

Equipment	Art. no.	Note
Base spacers	3HAC021899-002	Includes mounting set with attachment screws and mounting instruction.
Base plate	3HAC12937-8	
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .

Continues on next page

Equipment	Art. no.	Note
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

#### Installation, base spacers

The procedure below details how to fit the base spacers between the robot and the base plate.

	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
2	Unfasten the robot from the foundation, if fastened, and lift it away with lifting slings. Make sure the robot is positioned in the most stable position; the transport position!	Detailed in section <i>Lifting robot with lifting slings on page 76</i> .
3	Install the base plate to the foundation, if not used previously.	Detailed in section <i>Securing the base plate on page 81</i> .
4	Fit the four <i>base spacers</i> and <i>guiding sleeves</i> to the base plate.	Shown in the figure <i>Illustration, installation of base spacers on page 96</i> .
5	Lift the robot with lifting slings and move it to the prepared base plate.	
6	Guide the robot with the guiding sleeves as lowering it towards the base plate and spacers.	
7	Fasten the robot base to the spacers with enclosed attachment screws and washers.	M24 x 240, tightening torque: 775 Nm.
8	 <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <i>DANGER - First test run may cause injury or damage! on page 50</i> .	

## 2 Installation and commissioning

### 2.3.11 Installation of cooling fan for motors (option)

#### General

A cooling fan can be installed on the motors of axes 1, 2 and 3.

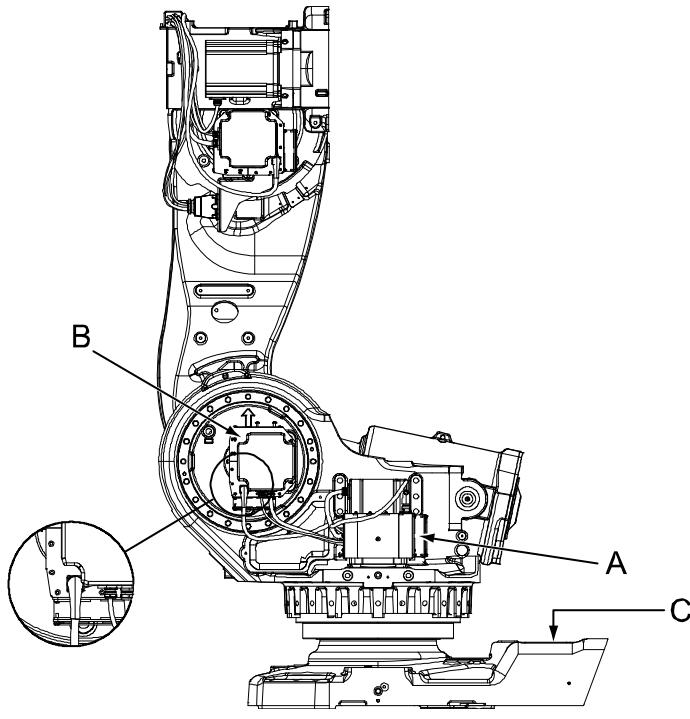
Cooling fans for axes 1 and 2 can not be combined!

The cabling for the fans is available in different design:

- complete cabling, including connections for both cooling fans and position switches, at axes 1, 2 and 3. Installation of this complete cabling is detailed in section *Installation of cable harness for position switches and fans on page 125*.
- separate cabling for axis 1 or 2, including only connections for the cooling fans on axes 1 or 2. Installation of this cabling is detailed in section *Installation, separate fan cabling axis 1 or 2 on page 104*.

#### Location of cooling fans

The fans are installed on the motors, axes 1 or 2, as shown in the figure below.



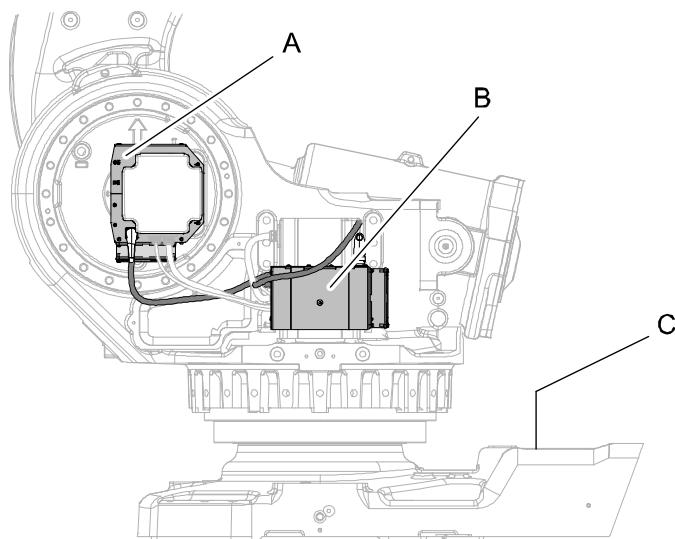
A	Cooling fan, axis 1
B	Cooling fan, axis 2
C	Rear cover plate

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## 2 Installation and commissioning

### 2.3.11 Installation of cooling fan for motors (option)

*Continued*

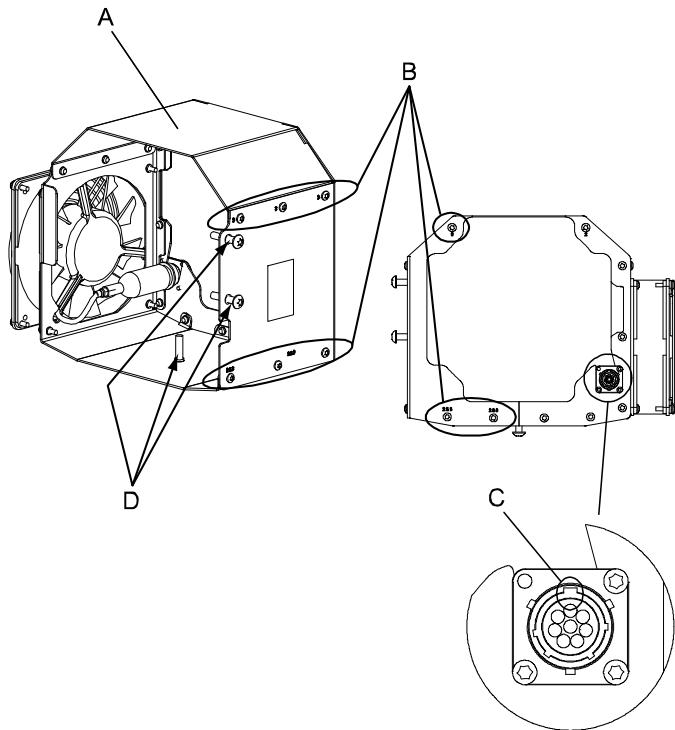


xx0700000671

A	Cooling fan, axis 2
B	Cooling fan, axis 1
C	Rear cover plate

#### Cooling fan

The details of the cooling fan are shown in the figure below.



xx0500002158

A	Fanbox
B	Attachment screws, fanbox plates (9 pcs)

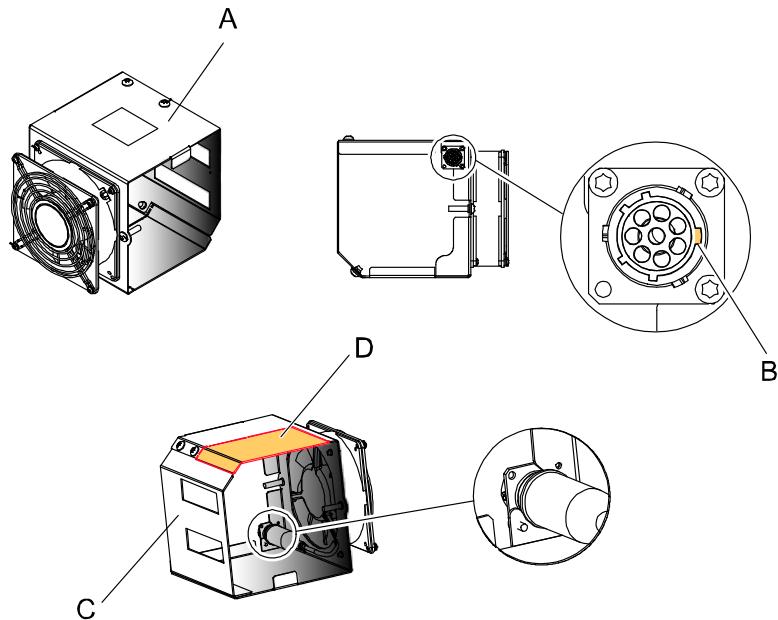
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## 2 Installation and commissioning

### 2.3.11 Installation of cooling fan for motors (option)

*Continued*

C	Groove in the connector
D	Tightening screws, fanbox (3 pcs)



xx0900000137

A	Fanbox
B	Groove in the connector
C	Back plate
D	Part of the fanbox that can be removed, if needed.

### Required equipment

Equipment	Art. no.	Note
Cooling fan	3HAC15374-1	
Cabling cooling fan, axes 1 or 2.	3HAC023599-001	Choose this cabling if equipping the robot with cooling fans on axis 1 or 2.
Plate for customer connections	3HAC025778-001	An additional connection plate must be fitted to the robot base, if not already installed. The plate is shown in the figure <a href="#">Plate for customer connections, at base on page 102</a> .
Additional cabling to and inside the controller	-	
Material set fan axes 1 and 2	3HAC023999-001	The set includes: <ul style="list-style-type: none"> <li>• fan axes 1 &amp; 2 cable harness</li> <li>• plate, customer</li> <li>• attachment screws and nuts.</li> </ul>
Cable harness inside controller	3HAC025488-001	
Locking liquid	-	Loctite 243. Used for the three tightening screws.

*Continues on next page*

## 2 Installation and commissioning

### 2.3.11 Installation of cooling fan for motors (option)

*Continued*

Equipment	Art. no.	Note
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Circuit diagram	-	See chapter <a href="#">Circuit diagram on page 441</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

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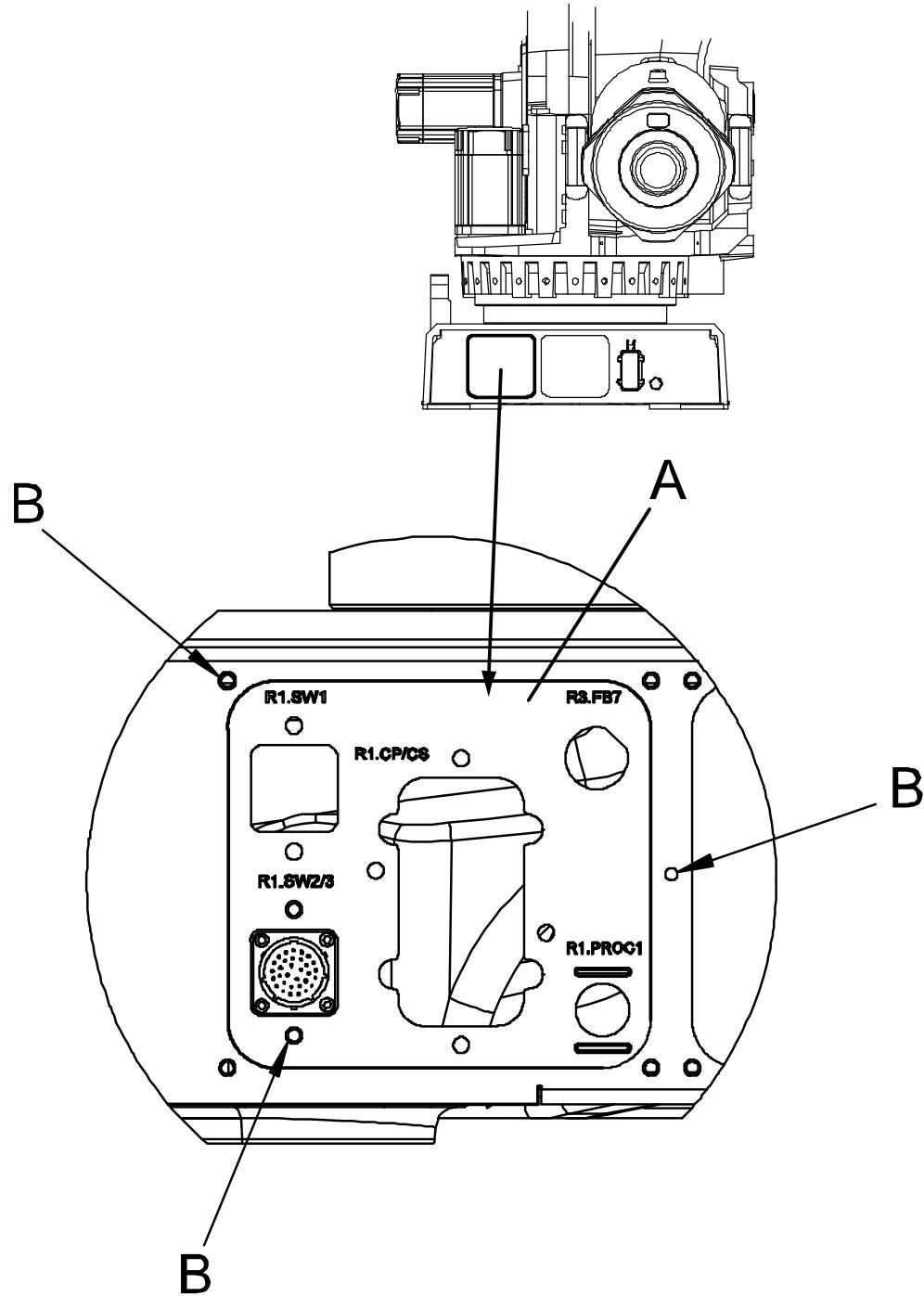
## 2 Installation and commissioning

### 2.3.11 Installation of cooling fan for motors (option)

*Continued*

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#### Plate for customer connections, at base



xx0500002301

A	Plate for customer connections
B	Attachment screws, 3 pcs, M6x16 quality 8.8-A2F

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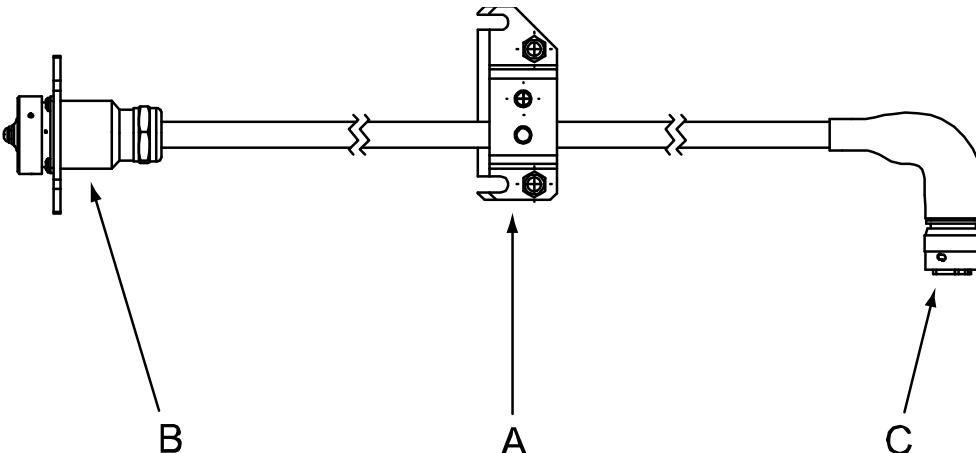
#### Installation, fan

The procedure below details how to install the cooling fan on any of the motors, axes 1-3.

Action	Note
<b>1</b>  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
<b>2</b> Prepare the fanbox for installation: <ul style="list-style-type: none"> <li>• disassemble the two parts of the box by removing the nine <i>attachment screws</i></li> <li>• loosen the three <i>tightening screws</i>, to avoid damaging the surfaces of the motor when fitting the fanbox</li> <li>• turn the connector to the correct position; axis 1: groove pointing inwards, as shown in the figure <a href="#">Cooling fan on page 99</a>. Positions for axis 2 and 3 are shown in the figure <a href="#">Location of cooling fans on page 98</a>.</li> </ul>	Shown in the figure <a href="#">Cooling fan on page 99</a> .
<b>3</b> Temporarily lift the motor cabling out of the way of the current motor to make room for the fanbox.	
<b>4</b> Fit the parts of the fanbox to the motor and reassemble with the nine <i>attachment screws</i> .	
<b>5</b> Lift the box (axis 1) so that it does not rest directly on the robot and secure the box with the three tightening screws, using locking liquid. Tighten them properly so that the box is firmly attached to the motor.	
<b>6</b> Install the cabling and make adjustments in RobotWare, as described in the following procedures.	

#### Separate cabling for axis 1 or 2

The figure below shows the cabling used only for the fan on axis 1 or 2.



xx0500002173

*Continues on next page*

## 2 Installation and commissioning

### 2.3.11 Installation of cooling fan for motors (option)

Continued

A	Cable bracket
B	Connector R1.SW2/3, connected to the robot base
C	Connector R3.FAN2, connected to the fan of axis 1 or 2

#### Installation, separate fan cabling axis 1 or 2

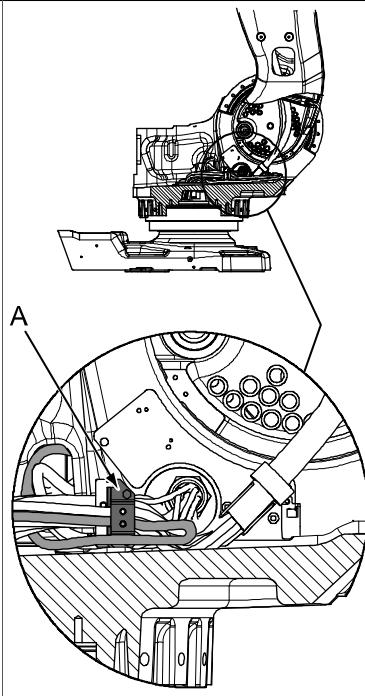
The procedure below details how to install the separate cabling for the cooling fan of axis 1 or 2.

	Action	Note
1	Move the robot to its calibration position.	This is detailed in section <a href="#">Synchronization marks and synchronization position for axes on page 398</a> .
2	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
3	Remove the <i>rear cover plate</i> from the robot base.	Shown in the figure <a href="#">Location of cooling fans on page 98</a> .
4	Remove the cable bracket (A)	Shown in the figure <a href="#">Separate cabling for axis 1 or 2 on page 103</a>
5	Fit the <i>plate for customer connections</i> , if not already fitted, to the connection plate of the robot base.	Shown in the figure <a href="#">Plate for customer connections, at base on page 102</a> . Art. no. is specified in <a href="#">Required equipment on page 100</a> .
6	Run the cabling up through the base and frame, beneath the balancing device.	

Continues on next page

### 2.3.11 Installation of cooling fan for motors (option)

*Continued*

Action	Note
7 Secure the <i>cable bracket</i> to the bracket of the robot cabling inside the frame. Run the cable underneath the robot cabling and out through the side of the frame, at motor, axis 1. The correct cable run is shown in the figure to the right!	 <b>Note</b> <p>There is a risk of the balancing device damaging the cable if it is not protected by the robot cabling!</p>  <p>xx0500002174</p> <p>A Cable bracket. Also shown in the figure <i>Separate cabling for axis 1 or 2 on page 103.</i></p>
8 Connect the connector R3.FAN2 to the fan of axis 1 or 2.	 <b>Note</b> <p>Fans on both axis 1 and 2 can not be used at the same time!</p>
9 Connect the connector R1.SW2/3 to the base of the robot. Make sure that the cabling, run through the frame and base, is not twisted and runs freely from the robot cabling.	
10 Refit the rear cover plate to the robot base.	
11 Install additional cabling to and inside the controller.  Also make adjustments in RobotWare, as described in the following procedure.	

#### Adjustments in RobotWare

Action	Note
1 Modify the settings in RobotWare to include the cooling fans.	<p>RobotWare 4.0: modify the settings in RobIn-stall. RobotWare 4.063 and older must be updated with a newer release.</p> <p>RobotWare 5.0: change the settings in the Modifying options dialogue, by using the Modify Controller System Wizard in the System Builder of RobotStudio. Read more about modifying the system in <i>Operating manual - RobotStudio</i>.</p>

## **2 Installation and commissioning**

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### **2.3.12 Installation of Foundry Plus Cable guard (option no. 908-1)**

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#### **Introduction**

How to install the Foundry Plus Cable guard is described in the instruction delivered with the cable guard.

Separate instructions for IRB 2600, 4600, 6620, 6640, 6650S, 6660 and 7600 are available in English, German, French, Spanish and Italian and can be found on the DVD delivered with the Cable guard, article number 3HAC035933-001.

### 2.3.13 Loads fitted to the robot, stopping time and braking distances

#### General

Any loads mounted on the robot must be defined correctly and carefully (with regard to the position of center of gravity and mass moments of inertia) in order to avoid jolting movements and overloading motors, gears and structure.



#### CAUTION

Incorrectly defined loads may result in operational stops or major damage to the robot.

#### References

Load diagrams, permitted extra loads (equipment) and their positions are specified in the product specification. The loads must also be defined in the software as detailed in:

- *User's guide - S4Cplus (BaseWare OS 4.0)*
- *Operating manual - IRC5 with FlexPendant*

#### Stopping time and braking distances

The performance of the motor brake depends on if there are any loads attached to the robot. For more information, see product specification for the robot.

## **2 Installation and commissioning**

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### **2.4.1 Axes with restricted working range**

## **2.4 Restricting the working range**

### **2.4.1 Axes with restricted working range**

---

#### **General**

When installing the robot, make sure that it can move freely within its entire working space. If there is a risk that it may collide with other objects, its working space should be limited.

The working range of the following axes may be restricted:

- Axis 1, hardware (mechanical stop) and software (signal from adjustable position switch)
- Axis 2, hardware (mechanical stop) and software (signal from adjustable position switch)
- Axis 3, hardware (mechanical stop) and software (signal from adjustable position switch)

This section describes how to install hardware that restricts the working range.



#### **Note**

Adjustments must also be made in the robot configuration software (system parameters). References to relevant manuals are included in the installation procedures.

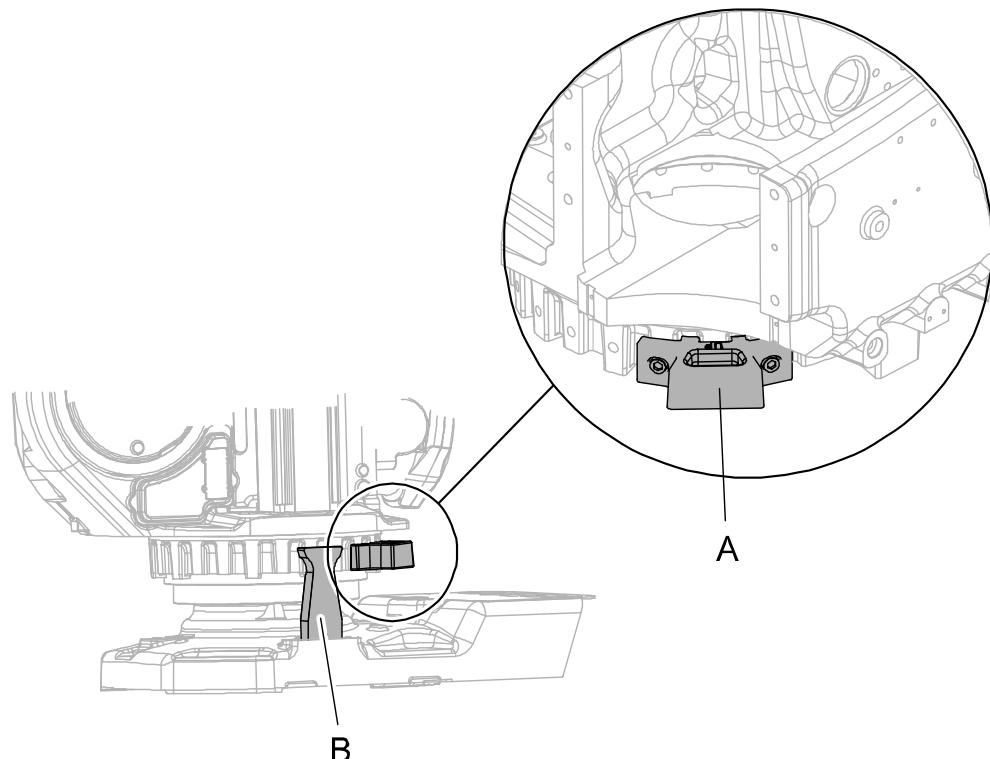
## 2.4.2 Mechanically restricting the working range of axis 1

### General

The working range of axis 1 is limited by fixed mechanical stops and adjustment of the system parameter configuration. The working range can be reduced by adding additional mechanical stops giving 7.5 or 15 graduation, between 22.5° and 135° in both directions.

### Mechanical stops, axis 1

The illustration shows the mounting position of the stop pin and one of the additional mechanical stops available for axis 1.



xx0300000049

A	Additional mechanical stop
B	Stop pin

### Required equipment

Equipment, etc.	Article number	Note
Mechanical stop for axis 1, 7.5°	3HAC11076-1	Includes attachment screws and an assembly drawing.
Mechanical stop for axis 1, 15°	3HAC11076-2	Includes attachment screws and an assembly drawing.
Standard toolkit	-	

*Continues on next page*

## 2 Installation and commissioning

### 2.4.2 Mechanically restricting the working range of axis 1

Continued

Equipment, etc.	Article number	Note
<i>User's guide - S4Cplus (BaseWare OS 4.0) (BaseWare 4.0)</i> <i>Technical reference manual - System parameters</i>	-	Article number is specified in section <a href="#">References on page 10</a> .

#### Installation, mechanical stops axis 1

Use this procedure to fit the additional mechanical stops to axis 1 of the robot. An assembly drawing is also enclosed with the product.

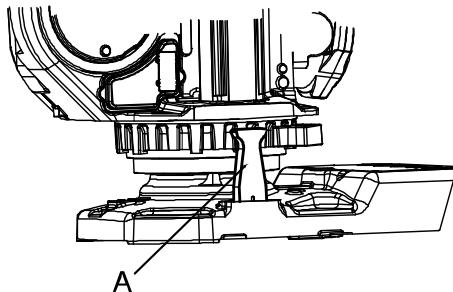
	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2	Fit the additional mechanical stop to the frame according to the figure <a href="#">Mechanical stops, axis 1 on page 109</a> .	Tightening torque: 120 Nm.
3	Adjust the software working range limitations (system parameter configuration) to correspond to the mechanical limitations.	How to define the range of movement in RobotWare 4.0 is detailed in <i>User's guide - S4Cplus (BaseWare OS 4.0)</i> , chapter <i>System Parameters - topic Manipulator</i> . The system parameters that must be changed ( <i>Upper joint bound</i> and <i>Lower joint bound</i> ) are described in <i>Technical reference manual - System parameters</i> .
4	 <b>WARNING</b> If the mechanical stop pin is deformed after a hard collision, it must be replaced! Deformed <i>movable stops</i> and/or <i>additional stops</i> as well as deformed <i>attachment screws</i> must also be replaced after a hard collision.	

## 2.4.3 Extended working range, axis 1 (option 561-1)

**2.4.3 Extended working range, axis 1 (option 561-1)****Overview**

The working range of axis 1 can be increased from standard range to extended  $\pm 220^\circ$ .

**Extending the working range**

	Action	Note/Illustration
1	Remove the mechanical stop pin from axis 1 (A).	 xx0400001034
2	Option 561-1 requires installation of option 810-1 <i>Electronic Position Switches</i> . Configure Electronic Position Switches.	See <i>Application manual - Electronic Position Switches</i> .
3	Option 561-1 requires installation of option 25-3 <i>Position switches axis 1</i> . Install position switches at axis 1.	See <i>Installation of position switches (option) on page 117</i> .
4	Redefine the software working range limitations in the system parameters, topic <i>Motion</i> . The Arm parameters <i>Upper Joint Bound</i> and <i>Lower Joint Bound</i> must be changed to 3.84 respectively -3.84. The values are in radians, that is 3.84 radians = 220 degrees.	How to define the range of movement in RobotWare 4.0 is detailed in <i>User's guide - S4Cplus (BaseWare OS 4.0)</i> , chapter <i>System Parameters - topic Manipulator</i> . The system parameters that must be changed ( <i>Upper joint bound</i> and <i>Lower joint bound</i> ) are described in <i>Technical reference manual - System parameters</i> .

## 2 Installation and commissioning

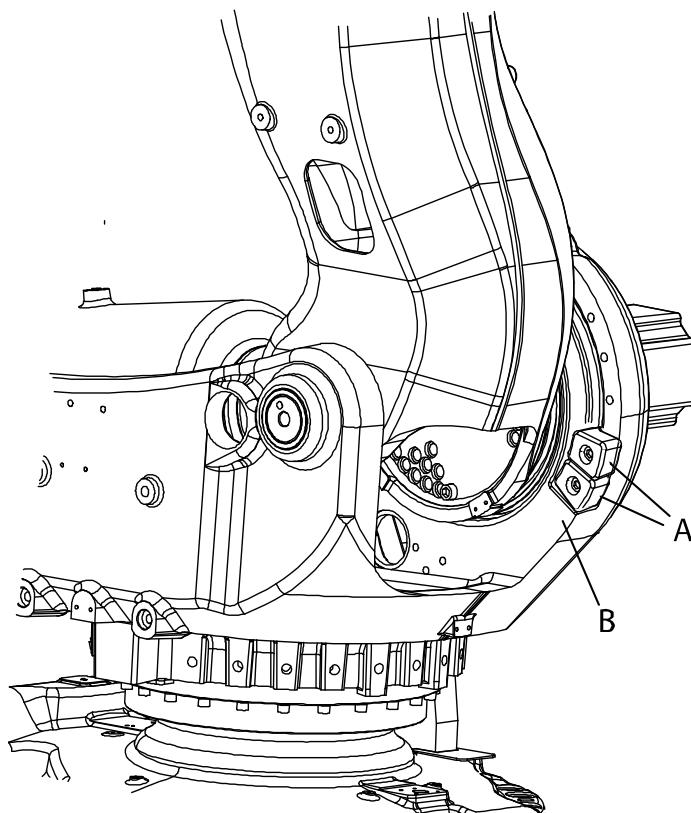
### 2.4.4 Mechanically restricting the working range of axis 2

#### General

The working range of axis 2 is limited by fixed mechanical stops and can be reduced by adding up to six additional mechanical stops with 15 graduation in respective direction.

#### Mechanical stops, axis 2

The illustration shows the mounting position of the mechanical stops on axis 2.



xx0300000047

A	Additional mechanical stops
B	Fixed mechanical stop

#### Required equipment

Equipment, etc.	Art. no.	Note
Mechanical stop set, axis 2	3HAC13787-1	Includes six stops, attachment screws, washers and assembly drawings.
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
<i>User's guide - S4Cplus (BaseWare OS 4.0) (Robot-Ware 4.0)</i> <i>Technical reference manual - System parameters</i>	-	Art. no. is specified in section <a href="#">References on page 10</a> .

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#### Installation, mechanical stops axis 2

Use the procedure to fit the mechanical stops for axis 2 to the robot. An assembly drawing is also enclosed with the product.

	Action	Note
1	 <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2	Fit and tighten the additional stops in a row, starting from the fixed stop.	Tightening torque: 115 Nm. Shown in the figure <a href="#">Mechanical stops, axis 2 on page 112</a> .
3	The software working range limitations must be redefined to correspond to the changes in the mechanical limitations of the working range.	How to define the range of movement in RobotWare 4.0 is detailed in <i>User's guide - S4Cplus (BaseWare OS 4.0)</i> , chapter <i>System Parameters</i> - topic <i>Manipulator</i> .  The system parameters that must be changed ( <i>Upper joint bound</i> and <i>Lower joint bound</i> ) are described in <i>Technical reference manual - System parameters</i> .
4	 <b>WARNING</b>  If the <i>mechanical stop pin</i> is deformed after a hard collision, it must be replaced! Deformed <i>movable stops</i> and/or <i>additional stops</i> as well as deformed <i>attachment screws</i> must also be replaced after a hard collision.	

## 2 Installation and commissioning

### 2.4.5 Mechanically restricting the working range of axis 3

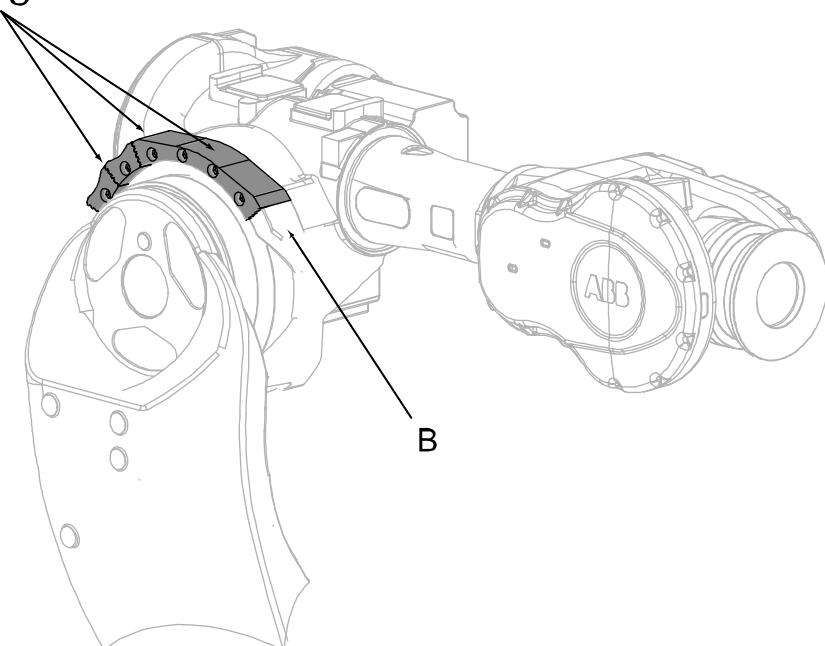
#### General

The working range of axis 3 is limited by fixed mechanical stops and can be reduced by adding additional mechanical stops with 20 graduation in respective direction.

#### Mechanical stops, axis 3

The illustration shows the mounting position of the mechanical stops on axis 3.  
The figure shows IRB 7600 but the principle is the same.

A, C



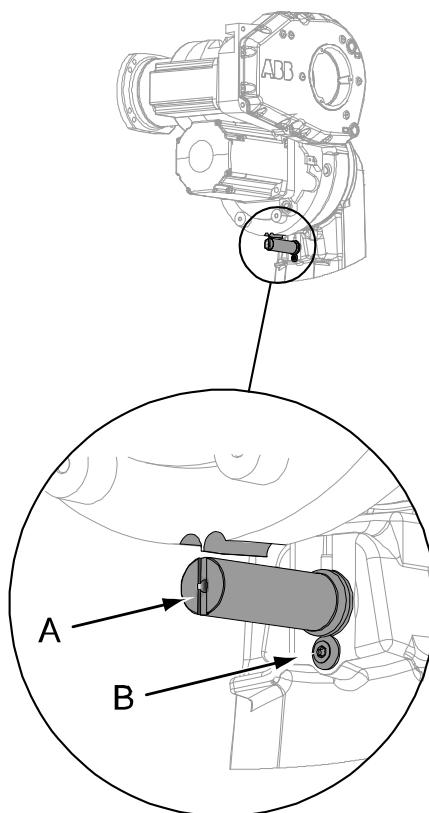
xx0300000048

A	Additional mechanical stops
B	Fixed mechanical stop
C	Attachment screw M16x60 quality 12.9

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### 2.4.5 Mechanically restricting the working range of axis 3

*Continued*



xx0600002973

A	Mechanical stop pin, axis 3
B	Attachment screw and washer

#### Required equipment

Equipment, etc.	Art. no.	Note
Mechanical stop set, axis 3	3HAC13128-1	Includes: <ul style="list-style-type: none"><li>• six stops, one with 80° restriction, 3HAC12708-3 (use when limitation angle &gt;=80), and five with 20°, 3HAC12708-1.</li><li>• attachment screws.</li></ul>
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
<i>User's guide - S4Cplus (Base-Ware OS 4.0) (RobotWare 4.0)</i> <i>Technical reference manual - System parameters</i>	-	Art. no. is specified in section <a href="#">References on page 10</a> .

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## 2 Installation and commissioning

### 2.4.5 Mechanically restricting the working range of axis 3

Continued

#### Installation, mechanical stops axis 3

Use the procedure to fit the mechanical stops for axis 3 to the robot. An assembly drawing is also enclosed with the product.

Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2 Fit and tighten the additional stops in a row, starting from the fixed stop.	Tightening torque: 115 Nm. Shown in the figure <a href="#">Mechanical stops, axis 3 on page 114</a>
3  <b>Note</b> The software working range limitations (system parameters) must be redefined to correspond to the changes in the mechanical limitations of the working range.	How to define the range of movement in RobotWare 4.0 is detailed in <i>User's guide - S4Cplus (BaseWare OS 4.0)</i> , chapter <i>System Parameters - topic Manipulator</i> . The system parameters that must be changed ( <i>Upper joint bound</i> and <i>Lower joint bound</i> ) are described in <i>Technical reference manual - System parameters</i> .
4  <b>WARNING</b> If the <i>mechanical stop pin</i> is deformed after a hard collision, it must be replaced! Deformed <i>movable stops</i> and/or <i>additional stops</i> as well as deformed <i>attachment screws</i> must also be replaced after a hard collision.	

#### 2.4.6 Installation of position switches (option)

##### General

Position switches can be installed on axes 1-3. The position switches include cams as shown in the figures below. The system parameter configuration must also be updated.

The position switch kits may be delivered in one of two ways:

- Fitted by ABB Robotics on delivery. In this case, the cams must still be fitted and locked by the user. For axis 1, the cover for the cams must also be fitted.
- As kits to be completely fitted to the robot and adjusted by the user.

##### Required equipment

Description	Art. no.	Note
Position switch, axis 1	3HAC15715-1	Includes position switch and plate for customer connections.
Position switch, axis 2	3HAC021884-001	Includes only the position switch.
Position switch, axis 3	3HAC16417-2	Includes only the position switch.
Cabling, position switches and cooling fans, axes 1, 2 and 3	3HAC16659-1	Cabling to be installed on the robot.
Attachment plate for axis-2 switch	3HAC020113-001	See <a href="#">Illustration, attachment plate for axis-2 switch on page 123</a> .
Plate for customer connections	3HAC025778-001	An additional connection plate must be fitted to the robot base, if not already installed. The plate is shown in the figure <a href="#">Plate for customer connections, at base on page 124</a> .
Additional cabling to and inside the controller	-	Specified in section <a href="#">Robot cabling and connection points on page 129</a> .
Connector kit R1.SW1	3HAC17252-1	
Connector kit R1.SW2/3	3HAC17253-1	

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## 2 Installation and commissioning

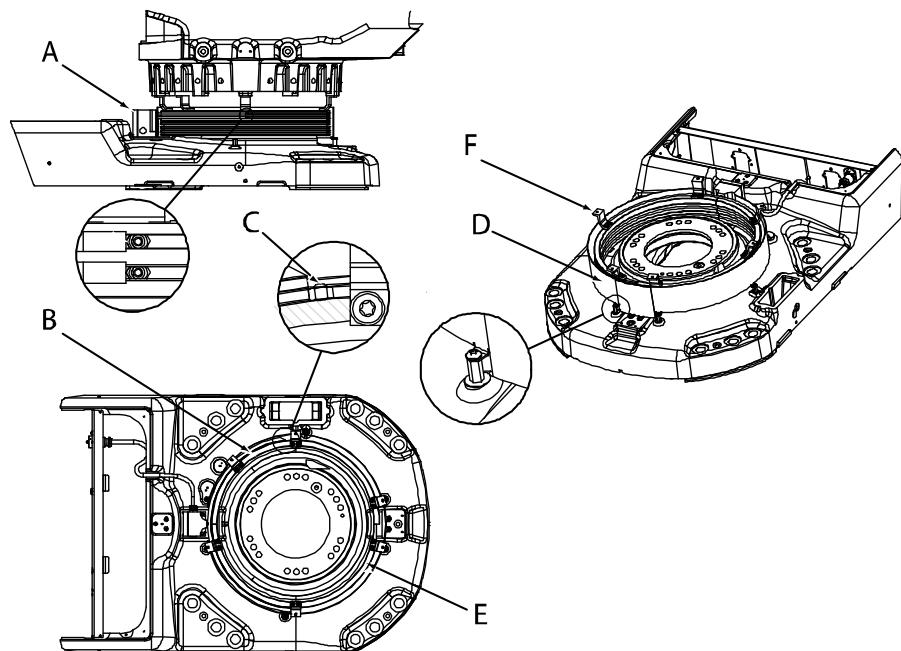
### 2.4.6 Installation of position switches (option)

*Continued*

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#### Axis 1

The illustration below shows the position switch for axis 1. There is no extra cabling installed on the robot, as for axes 2 and 3. Instead the switch is connected directly to the connector in the base, R1.SW1.



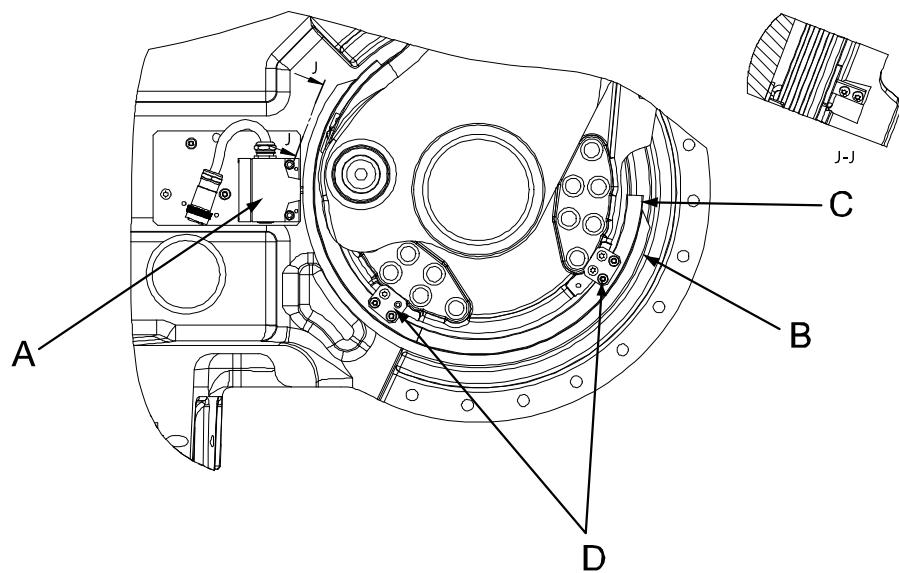
xx0100000158

A	Position switch, axis 1
B	Cam
C	Set screw, cam (cam stop)
D	Protection sheet
E	Rail
F	Rail attachment

*Continues on next page*

#### Axis 2

The illustration below shows the position switch for axis 2. In addition to the shown components, cabling must also be installed from the switch to the robot base.



xx0400001038

A	Position switch, axis 2
B	Cam
C	Rail
D	Rail attachment

*Continues on next page*

## 2 Installation and commissioning

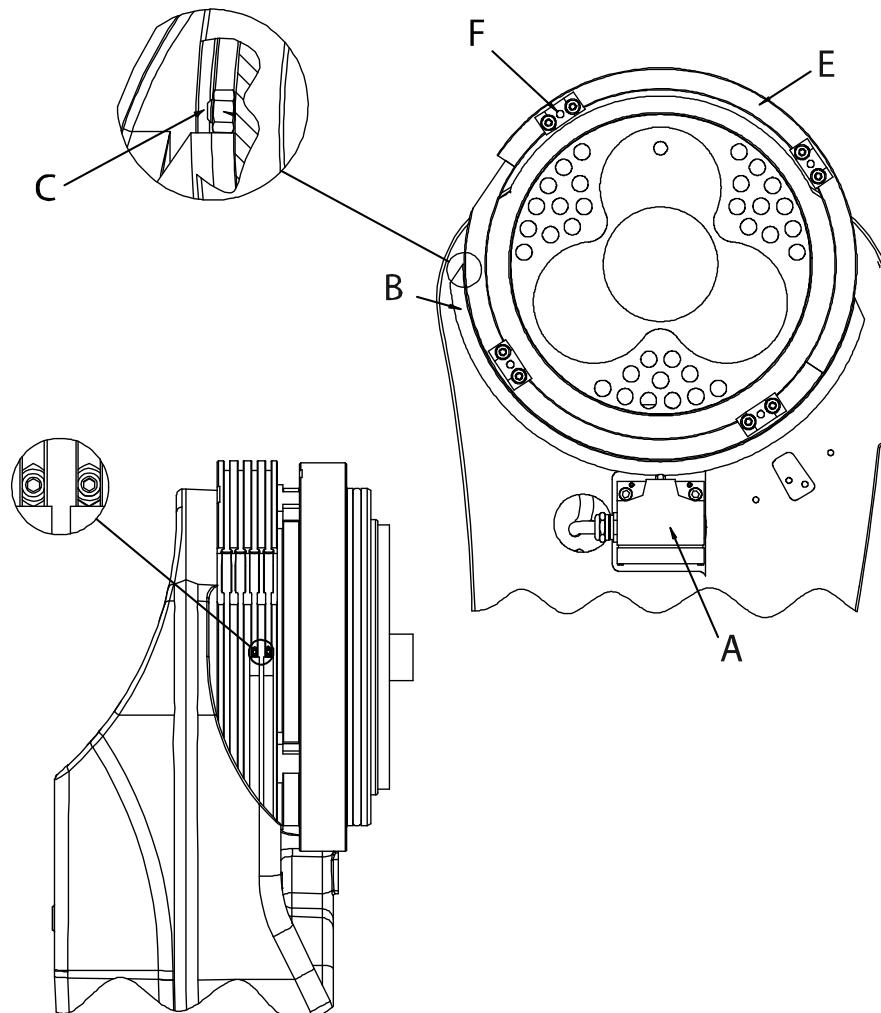
### 2.4.6 Installation of position switches (option)

*Continued*

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#### Axis 3

The illustration below shows the position switch for axis 3. In addition to the shown components, cabling must also be installed from the switch to the robot base.



xx0100000160

A	Position switch, axis 3
B	Cam
C	Set screw, cam (cam stop)
E	Rail
F	Rail attachment

---

#### Specifications

Maximum voltage/current for the position switches:

Parameter	Value
Voltage	Max. 50 VDC
Current	Max. 1 A

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#### Connections

The position switches are connected to different points on the robot system:

- XT8, screw terminal in the controller cabinet when position switch cables are used.
- R1.SW1 at the robot base. Customer connection kit is recommended, art. no. is specified in [Required equipment on page 117!](#)
- R1.SW2/3 at the robot base. Customer connection kit is recommended, art. no. is specified in [Required equipment on page 117!](#)

Further information about the cables and connection points, see section [Robot cabling and connection points on page 129](#).

#### Installation of position switch, axis 2

	Action
1	Remove the cable protection from the lower arm.
2	Fit the rail by pushing it against the support surface on the lower arm and tightening the two screws.
3	Fit the cam and the position switch unit.
4	Refit the cable protection to the lower arm with two screws.
5	Adjust the software working range limitations (system parameter configuration) to correspond to the mechanical limitations. The system parameters that must be changed ( <i>Upper joint bound</i> and <i>Lower joint bound</i> ) are described in <a href="#">Technical reference manual - System parameters</a> .

#### Fitting and adjusting cams and stops

The instruction below details how to fit and adjust the parts of the position switches:

	Action	Note
1	Cut the cam to a suitable length.	Use a sharp knife and rubber hammer or similar.
2	Cut the edge of the cam edge to max 30°!	Shown in <a href="#">Illustration, cutting the cam on page 122</a> . If the angle is larger, this may damage the position switch!
3	Cut the part of the cam running in the profile to 90°! Also see <a href="#">Illustration, cutting the cam on page 122</a> below!	
4	Make sure the ends of the profile are chamfered to enable the cam to run through the profile.	
5	Fit the cam with the M5 screw and nut. Tighten the M5 screw to secure the cam.	Shown in <a href="#">Illustration, adjust and secure cams on page 122</a> .
6	Install the cabling for axes 2 and/or 3.	Detailed in section <a href="#">Installation of cable harness for position switches and fans on page 125</a> .

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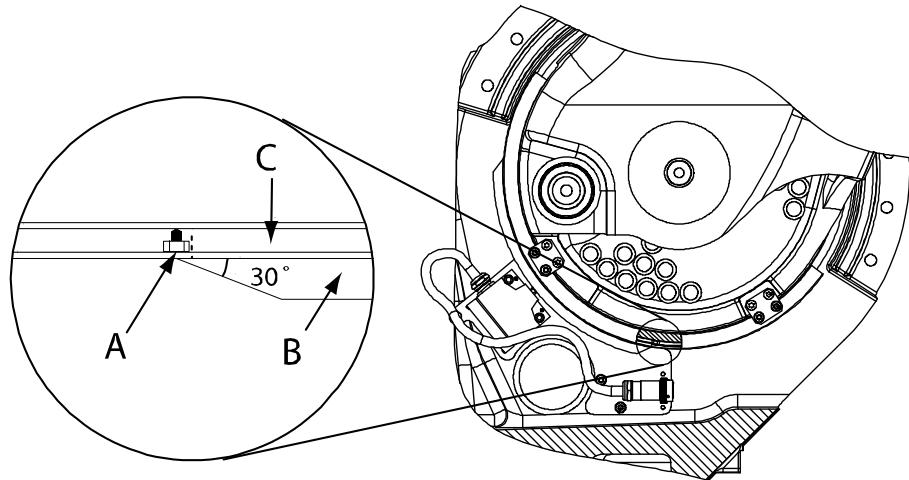
## 2 Installation and commissioning

### 2.4.6 Installation of position switches (option)

*Continued*

#### Illustration, adjust and secure cams

The illustration below show how to adjust and secure the position switch cams and profiles.

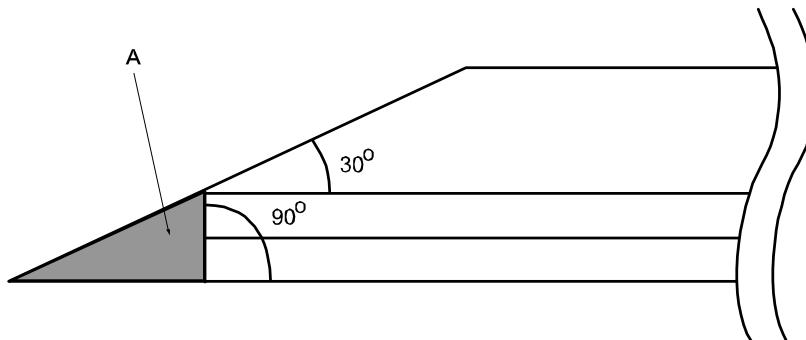


xx0100000113

A	Cam stop, M5 nut and M5 x 6 set screw
B	Adjustable cam
C	Profile

#### Illustration, cutting the cam

The illustration below show how to cut the position switch cam.



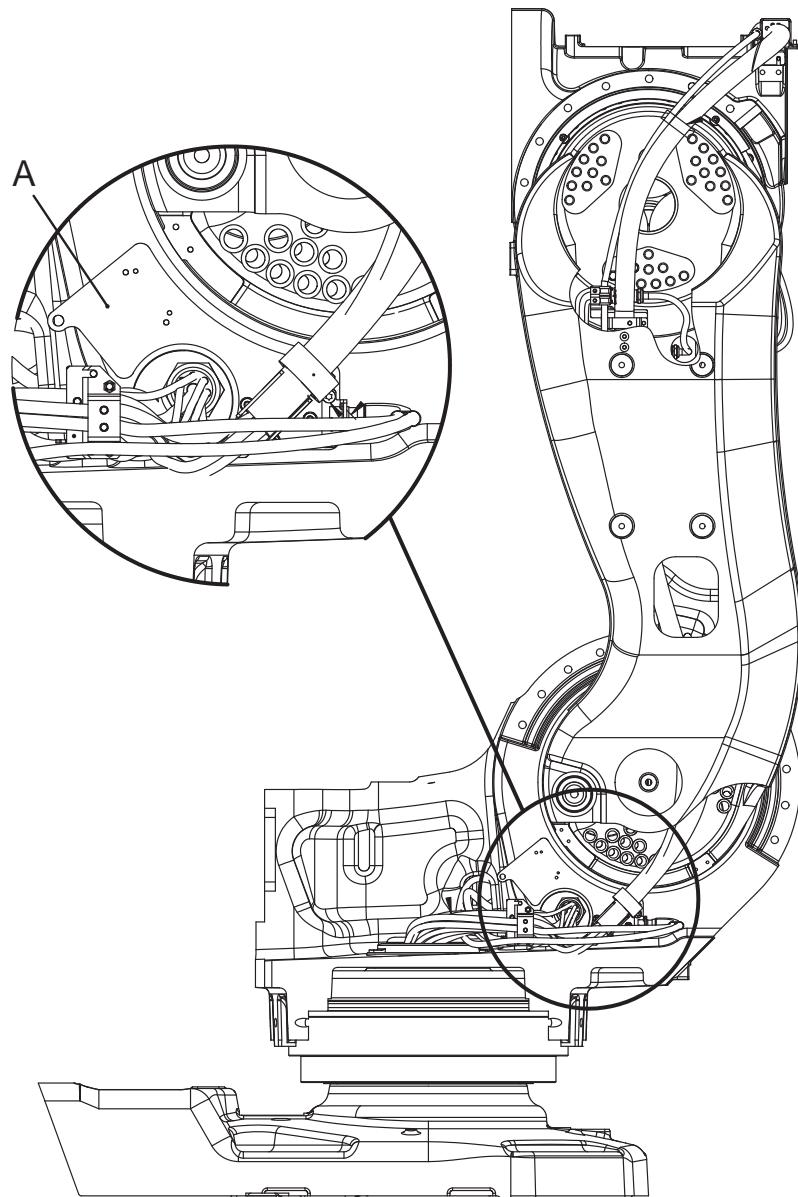
xx0100000114

A	Remove the gray section
---	-------------------------

*Continues on next page*

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#### Illustration, attachment plate for axis-2 switch



xx1200000523

*Continues on next page*

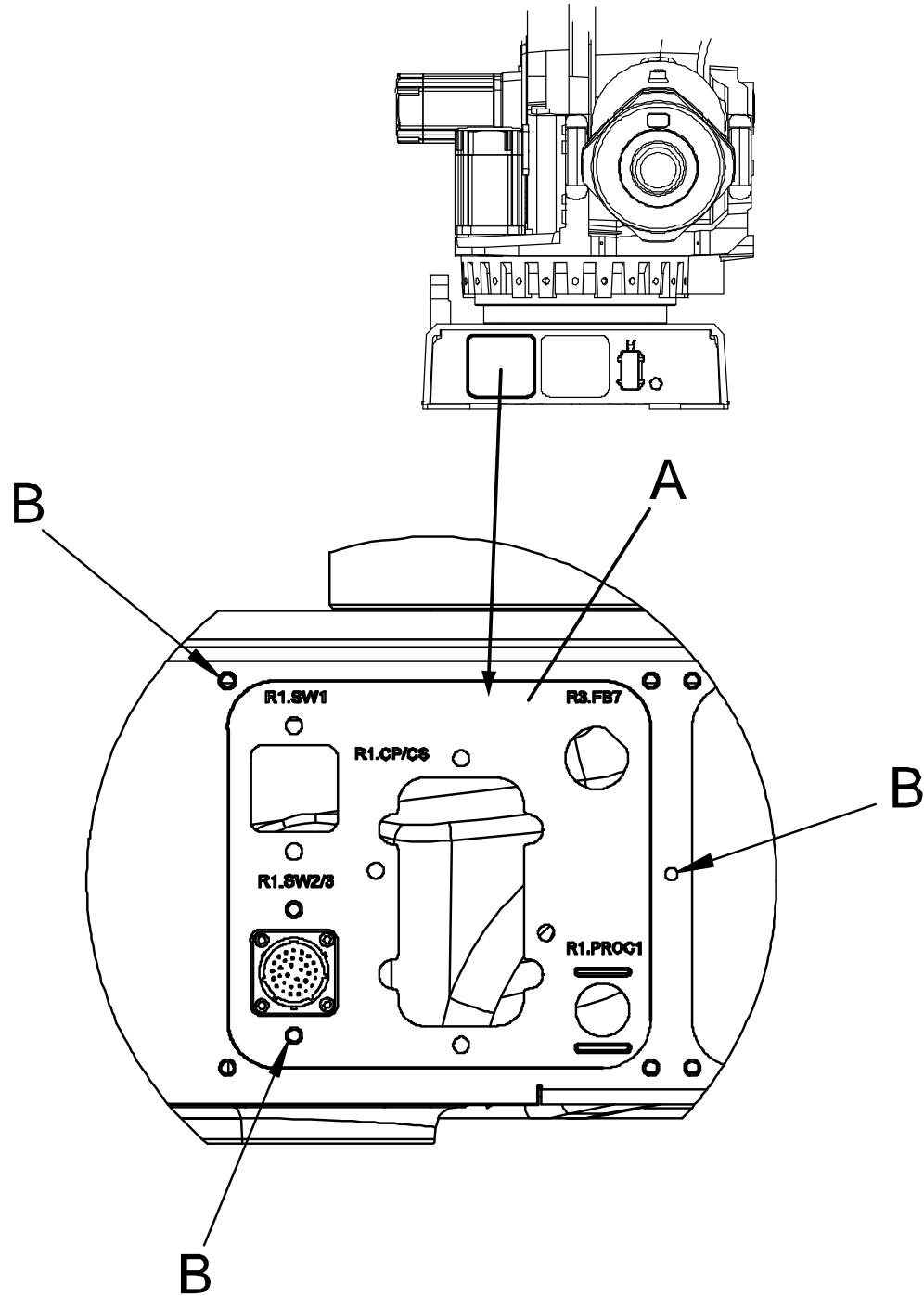
## 2 Installation and commissioning

### 2.4.6 Installation of position switches (option)

*Continued*

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#### Plate for customer connections, at base

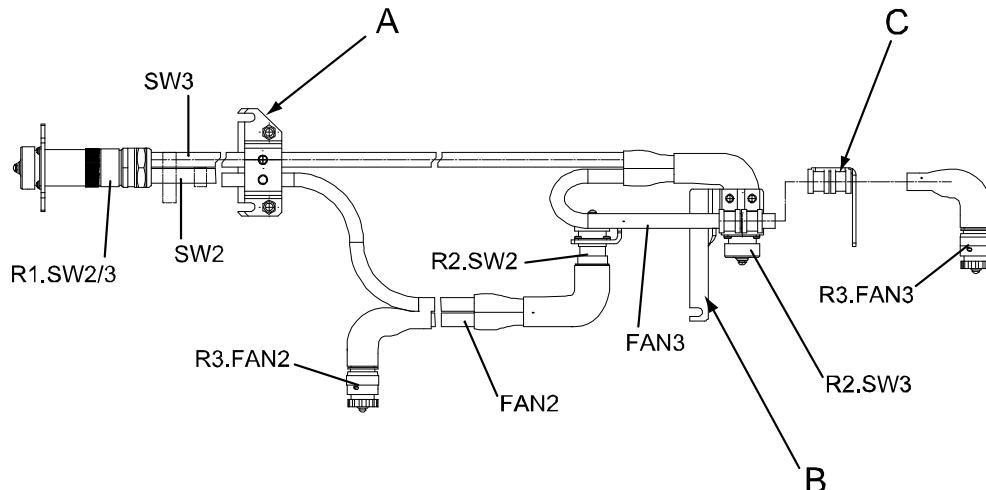


xx0500002301

A	Plate for customer connections
B	Attachment screws, 3 pcs, M6x16

*Continues on next page*

#### Cable harness for position switches and fans, axes 1-3



xx0500002305

A	Cable bracket, frame
B	Cable bracket, lower arm
C	Cable bracket, upper arm
R1.SW2/3	Connected to the robot base
R3.FAN2	Connected to the fan of axis 1 or 2
R3.FAN3	Connected to the fan of axis 3
R2.SW2	Connected to the position switch of axis 2
R2.SW3	Connected to the position switch of axis 3

#### Installation of cable harness for position switches and fans

The procedure below details how to fit the complete cable harness for position switches and cooling fans to the robot.

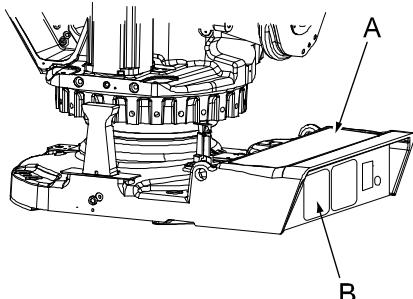
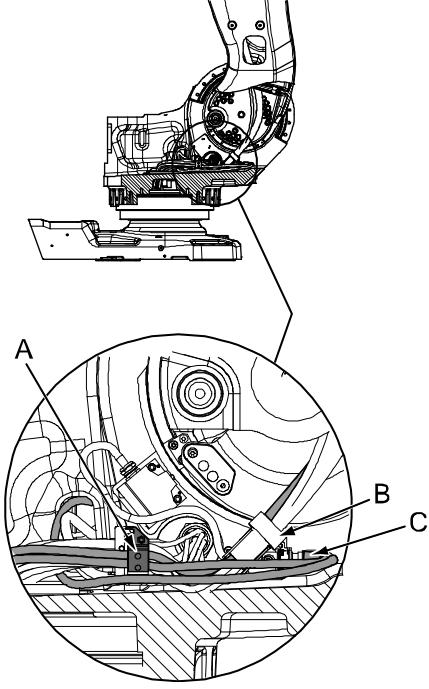
	Action	Note
1	Move the robot to its calibration position.	
2	<p> <b>DANGER</b></p> <p>Turn off all:</p> <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> <p>Before entering the robot working area.</p>	

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## 2 Installation and commissioning

### 2.4.6 Installation of position switches (option)

*Continued*

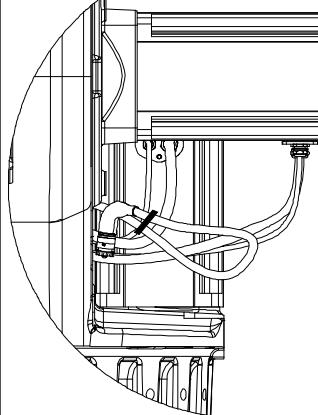
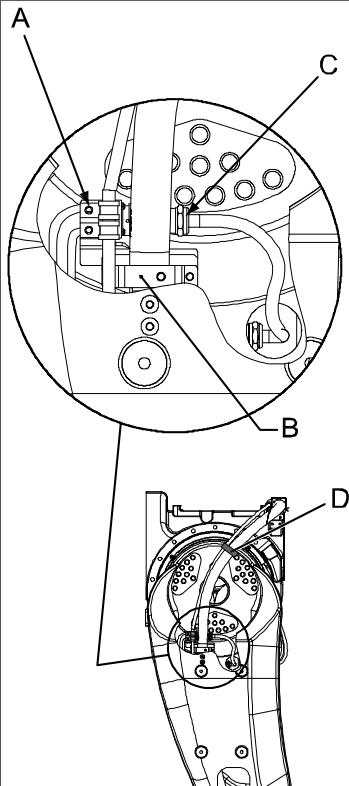
Action	Note
3 Remove the rear cover (A) from the robot base and replace the protection (B) with a plate for customer connections (if not already mounted).	 xx0500002306 Art. no. for the plate is specified in <a href="#">Required equipment on page 117</a> .
4 Run the cabling through the base and frame of the robot, up beneath the balancing device.	
5 Run and secure the cabling inside the frame as detailed below and as shown in the figure to the right: <ul style="list-style-type: none"> <li>• Secure the cable bracket (A) to the bracket of the robot cabling.</li> <li>• Run the cable for the fan of axis 1 or 2 under the robot cabling and through the side of the frame at motor axis 1.</li> <li>• Secure the cabling going up to the axis 3 fan and position switch with existing velcro strap (B), attached around the robot cabling.</li> <li>• Connect the connector R2.SW2 to the position switch of axis 2.</li> </ul> <p> <b>Note</b></p> <p>There is a risk of the balancing device damaging the fan cable if it is not protected by correct routing underneath the robot cabling!</p>	 xx0500002309 <ul style="list-style-type: none"> <li>A Cable bracket, frame. Also shown in the figure <a href="#">Cable harness for position switches and fans, axes 1-3 on page 125</a>.</li> <li>B Velcro strap</li> <li>C Connector R2.SW2</li> </ul>

*Continues on next page*

## 2 Installation and commissioning

### 2.4.6 Installation of position switches (option)

*Continued*

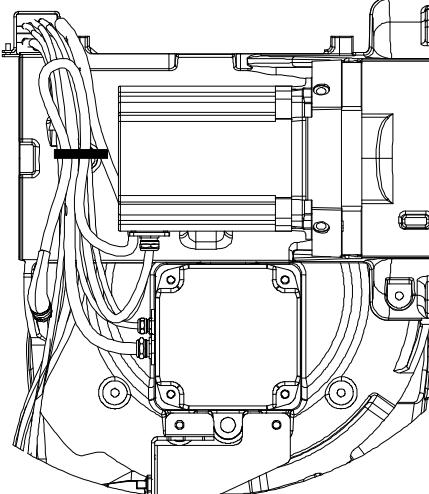
Action	Note
6 Connect the connector R3.FAN2 to the fan of either axis 1 or axis 2. If no fan is used, strap the cabling together with the motor cabling so that the connector stays close to the frame, as shown in the figure to the right.	 xx0500002312
7 Run the remaining cable harness up through the lower arm and: <ul style="list-style-type: none"> <li>secure with the <i>bracket, lower arm</i>, as shown in the figure to the right.</li> <li>connect the connector R2.SW3 to the position switch of axis 3.</li> <li>secure the cable going to the fan of axis 3, together with the robot cabling with a velcro strap.</li> </ul>	 xx0500002313 <p>A Bracket, lower arm. Also shown in the figure <a href="#">Cable harness for position switches and fans, axes 1-3 on page 125</a>.  B Bracket for robot cabling  C Connector R2.SW3  D Velcro strap</p>
8 Secure the axis 3 fan cable with the <i>bracket, upper arm</i> .	Shown in the figure <a href="#">Cable harness for position switches and fans, axes 1-3 on page 125</a> .

*Continues on next page*

## 2 Installation and commissioning

### 2.4.6 Installation of position switches (option)

*Continued*

Action	Note
9 Connect the connector R3.FAN3 to the fan of axis 3. If no fan is used, strap the cable together with the robot cabling.	 xx0500002314
10 Connect the connector R1.SW2/3 to the base of the robot. Make sure that the cabling, run through the base, frame and lower arm, is not twisted and is running free from the robot cabling.	
11 Refit the rear cover to the robot base.	
12 Install additional cabling to and inside the control cabinet.	Cabling is specified in section: • <i>Position switch cables, robot base to controller (option) on page 130</i>

## 2.5 Electrical connections

### 2.5.1 Robot cabling and connection points

#### Introduction

Connect the robot and controller to each other after securing them to the foundation. The lists below specify which cables to use for each respective application.

#### Main cable categories

All cables between the robot and controller are divided into the following categories:

Cable category	Description
Robot cables	Handles power supply to and control of the robot's motors as well as feedback from the serial measurement board. Specified in the table <a href="#">Robot cables on page 129</a> .
Position switch cables (option) Also includes fan cables.	Handles supply to and feedback from any position switch on the robot. Also handles supply to and feedback from cooling fans. Specified in the table <a href="#">Position switch cables, robot base to controller (option) on page 130</a> .
Fan cables (option)	Handles supply to and feedback from any cooling fan on the robot. Specified in the table <a href="#">Fan cables (option) on page 131</a> .
Customer cables (option)	Handles communication with equipment fitted on the robot by the customer, low voltage signals and high voltage power supply + protective ground. The customer cables also handle databus communication. See the product manual for the controller, see document number in <a href="#">References on page 10</a> .
External axes cables (option)	Handles power supply to and control of the external axes' motors as well as feedback from the servo system. See the <a href="#">Application manual - Additional axes and stand alone controller (M2004)</a> or <a href="#">Application manual - External axes (M2000)</a> , see document number in <a href="#">References on page 10</a> .

#### Robot cables

These cables are included in the standard delivery. They are completely pre-manufactured and ready to plug in.

Cable sub-category	Description	Connection point, cabinet	Connection point, robot
Robot cable, power	Transfers drive power from the drive units in the control cabinet to the robot motors.	XS1	R1.MP
Robot cable, signals	Transfers resolver data from and power supply to the serial measurement board.	XS2	R1.SMB

*Continues on next page*

## 2 Installation and commissioning

### 2.5.1 Robot cabling and connection points

*Continued*

#### Robot cable, power

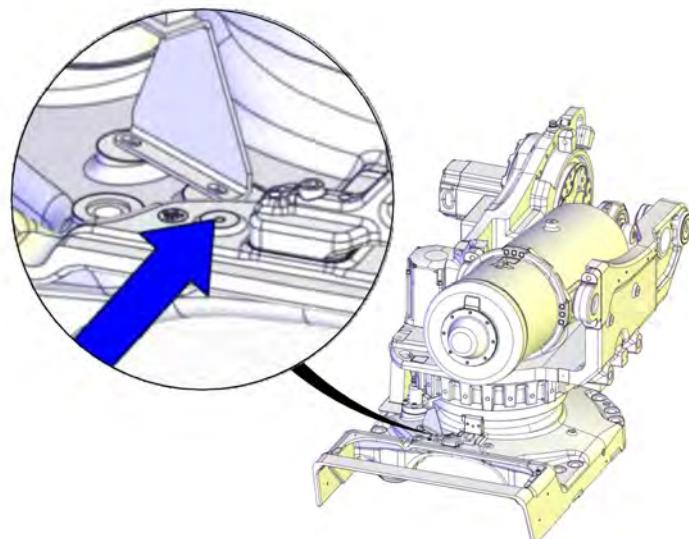
Cable	Art. no.
Robot cable, power: 7 m	3HAC026787-001
Robot cable, power: 15 m	3HAC026787-002
Robot cable, power: 22 m	3HAC026787-003
Robot cable, power: 30 m	3HAC026787-004

#### Robot cable, signals

Cable	Art. no.
Robot cable signal, shielded: 7 m	3HAC7998-1
Robot cable signal, shielded: 15 m	3HAC7998-2
Robot cable signal, shielded: 22 m	3HAC7998-3
Robot cable signal, shielded: 30 m	3HAC7998-4

#### Grounding and bonding point on manipulator

There is a grounding/bonding point on the manipulator base. The grounding/bonding point is used for potential equalizing between control cabinet, manipulator and any peripheral devices.



xx1500001599

#### Position switch cables, robot base to controller (option)

These cables are *not* included in the standard delivery, but are included in the delivery if the position switch option is ordered. The position switches can also be ordered without cables. The cables are completely pre-manufactured and ready to plug in.

*Continues on next page*

Cabling to be installed on the robot is specified in sections and [Installation of position switches \(option\) on page 117](#).

#### Cabling between robot base and controller

In a M2000 and M2000A robot system, the cables specified below are used for both position switches and cooling fans.

In a M2004 robot system, however, the cables below are only used for position switches. Cabling for the cooling fans is specified in the table [Fan cables \(option\) on page 131](#).

Cable	Art. no.	Connection point, robot	Connection point, cabinet
Position switch cable, axis 1, 7 m	3HAC13175-1	R1.SW	XS8
Position switch cable, axis 1, 15 m	3HAC13175-2	R1.SW	XS8
Position switch cable, axis 1, 22 m	3HAC13175-3	R1.SW	XS8
Position switch cable, axis 1, 30 m	3HAC13175-4	R1.SW	XS8
Position switch cable, axes 2 and 3, 7 m	3HAC13176-1	R1.SW2/3	XS58
Position switch cable, axes 2 and 3, 15 m	3HAC13176-2	R1.SW2/3	XS58
Position switch cable, axes 2 and 3, 22 m	3HAC13176-3	R1.SW2/3	XS58
Position switch cable, axes 2 and 3, 30 m	3HAC13176-4	R1.SW2/3	XS58

#### Cabling inside control cabinet

Additional cabling must be connected inside the control cabinet when installing position switches.

Additional cabling must also be connected inside the control cabinet when installing fans for robot systems M2000 and M2000A (fan cabling for M2004 runs all the way from the robot base to the inside of the cabinet and the additional cabling specified below is therefor not needed).

Cable	Art. no.	Connection point 1 inside cabinet	Connection point 2 inside cabinet
Bracket in the cabinet wall (M2000 and M2000A)	3HAB7286-5	-	-
Bracket in the cabinet wall (M2004)	3HAC020813-082	-	-
Harness position switch (M2000)	3HAC15899-1	XS58	XP57
Harness position switch axis 1 (M2004)	3HAC021117-001	XS8	XT8.1 and XT8.2
Harness position switch axes 2 and 3 (M2004)	3HAC021116-001	XS58	XT58.1 and XT58.2
Cable harness fans (M2000)	3HAC15666-1	XS57	XT31

#### Fan cables (option)

These cables are *not* included in the standard delivery, but are included in the delivery if the fan option is ordered. The cables are completely pre-manufactured and ready to plug in.

*Continues on next page*

## 2 Installation and commissioning

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### 2.5.1 Robot cabling and connection points

*Continued*

Cabling to be installed on the robot is specified in section [\*Installation of cooling fan for motors \(option\) on page 98.\*](#)

#### Cabling between robot base and control cabinet, cooling fans, M2004

The cables specified below are specific for the IRC5 controller and used when the robot is equipped with cooling fans. The cabling for the cooling fans runs all the way from the robot base to the inside of the cabinet. Fans can also be ordered without cables.

If equipping the robot with cooling fans, use the cabling specified below. The cables for cooling fans listed below are used together with a distributing cable, also specified below.

Cable	Art. no.	Connection point
Harness - cooling, 7 m	3HAC022723-001	Distributing cable: R1.FAN.SW2/3 Inside cabinet: A43.X10 and A43.X11
Harness - cooling, 15 m	3HAC022723-004	Distributing cable: R1.FAN.SW2/3 Inside cabinet: A43.X10 and A43.X11
Harness - cooling, 22 m	3HAC022723-005	Distributing cable: R1.FAN.SW2/3 Inside cabinet: A43.X10 and A43.X11
Harness - cooling, 30 m	3HAC022723-006	Distributing cable: R1.FAN.SW2/3 Inside cabinet: A43.X10 and A43.X11

# 3 Maintenance

## 3.1 Introduction

### Structure of this chapter

This chapter describes all the maintenance activities recommended for the IRB 6650S.

It is based on the maintenance schedule found at the beginning of the chapter. The schedule contains information about required maintenance activities including intervals, and refers to procedures for the activities.

Each procedure contains all the information required to perform the activity, including required tools and materials.

The procedures are gathered in different sections and divided according to the maintenance activity.

### Safety information

Observe all safety information before conducting any service work!

There are general safety aspects that must be read through, as well as more specific safety information that describes the danger and safety risks when performing the procedures. Read the chapter [Safety on page 19](#) before performing any service work!



#### Note

If the IRB 6650S is connected to power, always make sure that the IRB 6650S is connected to protective earth before starting any maintenance work!

For more information see:

- *Product manual - IRC5*

## **3 Maintenance**

---

### **3.2.1 Specification of maintenance intervals**

## **3.2 Maintenance schedule and expected component life**

### **3.2.1 Specification of maintenance intervals**

---

#### **Introduction**

The intervals are specified in different ways depending on the type of maintenance activity to be carried out and the working conditions of the IRB 6650S:

- Calendar time: specified in months regardless of whether the system is running or not.
- Operating time: specified in operating hours. More frequent running means more frequent maintenance activities.
- SIS: specified by the robot's SIS (Service Information System). A typical value is given for a typical work cycle, but the value will differ depending on how hard each part is run. The SIS used in M2000 and M2000A is further described in the section *Service Information System, M2000 on page 209*. The SIS used in M2004 is further described in the *Operating manual - Service Information System*.

## 3.2.2 Maintenance schedule

### General

The robot must be maintained regularly to ensure proper function. The maintenance activities and intervals are specified in the following table.

Non-predictable situations also give rise to inspections of the robot. Any damages must be attended to immediately!

The inspection intervals *do not* specify the life of each component. Values for these are specified in the section [Expected component life on page 138](#)

Instructions for how to perform the different maintenance activities are found in sections:

- [Inspection activities on page 139](#)
- [Replacement/changing activities on page 178](#)
- [Cleaning activities on page 206](#)

### Activities and intervals, standard equipment

The following table specifies the required maintenance activities and intervals.

Maintenance activity	Equipment	Interval	Detailed in section
Cleaning	Robot	-	• <a href="#">Cleaning the IRB 6650S on page 206</a>
Inspection	Oil level in axis-1 gearbox	Every: 12 months	<a href="#">Inspecting the oil level in axis-2 gearbox on page 142</a>
Inspection	Oil level in axis-2 gearbox	Every: 12 months	<a href="#">Inspecting the oil level in axis-2 gearbox on page 142</a>
Inspection	Oil level in axis-3 gearbox	Every: 12 months	<a href="#">Inspecting the oil level in axis-3 gearbox on page 144</a>
Inspection	Oil level in axis-4 gearbox	Every: 12 months	<a href="#">Inspecting the oil level in axis-4 gearbox on page 147</a>
Inspection	Oil level in axis-5 gearbox	Every: 12 months	<a href="#">Inspecting the oil level in axis-5 gearbox on page 149</a>
Inspection	Oil level in axis-6 gearbox	Every: 12 months	<a href="#">Inspecting the oil level in axis-6 gearbox on page 151</a>
Inspection	Balancing device	Every: • 6 months	• <a href="#">Inspecting the balancing device on page 156</a>
Inspection	Robot harness	Every: 12 months i	• <a href="#">Inspecting the cable harness on page 161</a>
Inspection	Information labels	Every: • 12 months	• <a href="#">Inspecting the information labels on page 165</a>
Inspection	Dampers	Every: • 12 months	<a href="#">Inspecting the damper on axes 2-5 on page 172</a>

*Continues on next page*

### 3 Maintenance

#### 3.2.2 Maintenance schedule

*Continued*

Maintenance activity	Equipment	Interval	Detailed in section
Inspection	Mechanical stops	Every: <ul style="list-style-type: none"> <li>• 12 months</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Inspecting the axis-1 mechanical stop pin on page 167</i></li> <li>• <i>Inspecting the additional mechanical stops on page 169</i></li> </ul>
Changing	Oil in axis-1 gearbox: Kyodo Yushi TMO 150	Every: <ul style="list-style-type: none"> <li>• 12,000 hours</li> </ul>	<i>Changing oil, axis-1 gearbox on page 180</i>
Changing	Oil in axis-2 gearbox: Optigear Synthetic RO	First change when DTC <sup>ii</sup> reads: 6,000 hours Second change when DTC <sup>ii</sup> reads: 24,000 hours Following changes: Every 24,000 hours	Do not mix with other oils! <ul style="list-style-type: none"> <li>• <i>Changing oil, axis-1 gearbox on page 180</i></li> </ul>
Changing	Oil in axis-2 gearbox: Kyodo Yushi TMO 150	First change when DTC <sup>ii</sup> reads: 6,000 hours Second change when DTC <sup>ii</sup> reads: 24,000 hours Following changes: Every 24,000 hours	Do not mix with other oils! <ul style="list-style-type: none"> <li>• <i>Changing oil, axis-2 gearbox on page 183</i></li> </ul>
Changing	Oil in axis-3 gearbox: Optigear Synthetic RO	Every: <ul style="list-style-type: none"> <li>• 12,000 hours</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Changing oil, axis-3 gearbox on page 186</i></li> </ul>
Changing	Oil in axis-3 gearbox: Kyodo Yushi TMO 150	First change when DTC <sup>ii</sup> reads: 6,000 hours Second change when DTC <sup>ii</sup> reads: 24,000 hours Following changes: Every 24,000 hours	Do not mix with other oils! <ul style="list-style-type: none"> <li>• <i>Changing oil, axis-3 gearbox on page 186</i></li> </ul>
Changing	Oil in axis-4 gearbox	Every: 24,000 hours	<ul style="list-style-type: none"> <li>• <i>Changing oil, axis-4 gearbox on page 189</i></li> </ul>
Changing	Oil in axis-5 gearbox	Every: 24,000 hours	<ul style="list-style-type: none"> <li>• <i>Changing oil, axis-5 gearbox on page 192</i></li> </ul>
Changing	Oil in axis-6 gearbox	Every: <ul style="list-style-type: none"> <li>• 12,000 hours</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Changing oil, axis-6 gearbox on page 195</i></li> </ul>

*Continues on next page*

## 3.2.2 Maintenance schedule

Continued

Maintenance activity	Equipment	Interval	Detailed in section
Changing	Oil in axis-6 gearbox: Kyodo Yushi TMO 150	First change when DTC <sup>ii</sup> reads: 6,000 hours Second change when DTC <sup>ii</sup> reads: 24,000 hours Following changes: Every 24,000 hours	Do not mix with other oils! • <i>Changing oil, axis-6 gearbox on page 195</i>
Overhaul	Robot	Every: 40,000 hours	• <i>Expected component life on page 138</i>
Replacement	Battery pack, measurement system of type RMU101 or RMU102 (3-pole battery contact)	36 months or battery low alert <sup>iii</sup>	• <i>Replacing the SMB battery on page 198</i>
Replacement	Battery pack, measurement system with 2-pole battery contact, e.g. DSQC633A	Battery low alert <sup>iv</sup>	• <i>Replacing the SMB battery on page 198</i>
Lubrication	Balancing device bearings	Every: 12,000 hours <sup>v</sup>	

<sup>i</sup> Replace when damage or cracks is detected or life limit is approaching that specified in section *Expected component life on page 138*.

<sup>ii</sup> DTC = Duty Time Counter. Shows the operational time of the robot.

<sup>iii</sup> The battery low alert (38213 **Battery charge low**) is displayed when the battery needs to be replaced. The recommendation to avoid an unsynchronized robot is to keep the power to the controller turned on until the battery is to be replaced.

See the replacement instruction for more details.

<sup>iv</sup> The battery low alert (38213 **Battery charge low**) is displayed when remaining backup capacity (robot powered off) is less than 2 months. The typical lifetime of a new battery is 36 months if the robot is powered off 2 days/week or 18 months if the robot is powered off 16 h/day. The lifetime can be extended with a battery shutdown service routine. See *Operating manual - IRC5 with FlexPendant* for instructions.

<sup>v</sup> Always lubricate the front eye bearing after refitting the shaft of the balancing device.

### Activities and intervals, optional equipment

The following table specifies the required maintenance activities and intervals for common optional equipment. The maintenance of other external equipment for the robot is detailed in separate documents.

Maintenance activity	Equipment	Interval	Note	Detailed in section
Inspection	Signal lamp	Every: 12 months		<i>Inspecting, signal lamp on page 176</i>
Inspection	Mechanical stop axes 1-2-3	Every: 12 months		<i>Inspecting the additional mechanical stops on page 169</i>
Inspection	Position switches, axes 1-2-3	Every: 12 months		<i>Inspection, position switch axes 1, 2 and 3 on page 174</i>

### 3 Maintenance

#### 3.2.3 Expected component life

##### 3.2.3 Expected component life

###### General

The expected life of a specific component of the robot can vary greatly depending on how hard it is run.

###### Expected component life - protection type Standard

Component	Expected life	Note
Cable harness Normal usage <sup>i</sup>	40,000 hours <sup>ii</sup>	Not including: <ul style="list-style-type: none"><li>• Possible SpotPack harnesses</li><li>• Optional upper arm harnesses</li></ul>
Cable harness Extreme usage <sup>iii</sup>	20,000 hours <sup>ii</sup>	Not including: <ul style="list-style-type: none"><li>• Possible SpotPack harnesses</li><li>• Optional upper arm harnesses</li></ul>
Balancing device	40,000 hours <sup>iv</sup>	
Gearboxes <sup>v</sup>	40,000 hours	

<sup>i</sup> Examples of "normal usage" in regard to movement: most material handling applications and limited use of bending backwards mode of axis 3.

<sup>ii</sup> Severe chemical or thermal environments, or similar environments, can result in shortened life expectancy.

<sup>iii</sup> Examples of "extreme usage" in regard to movement: press tending, very severe palletizing applications, major use of axis 1 movement and major use of bending backwards of axis 3.

<sup>iv</sup> The given life for the balancing device is based on a test cycle of 4,000,000 cycles that starts from the initial position and goes to maximum extension, and back. Deviations from this cycle will result in differences in expected life!

<sup>v</sup> Depending on application, the lifetime can vary. The Service Information System (SIS) that is integrated in the robot software can be used as guidance when planning gearbox service for the individual robot. This applies to gearboxes on axes 1, 2, 3 and 6. The lifetime of gearbox axes 4 and 5 is not calculated by SIS (See the *Operating manual - Service Information System*). In some applications, such as Foundry or Washing, the robot can be exposed to chemicals, high temperature or humidity, which can have an effect on the lifetime of the gearboxes. Contact the local *ABB Robotics Service team* for more information.

The SIS for an IRC5 system is described in the *Operating manual - Service Information System*.

For an M2000 system, the SIS is described in section [Service Information System, M2000 on page 209](#).

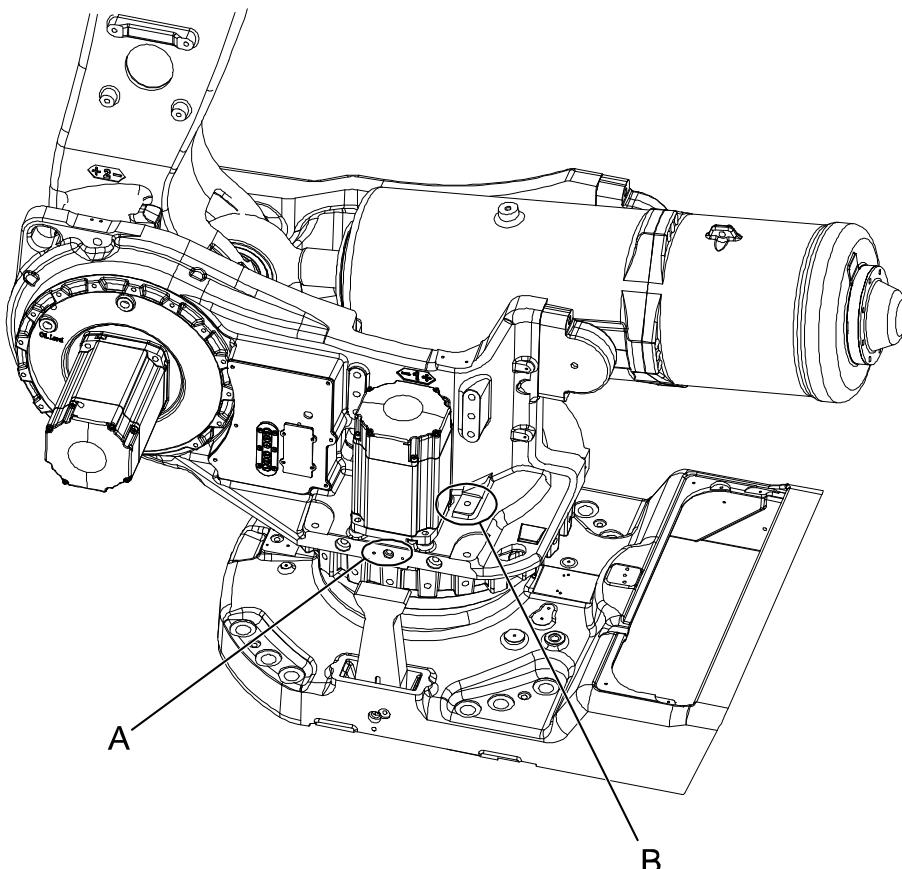
## 3.3.1 Inspecting the oil level in axis-1 gearbox

## 3.3 Inspection activities

## 3.3.1 Inspecting the oil level in axis-1 gearbox

## Location of gearbox

The axis-1 gearbox is located between the frame and base. See oil plugs in the following figure.



xx0300000583

A	Oil plug, inspection
B	Oil plug, filling

## Required equipment

Equipment	Art. no.	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	 Note Do not mix with other oils!
Standard toolkit	-	<a href="#">Content is defined in section Standard tools on page 435.</a>

*Continues on next page*

### 3 Maintenance

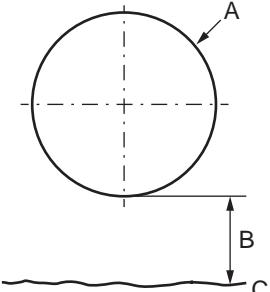
#### 3.3.1 Inspecting the oil level in axis-1 gearbox

Continued

Equipment	Art. no.	Note
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

#### Inspecting the oil level in axis-1 gearbox

Use this procedure to inspect the oil level in the axis-1 gearbox.

	Action	Note
1	 <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
2	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply</li><li>• hydraulic pressure supply</li><li>• air pressure supply</li></ul> to the robot, before entering the robot working area.	
3	Make sure that the oil temperature is $+25^{\circ}\text{C} \pm 10^{\circ}\text{C}$ .	This is a precaution to reduce the temperature dependency of the measurement.
4	Open the <i>oil plug, inspection</i> .	Shown in figure <a href="#">Location of gearbox on page 139</a> .
5	Measure the oil level. Required oil level: max. 10 mm below the oil plug hole.	 xx1400002785 A Oil plug hole B Required oil level C Gearbox oil
6	Adjust the oil level, if required.	Where to find type of oil and total amount is detailed in <a href="#">Type of lubrication in gearboxes on page 178</a> . Further information about how to fill with oil is found in section <a href="#">Changing oil, axis-1 gearbox on page 180</a> .
7	Refit the oil plug.	Tightening torque: 24 Nm

Continues on next page

#### 3.3.1 Inspecting the oil level in axis-1 gearbox

*Continued*

	Action	Note
8	 <b>WARNING</b>  Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <i>Technical reference manual - Lubrication in gearboxes</i> .	

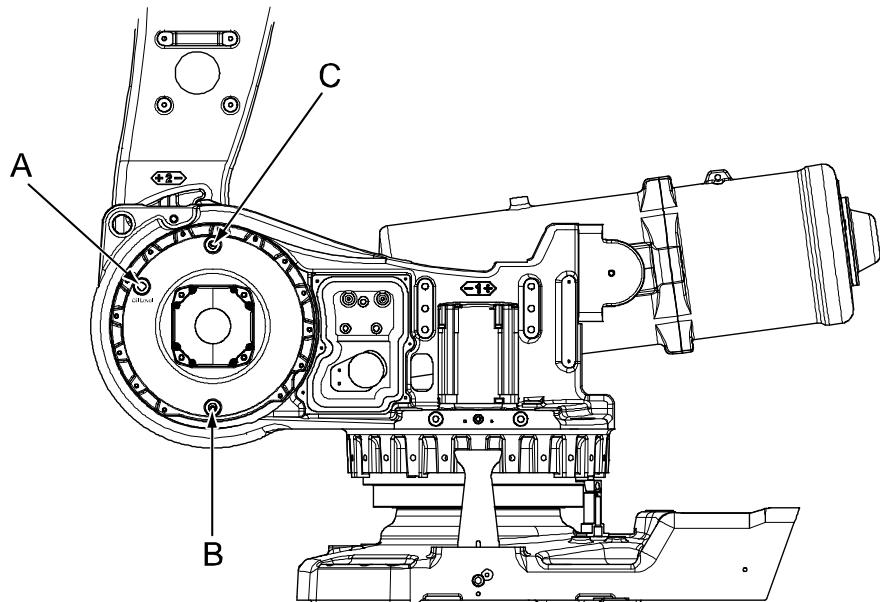
### 3 Maintenance

#### 3.3.2 Inspecting the oil level in axis-2 gearbox

#### 3.3.2 Inspecting the oil level in axis-2 gearbox

##### Location of gearbox

The axis-2 gearbox is located in the lower arm rotational center, underneath the motor attachment.



xx0300000631

A	Oil plug, filling and inspection
B	Oil plug, draining
C	Vent hole, gearbox axis 2

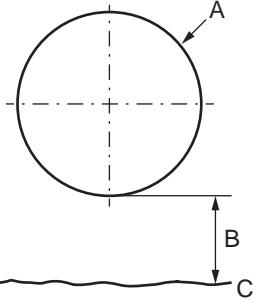
##### Required equipment

Equipment, etc.,	Art. no.	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	Note! Do not mix with other oils!
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

Continues on next page

**Inspecting the oil level in axis-2 gearbox**

Use this procedure to inspect the oil level in the axis-2 gearbox.

	Action	Note
1	 <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
2	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
3	Make sure that the oil temperature is +25°C ±10°C.	This is a precaution to reduce the temperature dependency of the measurement.
4	Open the <i>oil plug, filling and inspection</i> .	Shown in the figure <a href="#">Location of gearbox on page 142</a> .
5	Measure the oil level. Required oil level: max. 5 mm below the inspection oil plug hole.	 xx1400002785 A Oil plug hole B Required oil level C Gearbox oil
6	Adjust the oil level, if required.	Where to find type of oil and total amount is detailed in <a href="#">Type and amount of oil in gearboxes on page 178</a> .  Filling of oil is detailed further in the section <a href="#">Filling, oil on page 184</a> .
7	Refit the oil plug.	Tightening torque: 24 Nm.
8	 <b>WARNING</b> Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <a href="#">Technical reference manual - Lubrication in gearboxes</a> .	

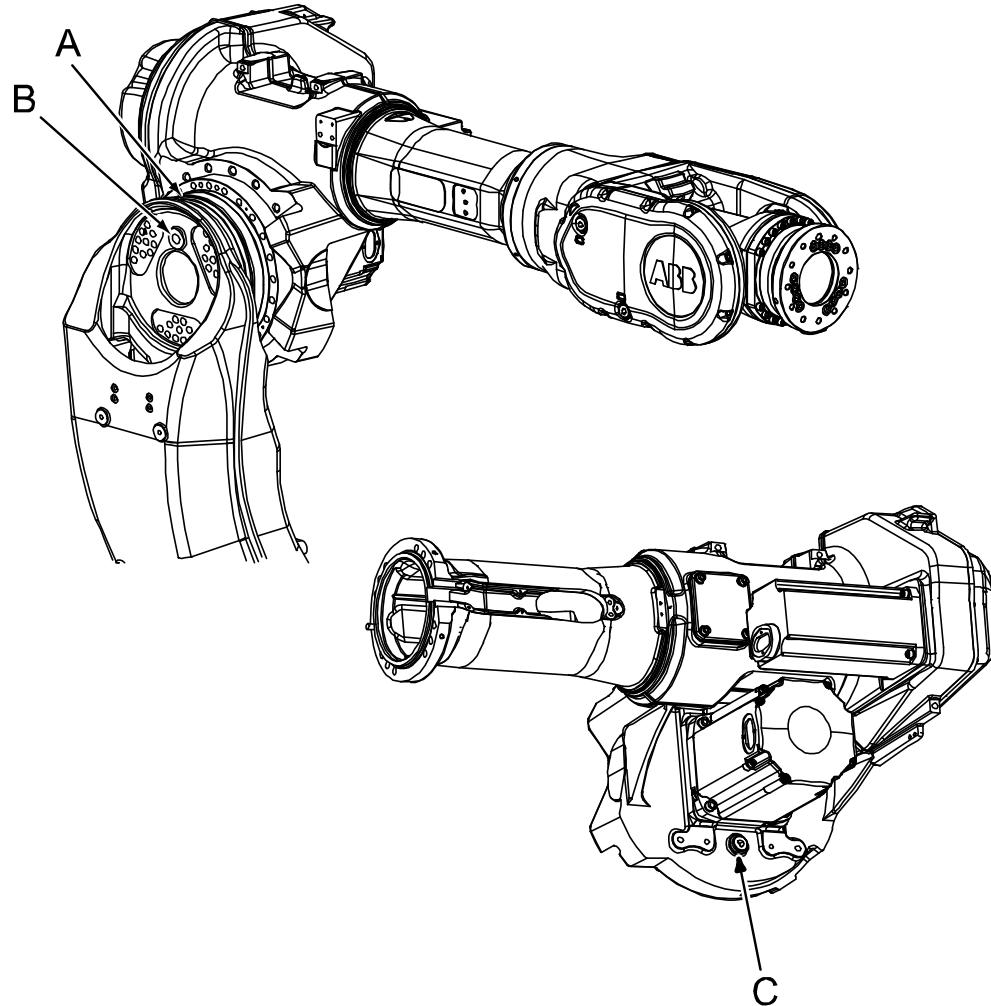
### 3 Maintenance

#### 3.3.3 Inspecting the oil level in axis-3 gearbox

#### 3.3.3 Inspecting the oil level in axis-3 gearbox

##### Location of gearbox

The axis 3 gearbox is located in the upper arm rotational center as shown in the figure.



xx0200000230

A	Gearbox axis 3
B	Oil plug, filling and inspection
C	Oil plug, draining

##### Required equipment

Equipment, etc.	Art. no.	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	<b>Note!</b> Do not mix with other oils!
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .

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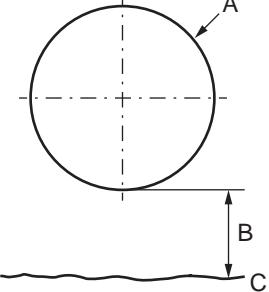
## 3.3.3 Inspecting the oil level in axis-3 gearbox

Continued

Equipment, etc.	Art. no.	Note
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

**Inspecting the oil level in axis-3 gearbox**

Use this procedure to inspect the oil level in the axis-3 gearbox.

	Action	Note
1	 <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
2	Move the robot to a position according to the illustration in <a href="#">Location of gearbox on page 144</a> .	Detailed in the section <a href="#">Synchronization marks and synchronization position for axes on page 398</a> .
3	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
4	Make sure that the oil temperature is +25°C ±10°C.	This is a precaution to reduce the temperature dependency of the measurement.
5	Open the <i>oil plug, filling and inspection</i> .	Shown in the figure <a href="#">Location of gearbox on page 144</a> .
6	Measure the oil level. Required oil level: max. 5 mm below the filling oil plug hole.	 xx1400002785 A Oil plug hole B Required oil level C Gearbox oil

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### 3 Maintenance

#### 3.3.3 Inspecting the oil level in axis-3 gearbox

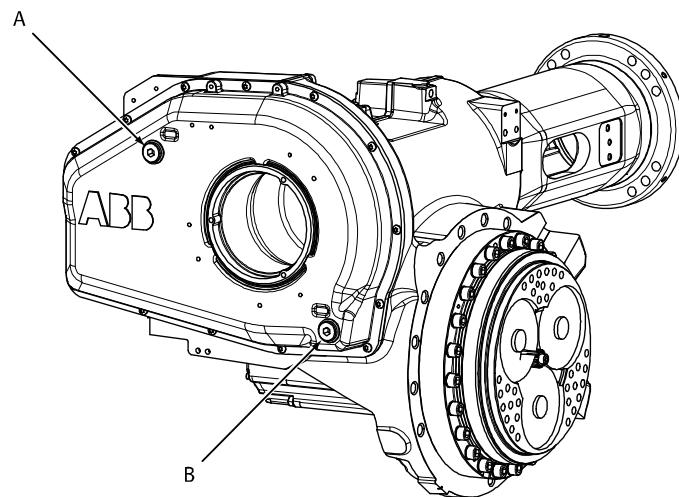
*Continued*

	Action	Note
7	Adjust the oil level, if required.	Where to find type of oil and total amount is detailed in <i>Type and amount of oil in gearboxes on page 178</i> . Further information about how to fill the oil may be found in the section <i>Filling, oil on page 188</i> .
8	Refit the oil plug.	Tightening torque:24 Nm
9	 <b>WARNING</b> Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <i>Technical reference manual - Lubrication in gearboxes</i> .	

### 3.3.4 Inspecting the oil level in axis-4 gearbox

#### Location of gearbox

The axis-4 gearbox is located in the rear part of the upper arm as shown in the figure.



xx0200000231

A	Oil plug, filling and inspection
B	Oil plug, draining

#### Required equipment

Equipment, etc.	Art. no.	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

#### Inspecting the oil level in axis-4 gearbox

Use this procedure to inspect the oil level in the axis-4 gearbox.

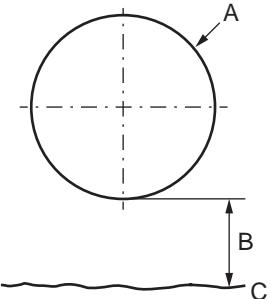
	Action	Note
1	<b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	

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### 3 Maintenance

#### 3.3.4 Inspecting the oil level in axis-4 gearbox

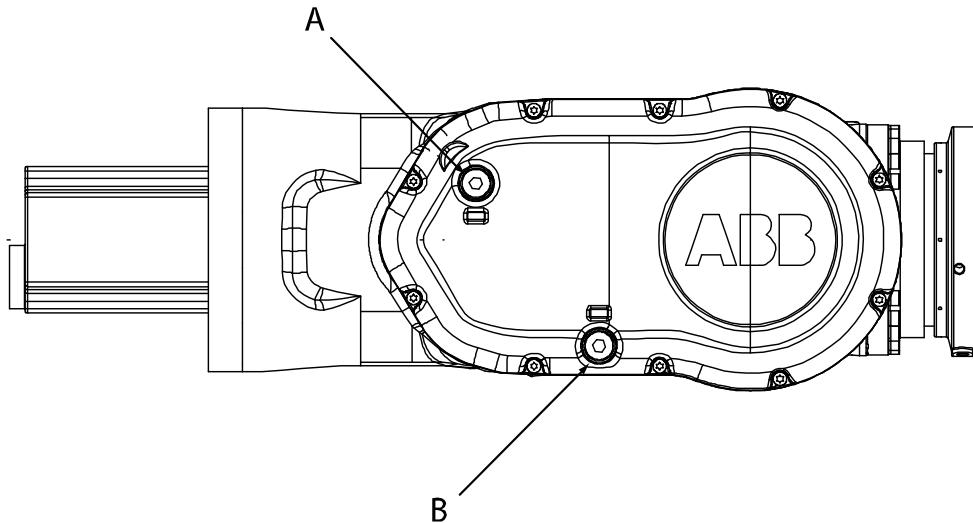
*Continued*

	Action	Note
2	Move the robot to the calibration position.	This is detailed in section <a href="#">Synchronization marks and synchronization position for axes on page 398</a> .
3	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
4	Make sure that the oil temperature is +25°C ±10°C.	This is a precaution to reduce the temperature dependency of the measurement.
5	Open the <i>oil plug, filling and inspection</i> .	Shown in the figure <a href="#">Location of gearbox on page 147</a> .
6	Measure the oil level. Required oil level: 0-10 mm	 xx1400002785 <p>A Oil plug hole B Required oil level C Gearbox oil</p>
7	Adjust the oil level, if required.	Where to find type of oil and total amount is detailed in <a href="#">Type and amount of oil in gearboxes on page 178</a> . Further information about how to fill the oil may be found in the section <a href="#">Filling, oil on page 190</a> .
8	Refit the oil plug.	Tightening torque: 24 Nm
9	 <b>WARNING</b> Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <i>Technical reference manual - Lubrication in gearboxes</i> .	

### 3.3.5 Inspecting the oil level in axis-5 gearbox

#### Location of gearbox

The axis-5 gearbox is located in the wrist unit as shown in the figure.



xx0200000232

-	The figure above shows the wrist unit of IRB 6600 and IRB 6650
A	Oil plug, filling and inspection
B	Oil plug, draining

#### Required equipment

Equipment etc.	Art. no.	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

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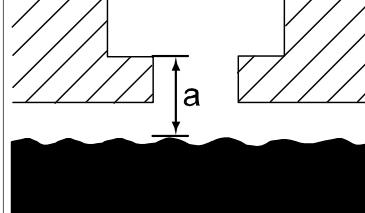
### 3 Maintenance

#### 3.3.5 Inspecting the oil level in axis-5 gearbox

Continued

##### Inspecting the oil level in axis-5 gearbox

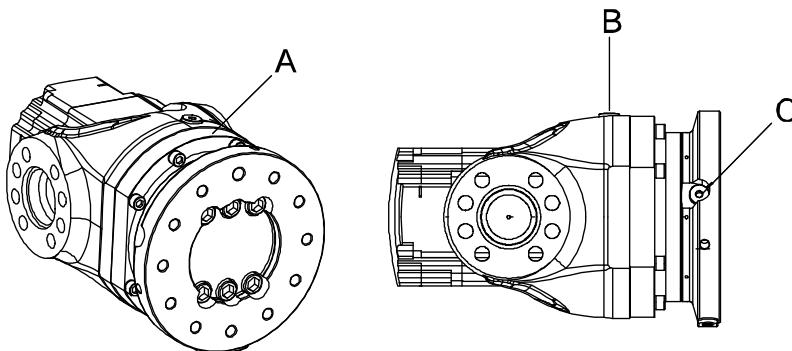
Use this procedure to inspect the oil level in the axis-5 gearbox.

Action	Note
1  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
2 Move the robot upper arm to a horizontal position.	
3 Turn the wrist unit in a way that both oil plugs are facing upwards.	
4  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
5 Make sure that the oil temperature is +25°C ±10°C.	This is a precaution to reduce the temperature dependency of the measurement.
6 Open the <i>oil plug, filling and inspection</i> .	Shown in the figure <a href="#">Location of gearbox on page 149</a> .
7 Measure the oil level. Required oil level to the upper edge of the filling and inspection oil plug hole (a): 30 mm	 xx0500002222
8 Adjust the oil level, if required.	Where to find type of oil and total amount is detailed in <a href="#">Type and amount of oil in gearboxes on page 178</a> . Further information about how to fill the oil may be found in the section <a href="#">Filling, oil, axis 5 on page 193</a> .
9 Refit the oil plug.	Tightening torque:24 Nm
10  <b>WARNING</b> Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <a href="#">Technical reference manual - Lubrication in gearboxes</a> .	

### 3.3.6 Inspecting the oil level in axis-6 gearbox

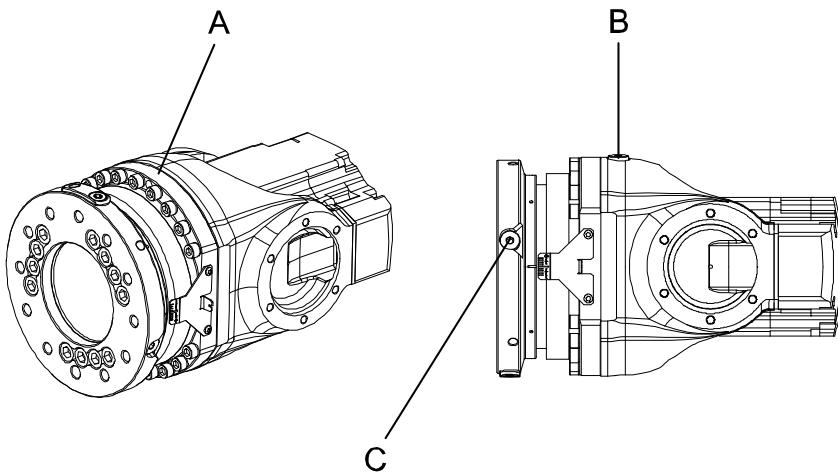
#### Location of gearbox

The axis-6 gearbox is located in the wrist unit as shown in this figure.



xx0600002964

	Type 1
A	Axis-6 gearbox
B	Oil plug, filling and inspection
C	Oil plug, draining



xx0400001092

	Type 2
A	Axis-6 gearbox
B	Oil plug, filling and inspection
C	Oil plug, draining

#### Inspection depending on type of wrist

To inspect oil level for wrist type 1, see [Inspecting the oil level in axis-6 gearbox, wrist type 1 on page 152](#).

To inspect oil level for wrist type 2, see [Inspecting the oil level in axis-6 gearbox, wrist type 2 on page 154](#).

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### 3 Maintenance

#### 3.3.6 Inspecting the oil level in axis-6 gearbox

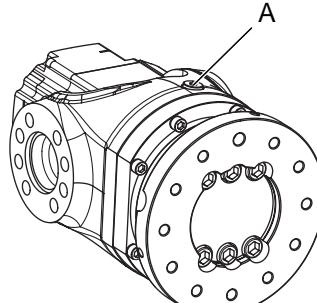
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##### Required equipment

Equipment	Art. no.	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

##### Inspecting the oil level in axis-6 gearbox, wrist type 1

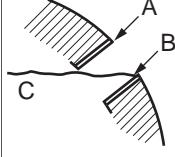
Use this procedure to inspect the oil level in the axis-6 gearbox, for wrist type 1.

Action	Note
<b>1</b>  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
<b>2</b> Move axes 3 and 5 to a horizontal position, and make sure that the <i>oil plug, filling and inspection</i> is facing upwards.	
<b>3</b>  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
<b>4</b> Make sure that the oil temperature is $+25^{\circ}\text{C} \pm 10^{\circ}\text{C}$ . This is a precaution to reduce the temperature dependency of the measurement.	
<b>5</b> Open the <i>oil plug, filling and inspection</i> .	 xx1300000244

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## 3.3.6 Inspecting the oil level in axis-6 gearbox

Continued

Action	Note
6 Turn axis 6 so that the <i>oil plug, draining</i> faces upwards.	
7 Open the <i>oil plug, draining</i> .	This is a precaution to avoid vacuum effects by allowing air to enter at the top of the gearbox.   Note  If equipment that covers the <i>oil plug, draining</i> is fitted on the robot so that the oil plug cannot be opened, then this step can be skipped.
8 Slowly turn axis 4, while adjusting axis 6 so that the <i>oil plug, draining</i> always faces upwards. Turn axis 4 until the axis-4 angle reads -45° to -55°.	
9 Inspect the oil level in the hole for the <i>oil plug, filling and inspection</i> .  The oil should reach all the way up to the external edge of the thread for the <i>oil plug, filling and inspection</i> .   Note  If the <i>oil plug, draining</i> is not opened, then use a clean, narrow object, for example an oil stick or a cable tie, to gently poke the oil surface. This will avoid surface tension from stopping air to enter into the gearbox.	 xx1400002786  A Oil plug hole B Required oil level C Gearbox oil
10 Adjust the oil level, if required.	Where to find type of oil and total amount is detailed in <a href="#">Type and amount of oil in gearboxes on page 178</a> .  Further information about how to fill the oil may be found in the section <a href="#">Filling, oil, axis 6 on page 196</a> .
11 Refit the oil plugs.	Tightening torque: 24 Nm.
12  <b>WARNING</b>  Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <i>Technical reference manual - Lubrication in gearboxes</i> .	

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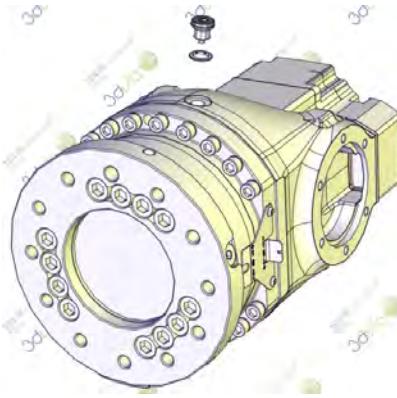
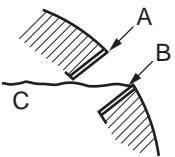
### 3 Maintenance

#### 3.3.6 Inspecting the oil level in axis-6 gearbox

Continued

##### Inspecting the oil level in axis-6 gearbox, wrist type 2

Use this procedure to inspect the oil level in the axis-6 gearbox, for wrist type 2.

Action	Note
1  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
2 Move axes 3 and 5 to a horizontal position, and make sure that the <i>oil plug, filling and inspection</i> is facing upwards.	
3  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
4 Make sure that the oil temperature is +25°C ±10°C.	This is a precaution to reduce the temperature dependency of the measurement.
5 Remove the <i>oil plug, filling and inspection</i> .	 xx1300002447
6 Slowly turn axis 4 until the axis-4 angle reads +72.5° to +77.5°.	
7 Inspect the oil level in the hole for the <i>oil plug, filling and inspection</i> . The oil should reach all the way up to the external edge of the thread for the <i>oil plug, filling and inspection</i> .	 xx1400002786 A Oil plug hole B Required oil level C Gearbox oil
 <b>Note</b> If needed, use a clean, narrow object, for example an oil stick or a cable tie, to gently poke the oil surface. This will avoid surface tension from stopping air to enter into the gearbox.	

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#### 3.3.6 Inspecting the oil level in axis-6 gearbox

*Continued*

	Action	Note
8	Adjust the oil level, if required.	Where to find type of oil and total amount is detailed in <i>Type and amount of oil in gearboxes on page 178</i> . Further information about how to fill the oil may be found in the section <i>Filling, oil, axis 6 on page 196</i> .
9	Refit the oil plug.	Tightening torque: 24 Nm.
10	 <b>WARNING</b>  Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <i>Technical reference manual - Lubrication in gearboxes</i> .	

### 3 Maintenance

#### 3.3.7 Inspecting the balancing device

#### 3.3.7 Inspecting the balancing device

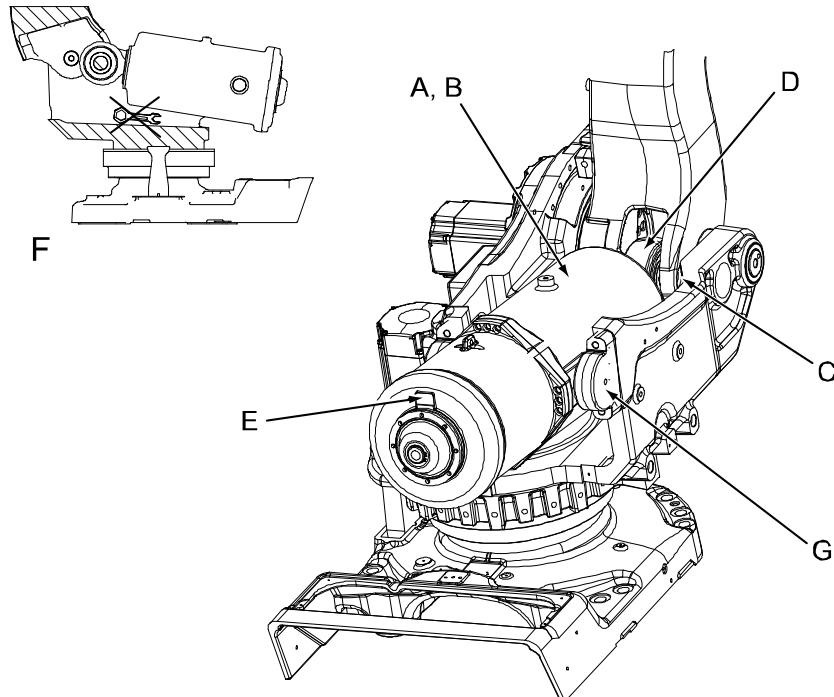
##### General

Several points are to be checked on the balancing device during the inspection. This section describes how to perform the inspection regarding:

- dissonance
- damage
- leakage
- contamination / lack of free space.

##### Inspection points, balancing device

The balancing device is located at the top rear of the frame as shown in the figure. The figure also shows the inspection points, further described in the instructions.



xx0400001025

A	Balancing device
B	Piston rod (inside)
C	Shaft, including securing screw
D	Ear, bearing and o-rings
E	Label with article number
F	Inspect the surroundings
G	Bearing, balancing device attachments

Continues on next page

**Required equipment**

Equipment, etc.	Spare part no.	Art. no.	Note
Maintenance kit, complete	-		Includes: <ul style="list-style-type: none"><li>• complete kit including the kit with bearings and seals</li><li>• instructions for maintenance.</li></ul>
Maintenance kit, bearings and seals	-		Includes: <ul style="list-style-type: none"><li>• kit with bearings, o-rings and seals only</li><li>• instructions for maintenance.</li></ul>
Securing screw			Securing screw in the shaft. M16 x 180 Locking liquid must be used when fitting the screw (Loctite 243)!
Toolkit for maintenance			See chapter <i>Reference information</i> .
Puller for separator		4552-2 (Bahco)	Used for removing the spherical roller bearings.
Separator		4551-C (Bahco)	Used for removing the spherical roller bearings.
Standard toolkit		3HAC15571-1	Content is defined in section <i>Standard tools on page 435</i> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

**Check for dissonance**

The check points are shown in the figure [Inspection points, balancing device on page 156](#).

	Check for dissonance from...	If dissonance is detected...
1	<ul style="list-style-type: none"> <li>• bearing at the link ear</li> <li>• bearings at the balancing devices attachments.</li> </ul>	<p>... perform maintenance according to given instructions in Maintenance kit, bearings and seals. The replacement of the bearing at the ear is also detailed in section <a href="#">Replacement of spherical roller bearing, balancing device on page 306</a>.</p> <p>Art. no. for the kit and the documentation are specified in section <a href="#">Required equipment on page 157</a>.</p>
2	<ul style="list-style-type: none"> <li>• balancing device (a tapping sound, caused by the springs inside the cylinder).</li> </ul>	<p>... replace the balancing device or consult ABB Robotics. How to replace the device is detailed in section <a href="#">Replacing the balancing device on page 309</a>. This section also specifies the spare part number!</p>

*Continues on next page*

### 3 Maintenance

#### 3.3.7 Inspecting the balancing device

*Continued*

	<b>Check for dissonance from...</b>	<b>If dissonance is detected...</b>
3	<ul style="list-style-type: none"><li>• piston rod (squeaking may indicate worn plain bearings, internal contamination or insufficient lubrication).</li></ul>	... perform maintenance according to given instructions in Maintenance kit, complete. Art. no. for the kit and the documentation are specified in section <a href="#">Required equipment on page 157</a> .

#### Check for damage

Check for damages, such as scratches, general wear, uneven surfaces or incorrect positions.

The check points are shown in the figure [Inspection points, balancing device on page 156](#).

	<b>Check for damage on...</b>	<b>If damage is detected...</b>
1	<ul style="list-style-type: none"><li>• the piston rod (part of the piston rod that is visible at the front of the balancing device).</li></ul>	... perform maintenance according to given instructions in Maintenance kit, complete. Art. no. for the kit and the documentation are specified in section <a href="#">Required equipment on page 157</a> .
2	<ul style="list-style-type: none"><li>• the securing screw in the front ear shaft.</li></ul> <p>Also check the tightening torque (50 Nm).</p>	...replace. Dimension is specified in section <a href="#">Required equipment on page 157</a> .

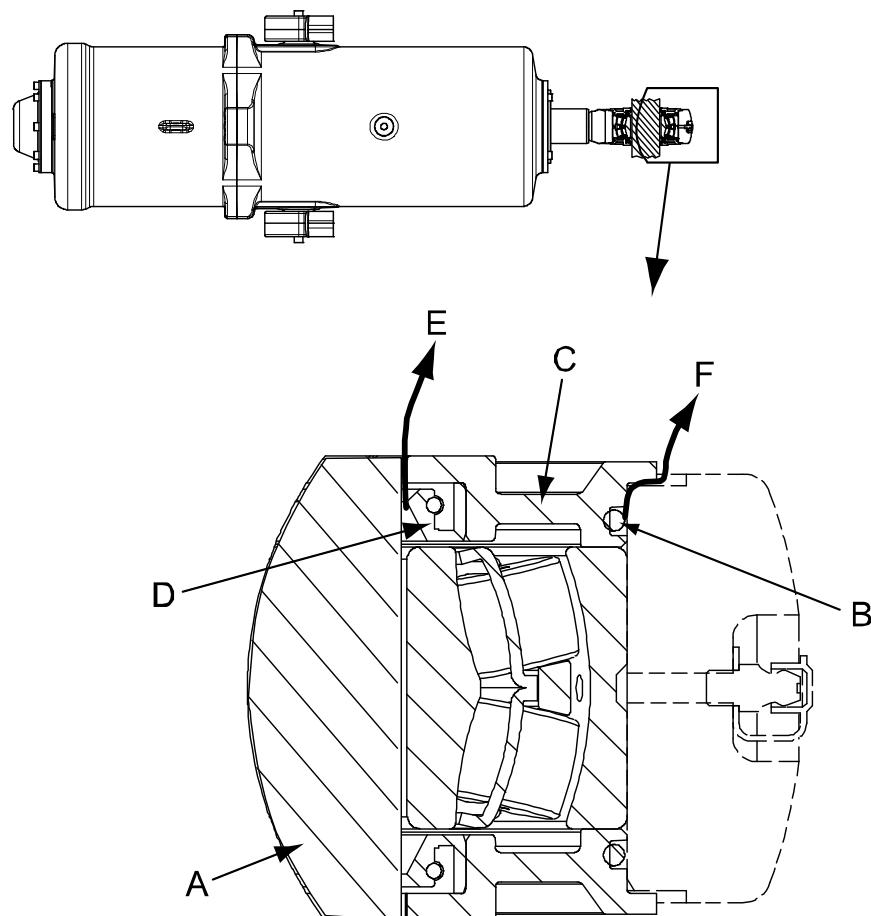
#### Check for leakage

The front ear of the balancing device is lubricated with grease. After filling, excessive grease may normally be forced out between the shaft and the sealing ring in the sealing spacer. This is normal behaviour and must not be confused with incorrect leaks from the ear.

Leaks at the o-rings and/or sealings, are not acceptable and must be attended to immediately in order to avoid any damage to the bearing!

*Continues on next page*

Check the o-rings in the front ear of the balancing device for leaks, as shown and detailed below.



xx0400001026

A	Shaft
B	O-ring
C	Sealing spacer
D	Sealing ring in sealing spacer
E	Correct way out for excessive grease from inside the front ear
F	Incorrect leakage from the front ear

	Action	Note
1	Clean the area at the front ear from old grease.	
2	Run the robot for some minutes, in order to move the balancing device piston.	

*Continues on next page*

### 3 Maintenance

#### 3.3.7 Inspecting the balancing device

Continued

Action	Note
3 Check the o-rings at the front ear for leakage. Replace the o-rings, if any leaks are detected. Excessive grease from between the shaft and the sealing ring is normal and is not considered as a leak!	The o-rings are included in the <i>Maintenance kit, bearings and seals</i> , already assembled with sealing spacers and sealing rings. Art. no. for the kit is specified in <a href="#">Required equipment on page 157</a> . The replacement of the complete bearing is also detailed in section <a href="#">Replacement of spherical roller bearing, balancing device on page 306</a> . Incorrect leakage is shown in the previous figure.

#### Check for contamination / lack of free space

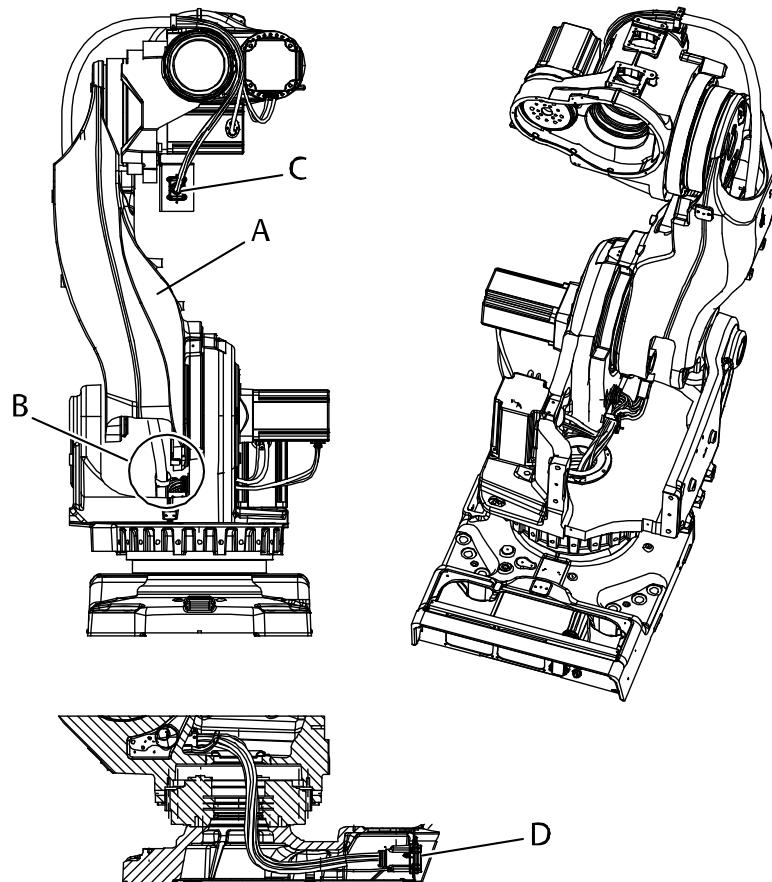
Action
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.
2 Check that there are no obstacles inside the frame, that could prevent the balancing device from moving freely. See the figure <a href="#">Inspection points, balancing device on page 156</a> . Keep the areas around the balancing device clean and free from objects, such as service tools.

### 3.3.8 Inspecting the cable harness

#### Location of cable harness, axes 1-4

The robot cable harness, axes 1-4, is located as shown in the figure below.

**Note!** The cable harness is also available without the division point R2.M5/6. Except for the connectors at the division point, the rest of the inspection points are the same for the harness that runs undivided from axis 1 to axis 6.



xx020000097

A	Lower arm
B	Cables attached with velcro straps and mounting plate
C	Connectors at cable harness division point, R2.M5/6
D	Connectors at base

#### Required equipment

Equipment, etc.	Art. no.	Note
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .

*Continues on next page*

### 3 Maintenance

#### 3.3.8 Inspecting the cable harness

Continued

Equipment, etc.	Art. no.	Note
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.
Circuit diagram		See chapter <i>Circuit diagram on page 441</i> .

#### Inspection, cable harness 1-4

The procedure below details how to inspect the cable harness of axes 1-4.

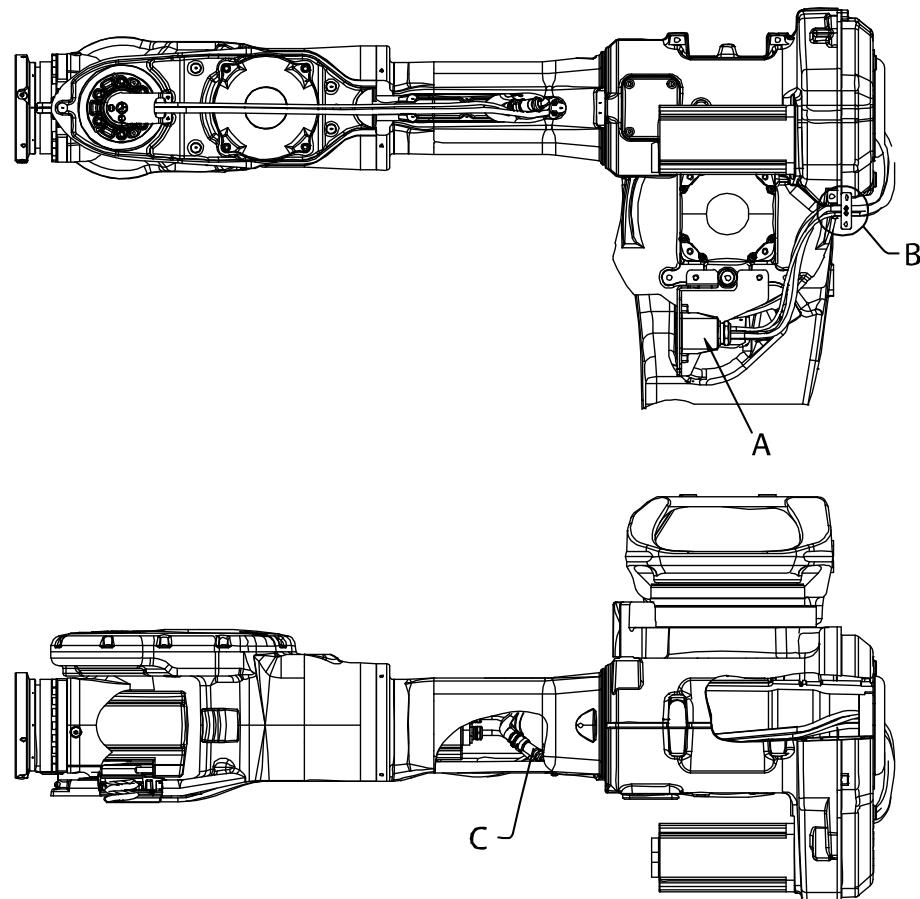
	Action	Note
1	 <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2	Make an overall visual inspection of the cable harness, in order to detect wear and damage.	
3	Check the <i>connectors at the division point and at the base</i> .	Shown in the figure <i>Location of cable harness, axes 1-4 on page 161</i> .
4	Check that <i>velcro straps and the mounting plate</i> are properly attached to the frame. Also check the cabling, leading into the lower arm. Make sure it is attached by the straps and not damaged.	Location is shown in the figure <i>Location of cable harness, axes 1-4 on page 161</i> . A certain wear of the hose at the entrance to the lower arm is natural.
5	Replace the cable harness if wear, cracks or damage is detected.	Described in section <i>Replacing cable harness, axes 1-6 on page 223</i> .

Continues on next page

**Location of cabling axes 5-6**

The robot cable harness, axes 5-6, is located as shown in the figure below.

**Note!** The cable harness is also available without the division point R2.M5/6. Except for the connectors at the division point, the rest of the inspection points are the same for the harness that runs undivided from axis 1 to axis 6.



xx0200000234

A	Connectors at cable harness division point, R2.M5/6
B	Cable attachment, rear of upper arm
C	Cable attachment, upper arm tube

**Inspection, cable harness, axes 5-6**

The procedure below details how to inspect the cable harness of axes 5-6.

	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	

Continues on next page

### 3 Maintenance

#### 3.3.8 Inspecting the cable harness

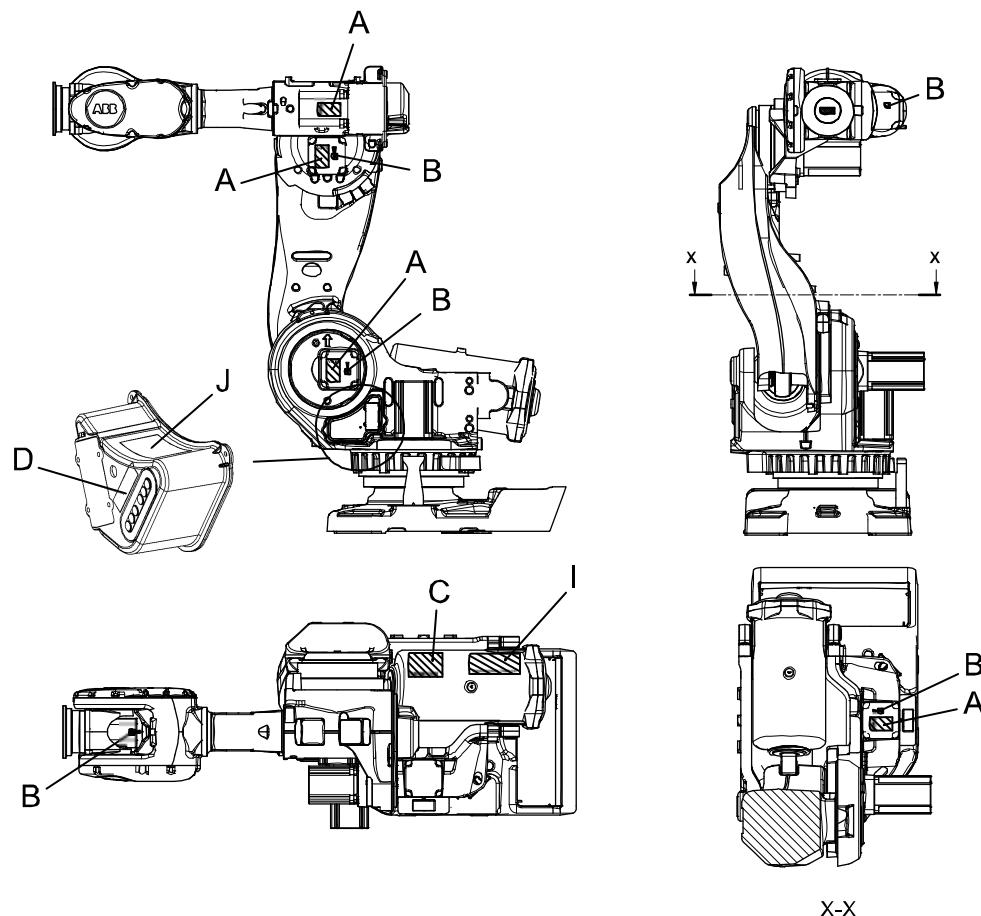
*Continued*

	Action	Note
2	Make an overall visual inspection of the cable harness, in order to detect wear and damage.	
3	Check the <i>attachments at the rear of the upper arm and in the upper arm tube.</i> Check the <i>connectors at the cable harness division.</i> Make sure the attachment plate is not bent or in any other way damaged.	Shown in the figure <a href="#">Location of cabling axes 5-6 on page 163</a> .
4	Replace the cable harness if wear, cracks or damage is detected.	Described in section <a href="#">Replacement of cable harness, axes 5-6 on page 245!</a>

### 3.3.9 Inspecting the information labels

#### Location of labels

These figures show the location of the information labels to be inspected. The symbols are described in section [Safety symbols on product labels on page 43](#).



xx0200000236

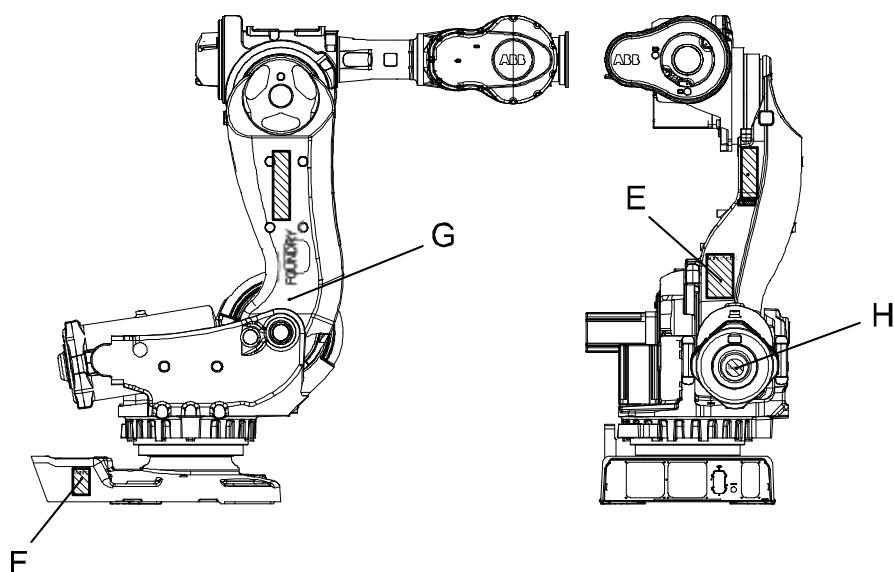
A	Warning label concerning high temperature (4 pcs)
B	Warning label, symbol of a flash (located on motor cover) (5 pcs)
C	Instruction label
D	Warning label concerning brake release
I	Warning label, tools are not allowed around the balancing device during operation
J	Warning label concerning shutting off power
-	Information labels at gearboxes and at robot base, if gearboxes are filled with Kyodo Yushi TMO 150

*Continues on next page*

### 3 Maintenance

#### 3.3.9 Inspecting the information labels

*Continued*



xx0400000786

E	Instruction label concerning lifting the robot
F	Warning label concerning risk of tipping
G	Foundry logotype
H	Warning label concerning stored energy

#### Required tools and equipment

Visual inspection, no tools are required.

#### Inspecting, labels

Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply</li><li>• hydraulic pressure supply</li><li>• air pressure supply</li></ul> to the robot, before entering the robot working area.	
2 Inspect the labels, located as shown in the figures.	
3 Replace any missing or damaged labels.	Article numbers for the labels and plate set is specified in <a href="#">Spare part lists on page 425</a> .

## 3.3.10 Inspecting the axis-1 mechanical stop pin

## 3.3.10 Inspecting the axis-1 mechanical stop pin



## WARNING

Mechanical stop pin can not be fitted onto robot if option 810-1 *Electronic Position Switch* is used.

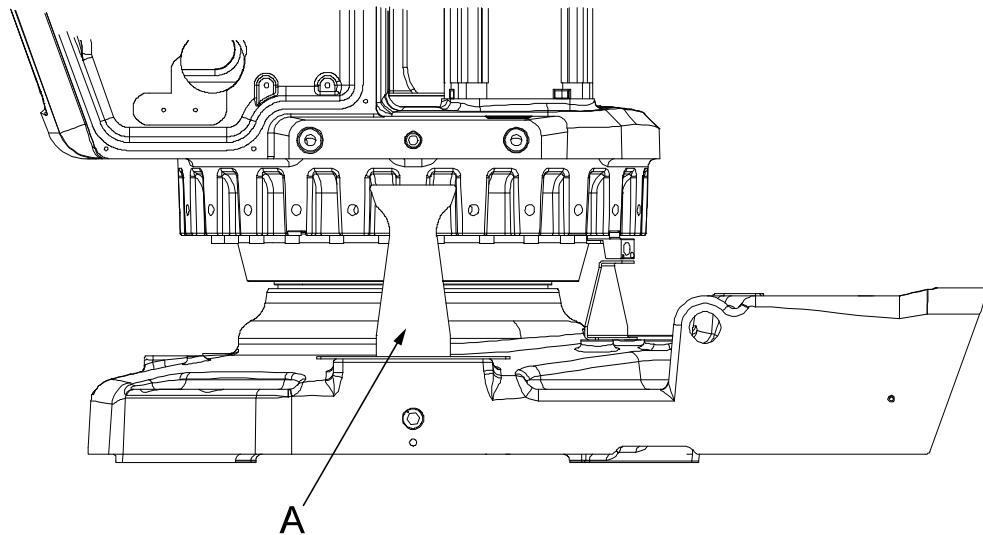


## WARNING

Mechanical stop pin can not be fitted onto robot if option 561-1 *Extended work range axis 1* is used.

## Location of mechanical stop pin

The axis-1 mechanical stop is located as shown in the figure.



xx0200000151

A

Mechanical stop pin

## Required equipment

Visual inspection, no tools are required.

Continues on next page

### 3 Maintenance

#### 3.3.10 Inspecting the axis-1 mechanical stop pin

*Continued*

##### Inspecting, mechanical stop pin

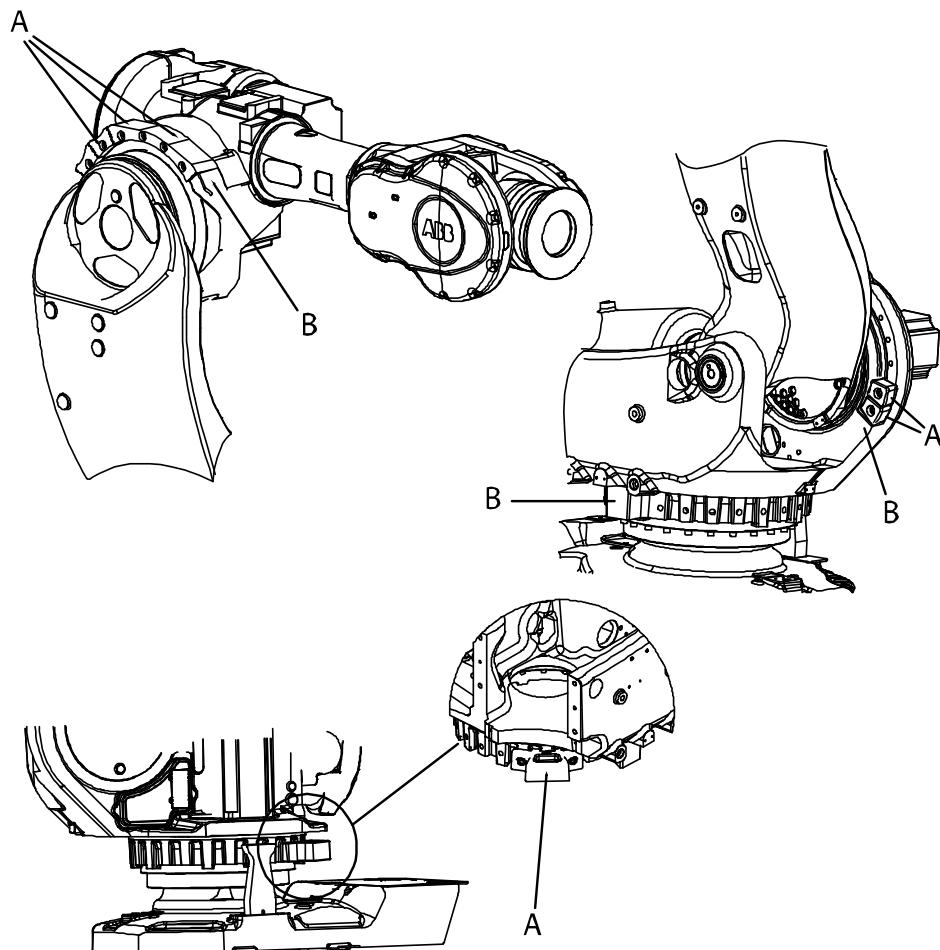
Use this procedure to inspect the axis-1 mechanical stop pin.

Action	Note
<p>1</p> <p> <b>DANGER</b></p> <p>Turn off all:</p> <ul style="list-style-type: none"><li>• electric power supply</li><li>• hydraulic pressure supply</li><li>• air pressure supply</li></ul> <p>to the robot, before entering the robot working area.</p>	
<p>2</p> <p>Inspect the axis-1 mechanical stop pin. If the mechanical stop pin is bent or damaged, it must be replaced.</p> <p> <b>Note</b></p> <p>The expected life of gearboxes can be reduced after collision with the mechanical stop.</p>	
<p>3</p> <p>Make sure the mechanical stop pin can move in both directions.</p>	

## 3.3.11 Inspecting the additional mechanical stops

**3.3.11 Inspecting the additional mechanical stops****Location of mechanical stops**

The figure shows the location of the additional mechanical stops on axes 1, 2 and 3 (IRB 7600 shown).



xx0200000150

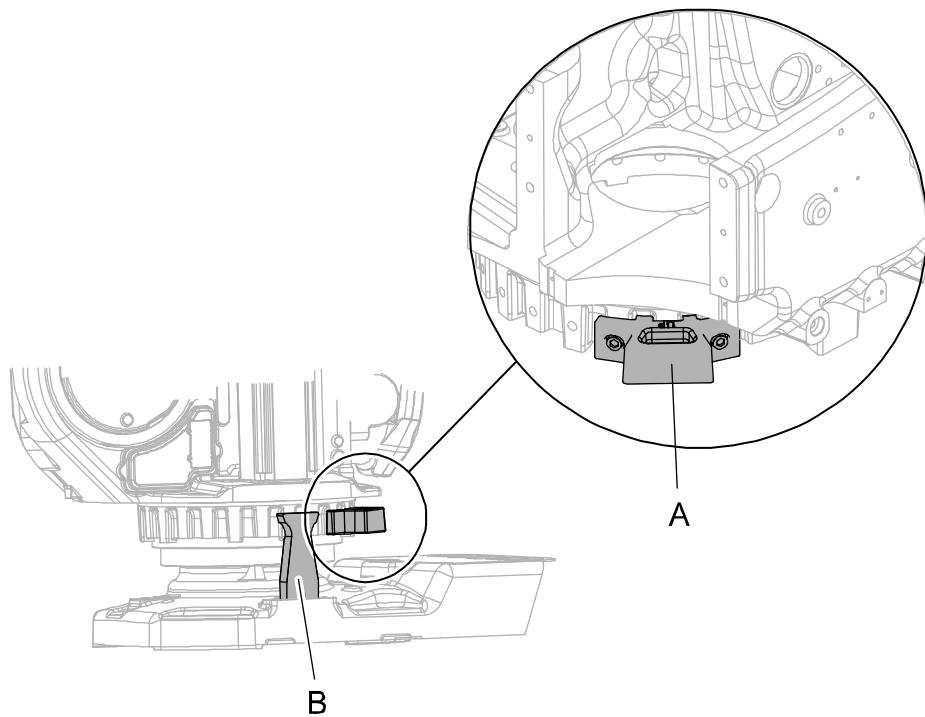
A	Additional stop
B	Fixed stop

*Continues on next page*

### 3 Maintenance

#### 3.3.11 Inspecting the additional mechanical stops

*Continued*



xx0300000049

A	Additional mechanical stop
B	Stop pin

#### Required equipment

Equipment etc.	Article number	Note
Mechanical stop axis 1	3HAC11076-1	Limits the robot working range by 7.5°.
Mechanical stop axis 1	3HAC11076-2	Limits the robot working range by 15°.
Mechanical stop axis 2	3HAC13787-1	Includes: <ul style="list-style-type: none"><li>• Mechanical stop</li><li>• Attachment screw and washer</li><li>• Document for mechanical stop</li></ul>
Mechanical stop set axis 3	3HAC13128-1	Includes: <ul style="list-style-type: none"><li>• Mechanical stop</li><li>• Attachment screw and washer</li><li>• Document for mechanical stop</li></ul>
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .

*Continues on next page*

## 3.3.11 Inspecting the additional mechanical stops

*Continued***Inspecting, mechanical stops**

Use this procedure to inspect the additional mechanical stops.

	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply</li> <li>• hydraulic pressure supply</li> <li>• air pressure supply</li> </ul> to the robot, before entering the robot working area.	
2	Make sure no additional stops are damaged.	Shown in figure <a href="#">Location of mechanical stops on page 169</a> .
3	Make sure the stops are properly attached. Correct tightening torque, additional mechanical stops: <ul style="list-style-type: none"> <li>• Axis 1 = 115 Nm</li> <li>• Axes 2 and 3 = 115 Nm</li> </ul>	
4	If any damage is detected, the mechanical stops must be replaced!  Correct attachment screws: <ul style="list-style-type: none"> <li>• Axis 1: M16 x 35, quality 12.9.</li> <li>• Axis 2: M16 x 50</li> <li>• Axis 3: M16 x 60</li> </ul>	Article number is specified in <a href="#">Required equipment on page 170</a> .

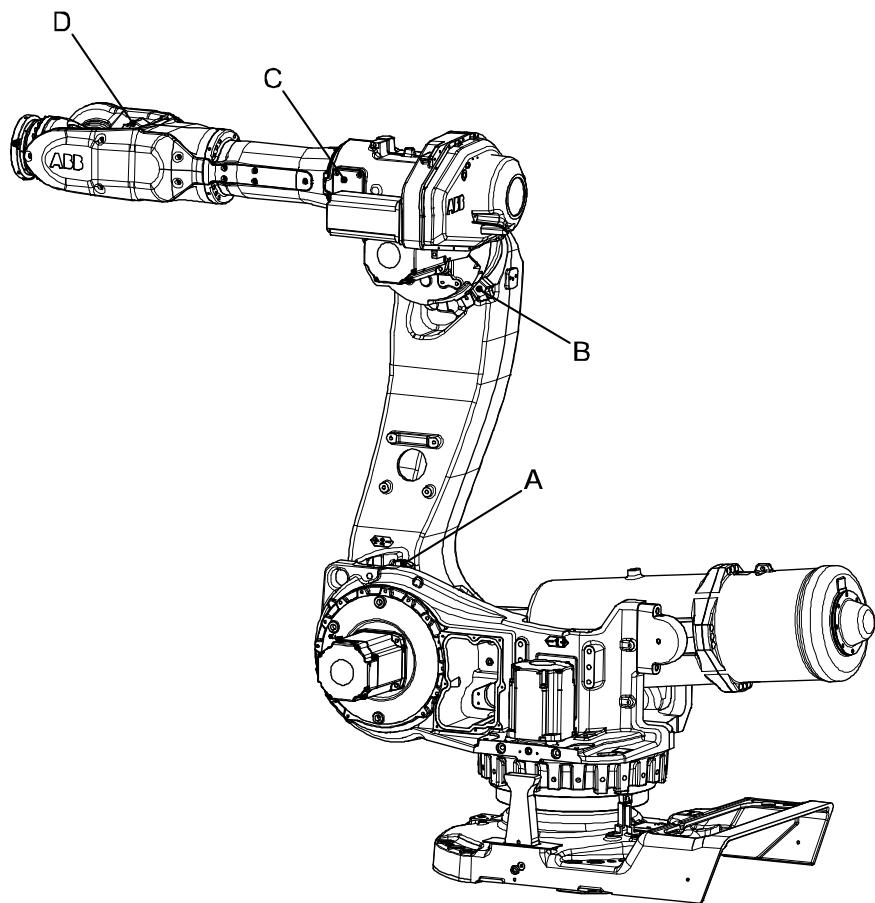
### 3 Maintenance

#### 3.3.12 Inspecting the damper on axes 2-5

#### 3.3.12 Inspecting the damper on axes 2-5

##### Location of dampers

The figure below shows the location of all the dampers to be inspected.



xx0400001024

A	Damper, axis 2 (2 pcs)
B	Damper, axis 3 (2 pcs)
C	Damper, axis 4 (1 pc)
D	Damper, axis 5 (2 pcs)

##### Required equipment

A damper must be replaced if damaged!

Equipment	Spare part/ art. no.	Note
Damper axis 2	3HAC12991-1	
Damper axis 3	3HAC12320-1	
Damper axis 4	3HAC13564-1	
Standard toolkit	3HAC15571-1	Content is defined in section <a href="#">Standard tools on page 435</a> .

*Continues on next page*

**Inspection, dampers**

The procedure below details how to inspect the dampers, axes 2-5.

	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
2	Check all <i>dampers</i> for damage, and for cracks or existing impressions larger than 1 mm. To inspect the damper axis 4, remove the two covers on top of the upper arm!	Shown in the figure <a href="#">Location of dampers on page 172</a> .
3	Check attachment screws for deformation.	
4	If any damage is detected, the damper must be replaced with a new one!	Art. no. is specified in <a href="#">Required equipment on page 172</a> .

### 3 Maintenance

#### 3.3.13 Inspection, position switch axes 1, 2 and 3

#### 3.3.13 Inspection, position switch axes 1, 2 and 3

##### Position switches, axes 1-3

The position switches are shown, fitted to the robot, in section [Installation of position switches \(option\) on page 117](#).

##### Required equipment

Equipment, etc.	Art. no.	Note
Position switch, axes 1-3	-	The article numbers of the position switches are specified in section <a href="#">Installation of position switches (option) on page 117</a> .
Standard toolkit	-	The contents are defined in section <a href="#">Standard tools on page 435</a> in part 2 of the Product manual.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

##### Inspection, position switches

The procedure below details how to inspect the position switch, axes 1, 2 and 3.

See the figures in section [Installation of position switches \(option\) on page 117](#) to locate the different components to be inspected.

	Action	Note
1	 <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2	Check the position switch! <ul style="list-style-type: none"><li>• Check that the rollers are easy to push in and that they roll freely.</li></ul>	
3	Check the rail! <ul style="list-style-type: none"><li>• Check that the rail is firmly attached with the attachment screws.</li></ul>	
4	Check the cams! <ul style="list-style-type: none"><li>• Check that the rollers have not caused any impressions on the cams.</li><li>• Check that the cams are clean. Wipe them if necessary!</li><li>• Check that the set screws holding the cams in position are firmly attached.</li></ul>	

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#### 3.3.13 Inspection, position switch axes 1, 2 and 3

*Continued*

Action	Note
5 Check the protection sheets on axis 1! <ul style="list-style-type: none"><li>• Check that the three sheets are in position and not damaged. Deformation can result in rubbing against the cams!</li><li>• Check that the area inside of the sheets is clean enough not to interfere the function of the position switch.</li></ul>	
6 If any damage is detected, the position switch must be replaced!	Art. no. is specified in <a href="#">Required equipment on page 174!</a>

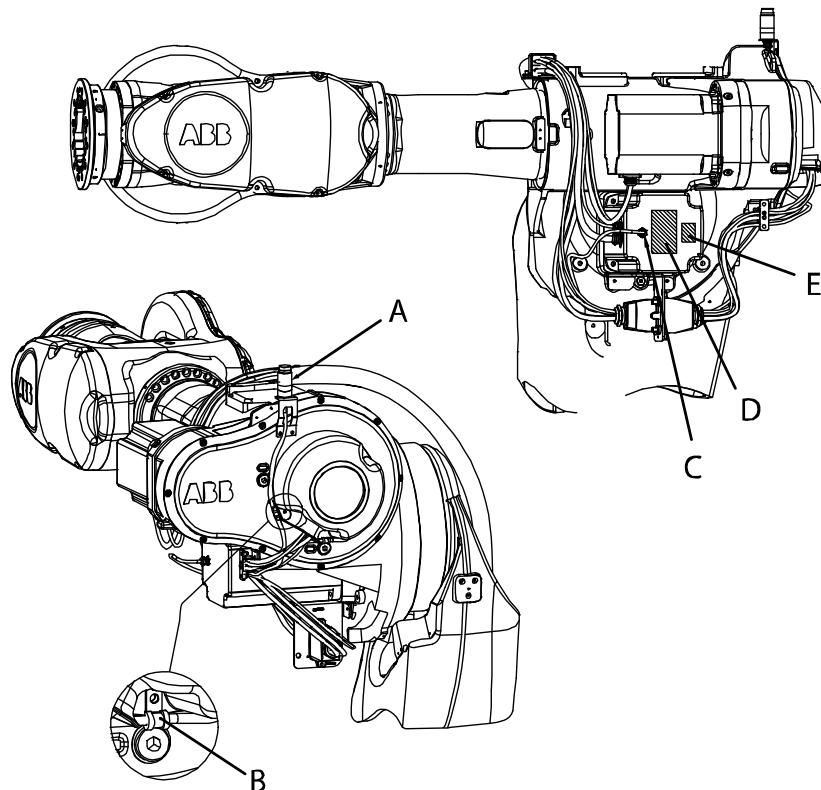
### 3 Maintenance

#### 3.3.14 Inspecting, signal lamp

#### 3.3.14 Inspecting, signal lamp

##### Location of signal lamp

The signal lamp is located as shown in figure below. Note that the position can differ depending on how the customer harness for axis 4-6 is mounted. See assembly drawing on the current harness for alternative positioning.



xx0200000240

A	Signal lamp
B	Clamp
C	Position for cable gland
D	Warning label on motor cover
E	Warning sign on motor cover

##### Required equipment

Equipment, etc.	Art. no.	Note
Signal lamp	3HAC10830-1	To be replaced in case of detected damage.
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

Continues on next page

**Inspecting, signal lamp**

Use this procedure to inspect the function of the signal lamp.

	Action	Note
1	Check that signal lamp is lit when motors are put in operation ("MOTORS ON").	
2	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
3	If the lamp is not lit, trace the fault by: <ul style="list-style-type: none"> <li>• Checking whether the <i>signal lamp</i> is broken. If so, replace it.</li> <li>• Checking cable connections.</li> <li>• Measuring the voltage in connectors motor axis 3 (=24V).</li> <li>• Checking the cabling. Replace cabling if a fault is detected.</li> </ul>	Art. no. is specified in <a href="#">Required equipment on page 176</a> .

## 3 Maintenance

### 3.4.1 Type of lubrication in gearboxes

## 3.4 Replacement/changing activities

### 3.4.1 Type of lubrication in gearboxes

#### Introduction

This section describes where to find information about the *type of lubrication*, *article number* and the *amount of lubrication* in the specific gearbox. It also describes the equipment needed when working with lubrication.

#### Type and amount of oil in gearboxes

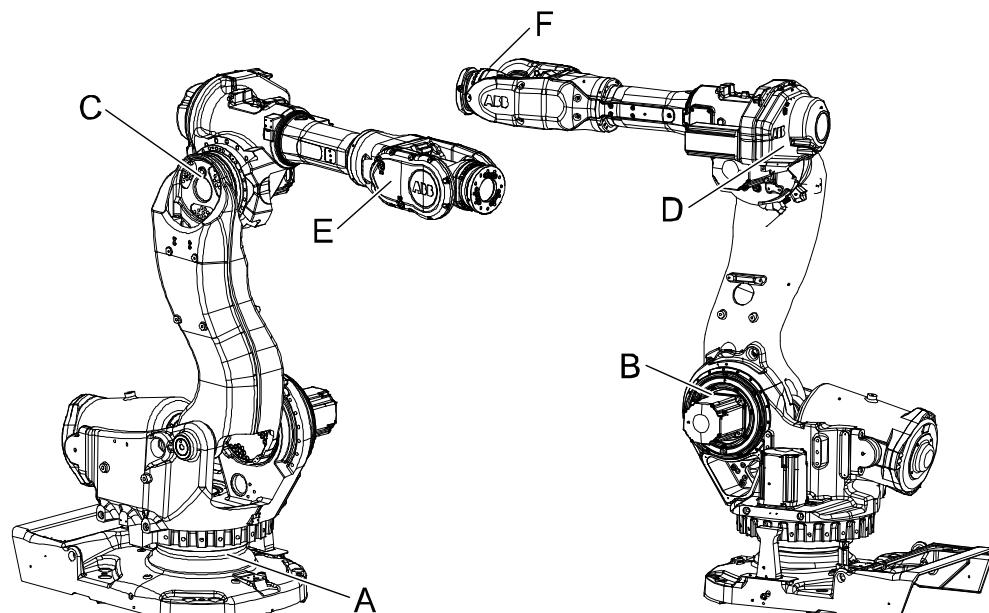
Information about the *type of lubrication*, *article number* as well as the *amount* in the specific gearbox can be found in *Technical reference manual - Lubrication in gearboxes* on the Documentation DVD (released twice a year). The revision of the manual published on the Documentation DVD, will contain the latest updates when the Documentation DVD is released.

Before starting any inspection, maintenance, or changing activities of lubrication, **always** contact the local ABB Service organization for more information.

For ABB personnel: Always check ABB Library for the latest revision of the manual *Technical reference manual - Lubrication in gearboxes*, in order to always get the latest information of updates about lubrication in gearboxes. A new revision will be published on ABB Library immediately after any updates. Therefore the manual published on the documentation DVD may not contain the latest updates about lubrication.

#### Location of gearboxes

The figure shows the location of the gearboxes.



xx0800000247

A	Axis 1 gearbox
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#### 3.4.1 Type of lubrication in gearboxes

*Continued*

B	Axis 2 gearbox
C	Axis 3 gearbox
D	Axis 4 gearbox
E	Axis 5 gearbox
F	Axis 6 gearbox

---

#### Equipment

Equipment	Note
Oil dispenser	<p>Includes pump with outlet pipe. Use the suggested dispenser or a similar one:</p> <ul style="list-style-type: none"><li>• Orion OriCan article number 22590 (pneumatic)</li></ul>
Nipple for quick connect fitting, with o-ring	

### 3 Maintenance

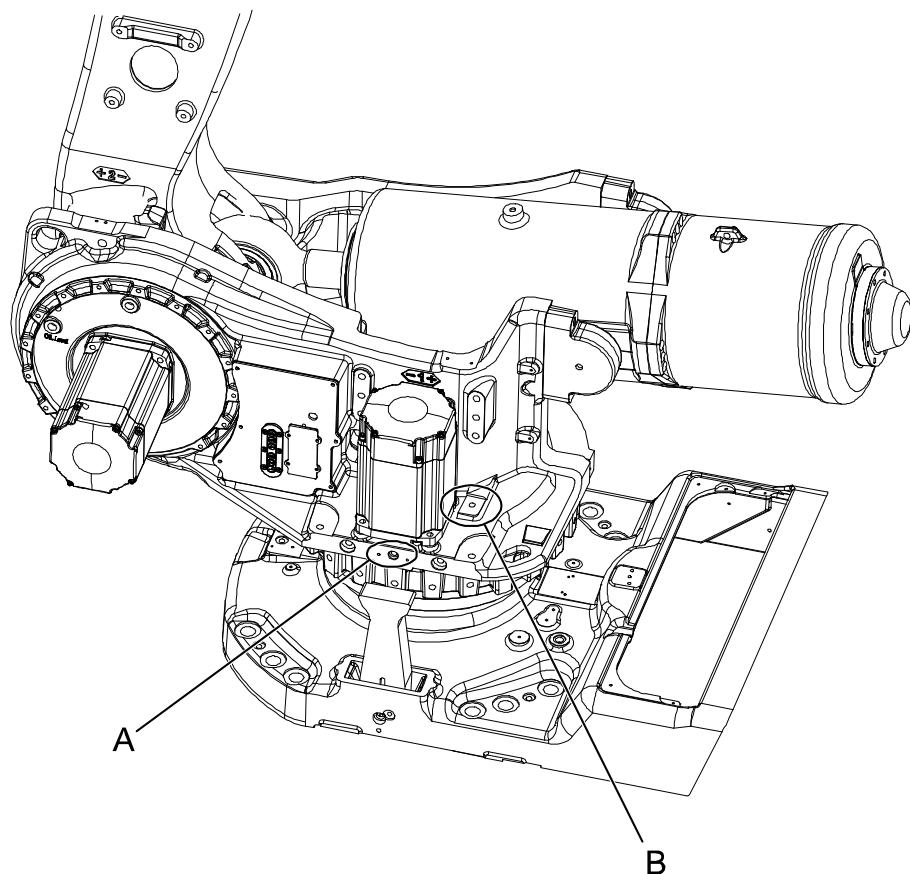
#### 3.4.2 Changing oil, axis-1 gearbox

#### 3.4.2 Changing oil, axis-1 gearbox

##### Location of oil plugs

The axis-1 gearbox is located between the frame and base. See oil plugs in the following figure.

The oil is drained through a hose, which is located at the rear of the robot base.



xx0300000583

A	Oil plug, inspection
B	Oil plug, filling

##### Required equipment

Equipment, etc.	Art. no.	Amount	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	 Note Do not mix with other oils!
Oil collecting vessel	-		Capacity: 8,000 ml.
Oil exchange equipment	3HAC021745-001		Content is defined in section <a href="#">Special tools on page 436</a> .

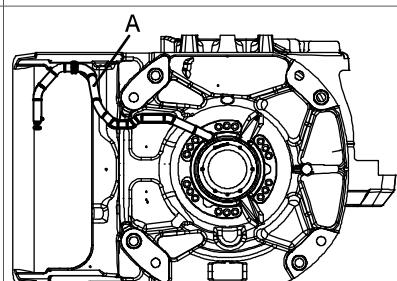
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Equipment, etc.	Art. no.	Amount	Note
Standard toolkit	-		Content is defined in section <a href="#">Standard tools on page 435</a> .

**Draining oil, axis-1 gearbox**

Use this procedure to drain the oil in gearbox axis 1.

When using oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 180](#).

	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply</li> <li>• hydraulic pressure supply</li> <li>• air pressure supply</li> </ul> to the robot, before entering the robot working area.	
2	 <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
3	Remove rear cover on the base by unscrewing its attachment screws.	
4	Pull out the draining hose from the rear of the base.	 xx0200000237 The hose is located beneath the base, seen from below. A Oil draining hose
5	Place an oil vessel close to hose end.	Vessel capacity is specified in <a href="#">Required equipment on page 180</a> .
6	Remove oil plug, filling in order to drain oil quicker!	Shown in figure <a href="#">Location of oil plugs on page 180</a> .

Continues on next page

### 3 Maintenance

#### 3.4.2 Changing oil, axis-1 gearbox

*Continued*

Action	Note
7 Open the hose end and drain the oil into a vessel.   <b>CAUTION</b> Drain as much oil as possible. See <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57.</a>	 Note Draining is time-consuming. Elapsed time depends on the temperature of the oil.
8 Close the oil drain hose, and put it back inside the base.	
9 Refit rear cover by securing it with its attachment screws.	

#### Filling oil, axis-1 gearbox

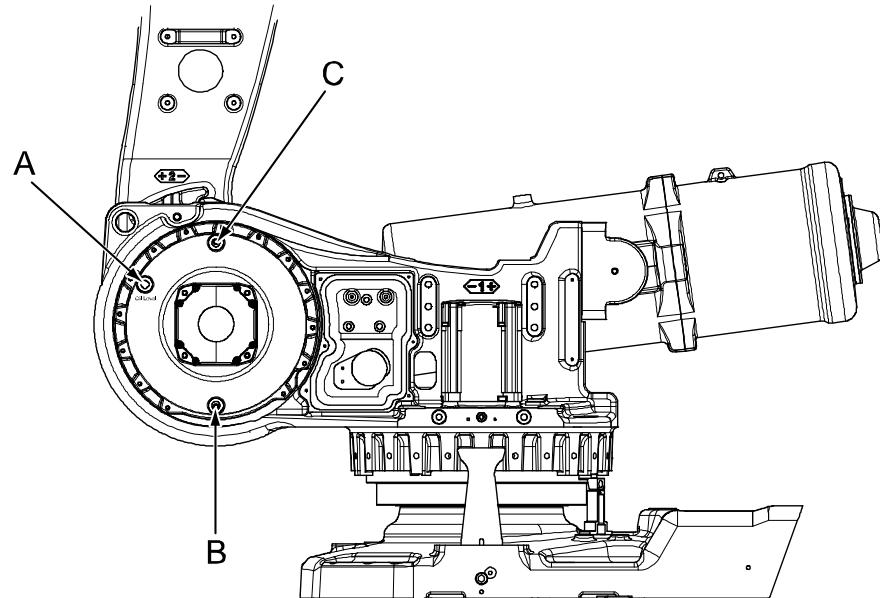
Use this procedure to fill gearbox axis 1 with oil.

Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply</li><li>• hydraulic pressure supply</li><li>• air pressure supply</li></ul> to the robot, before entering the robot working area.	
2  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57.</a>	
3 Open the <i>oil plug, filling.</i>	Shown in figure <a href="#">Location of oil plugs on page 180.</a>
4 Refill the gearbox with clean <i>lubricating oil.</i> The correct oil level is detailed in section <a href="#">Inspecting the oil level in axis-1 gearbox on page 139.</a>	Where to find type of oil and total amount is detailed in <a href="#">Type and amount of oil in gearboxes on page 178.</a>
5  <b>WARNING</b> Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <a href="#">Technical reference manual - Lubrication in gearboxes.</a>	
6 Refit the <i>oil plug, filling.</i>	Tightening torque: 24 Nm.

### 3.4.3 Changing oil, axis-2 gearbox

#### Location of oil plugs

The axis-2 gearbox is located in the lower arm rotational center, underneath the motor attachment.



xx0300000631

A	Oil plug, filling
B	Oil plug, draining
C	Vent hole

#### Required equipment

Equipment, etc.	Art. no.	Amount	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178.</a>	See <a href="#">Type and amount of oil in gearboxes on page 178.</a>	<b>Note!</b> Do not mix with other oil types!
Oil collecting vessel	-		Capacity: 6,000 ml.
Oil exchange equipment	3HAC021745-001		Content is defined in section <a href="#">Special tools on page 436.</a>
Standard toolkit	-		Content is defined in section <a href="#">Standard tools on page 435.</a>

*Continues on next page*

### 3 Maintenance

#### 3.4.3 Changing oil, axis-2 gearbox

Continued

##### Draining, oil

The procedure below details how to drain the oil in gearbox axis 2.

When using the oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 183](#).

	Action	Note
1	 <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2	 <b>WARNING</b>  Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
3	Remove the plug of the <i>filling/inspection hole</i> .	Shown in the figure <a href="#">Location of oil plugs on page 183</a> .
4	Remove the <i>oil plug, draining</i> , and drain the gearbox oil using a hose with nipple and an oil collecting vessel.   <b>CAUTION</b>  Drain as much oil as possible. See <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	Shown in the figure <a href="#">Location of oil plugs on page 183</a> .  Vessel capacity is specified in <a href="#">Required equipment on page 183</a> .   <b>Note</b>  Draining is time-consuming. Elapsed time varies depending on the temperature of the oil.
5	Refit the oil plug.	Tightening torque: 24 Nm.

##### Filling, oil

Use this procedure to fill oil into the axis-2 gearbox.

When using the oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 183](#).

	Action	Note
1	 <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	

Continues on next page

Action	Note
2  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
3 Remove the <i>oil plug for filling</i> and the plug from the <i>vent hole</i> .	Shown in the figure <a href="#">Location of oil plugs on page 183</a> .
4 Refill the gearbox with clean <i>lubricating oil</i> . The correct oil level is detailed in section <a href="#">Inspecting the oil level in axis-2 gearbox on page 142</a> .	Where to find type of oil and total amount is detailed in <a href="#">Type and amount of oil in gearboxes on page 178</a> .
5  <b>WARNING</b> Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <i>Technical reference manual - Lubrication in gearboxes</i> .	
6 Refit the oil plug and the plug in the vent hole.	Tightening torque: 24 Nm.

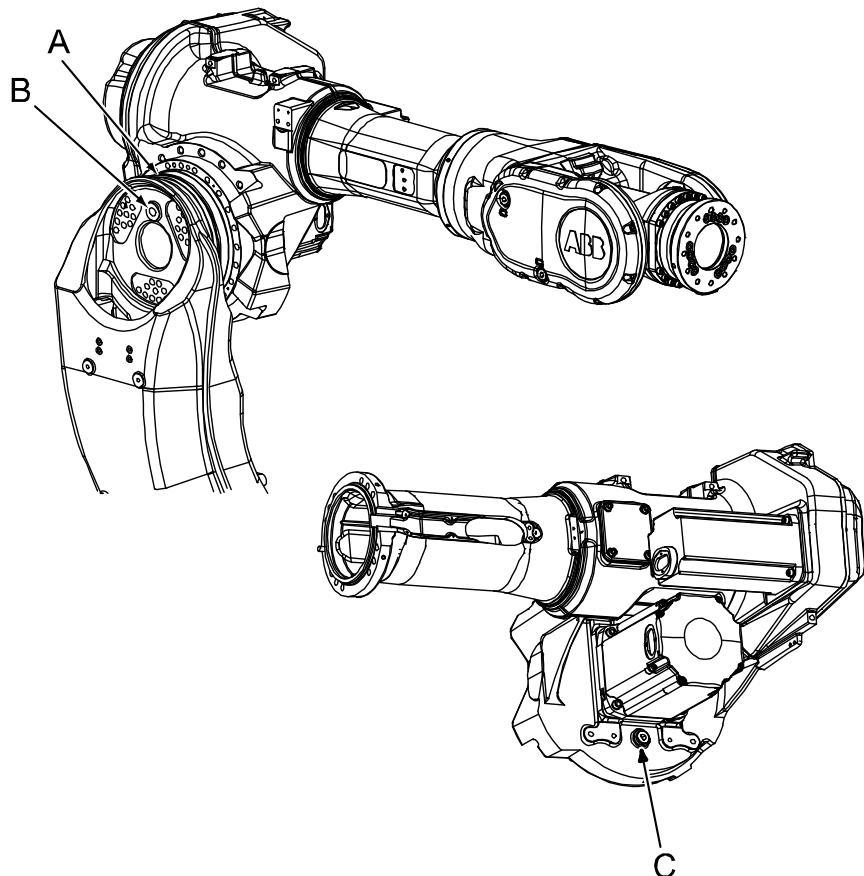
### 3 Maintenance

#### 3.4.4 Changing oil, axis-3 gearbox

#### 3.4.4 Changing oil, axis-3 gearbox

##### Location of gearbox

The axis-3 gearbox is located in the upper arm rotational center as shown in the following figure.



xx0200000230

A	Gearbox axis 3
B	Oil plug, filling
C	Oil plug, draining

##### Required equipment

Equipment, etc.	Art. no.	Amount	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178.</a>	See <a href="#">Type and amount of oil in gearboxes on page 178.</a>	Note! Do not mix with other oil types!
Oil exchange equipment	3HAC021745-001		Content is defined in section <a href="#">Special tools on page 436.</a>
Oil collecting vessel	-		Capacity: 3,000 ml.

Continues on next page

Equipment, etc.	Art. no.	Amount	Note
Standard toolkit	-		Content is defined in section <a href="#">Standard tools on page 435</a> .

**Draining, oil**

The procedure below details how to drain oil from the gearbox, axis 3.

When using the oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 186](#).

	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
2	 <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
3	Remove the <i>oil plug, filling</i> .	
4	Remove the <i>oil plug, draining</i> , and drain the gearbox oil using a hose with nipple and an oil collecting vessel.  <b>CAUTION</b> Drain as much oil as possible. See <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	Shown in the figure <a href="#">Location of gearbox on page 186</a> . Vessel capacity is specified in <a href="#">Required equipment on page 186</a> .  <b>Note</b> Draining is time-consuming. Elapsed time varies depending on the temperature of the oil.
5	Refit the oil plug.	Tightening torque: 24 Nm.

Continues on next page

### 3 Maintenance

#### 3.4.4 Changing oil, axis-3 gearbox

Continued

##### Filling, oil

The procedure below details how to fill oil into the gearbox, axis 3.

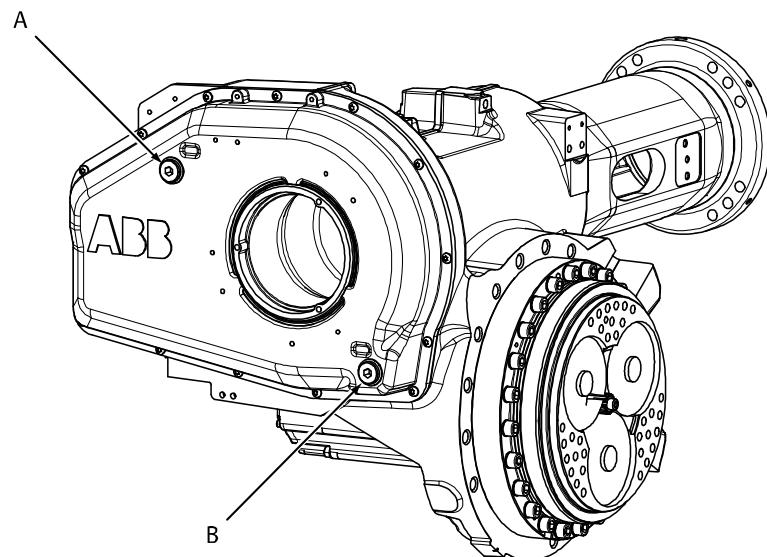
When using the oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 186](#).

Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
3 Remove the <i>oil plug, filling</i> .	Shown in the figure <a href="#">Location of gearbox on page 186</a> .
4 Refill the gearbox with clean <i>lubricating oil</i> . The correct oil level is detailed in section <a href="#">Inspecting the oil level in axis-3 gearbox on page 144</a> .	Where to find type of oil and total amount is detailed in <a href="#">Type and amount of oil in gearboxes on page 178</a> .
5  <b>WARNING</b> Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <a href="#">Technical reference manual - Lubrication in gearboxes</a> .	
6  <b>Note</b> Do not mix Kyodo Yushi TMO 150 with other oil types!	
7 Refit the <i>oil plug</i> .	Tightening torque: 24 Nm.

### 3.4.5 Changing oil, axis-4 gearbox

#### Location of gearbox

The axis 4 gearbox is located in the rearmost part of the upper arm as shown in the figure below.



xx0200000231

A	Oil plug, filling
B	Oil plug, draining

#### Required equipment

Equipment, etc.	Art. no.	Amount	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	
Oil exchange equipment	3HAC021745-001		Content is defined in section <a href="#">Special tools on page 436</a> .
Oil collecting vessel	-		Capacity: 9,000 ml.
Standard toolkit	-		Content is defined in section <a href="#">Standard tools on page 435</a> .

#### Draining, oil

The procedure below details how to drain the oil in the gearbox, axis 4.

When using the oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 189](#).

	Action	Note
1	Run the upper arm -45° from the calibration position.	

*Continues on next page*

### 3 Maintenance

#### 3.4.5 Changing oil, axis-4 gearbox

*Continued*

Action	Note
<b>2</b>  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
<b>3</b>  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
<b>4</b> Remove the <i>oil plug, filling</i> .	
<b>5</b> Drain the oil from the gearbox into a vessel by opening the <i>oil plug, draining</i> .	Shown in the figure <a href="#">Location of gearbox on page 189</a> . Vessel capacity is specified in <a href="#">Required equipment on page 189</a> .
<b>6</b> Run the upper arm back to its calibration position (horizontal position).	This is detailed in section <a href="#">Synchronization marks and synchronization position for axes on page 398</a> .
<b>7</b> Refit the oil plug, draining.	Tightening torque: 24 Nm.

#### Filling, oil

The procedure below details how to fill the oil in the gearbox, axis 4.

When using the oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 189](#).

Action	Note
<b>1</b>  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
<b>2</b>  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	

*Continues on next page*

Action	Note
3 Refill the gearbox with clean <i>lubricating oil</i> . The correct oil level is detailed in section <i>Inspecting the oil level in axis-4 gearbox on page 147</i> .	Shown in the figure <i>Location of gearbox on page 189</i> . Where to find type of oil and total amount is detailed in <i>Type and amount of oil in gearboxes on page 178</i> .
4  <b>WARNING</b>  Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <i>Technical reference manual - Lubrication in gearboxes</i> .	
5 Refit the oil plug, filling.	Tightening torque: 24 Nm.

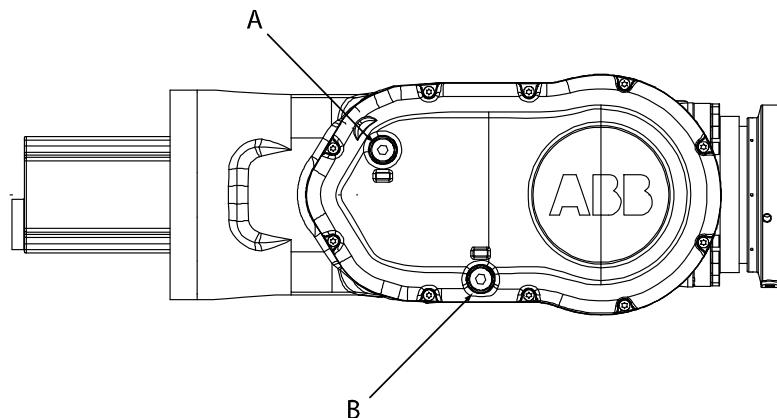
### 3 Maintenance

#### 3.4.6 Changing oil, axis-5 gearbox

#### 3.4.6 Changing oil, axis-5 gearbox

##### Location of gearbox

The axis 5 gearbox is located in the wrist unit as shown in the figure below.



xx0200000232

-	Wrist unit of IRB 6600 and IRB 6650
A	Oil plug, filling
B	Oil plug, draining

##### Required equipment

Equipment, etc.	Art. no.	Amount	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	See <a href="#">Type and amount of oil in gearboxes on page 178</a> .	
Oil exchange equipment	3HAC021745-001		Content is defined in section <a href="#">Special tools on page 436</a> .
Oil collecting vessel	-		Capacity: 7,000 ml.
Standard toolkit	-		Content is defined in section <a href="#">Standard tools on page 435</a> .

##### Draining, oil, axis 5

The procedure below details how to change the oil in gearbox, axis 5.

When using the oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 192](#).

	Action	Note
1	Run axis 4 to a position where the oil plug for draining is facing downwards.	

Continues on next page

Action	Note
2  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
3  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
4 Remove the <i>oil plug, filling</i> .	
5 Drain the oil from the gearbox by opening the <i>oil plug, draining</i> .	Shown in the figure <a href="#">Location of gearbox on page 192</a> . Vessel capacity is specified in <a href="#">Required equipment on page 192</a> .
6 Refit the oil plug, draining.	Tightening torque: 24 Nm.

**Filling, oil, axis 5**

The procedure below details how to change the oil in gearbox, axis 5.

When using the oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 192](#).

Action	Note
1 Run axis 4 to a position where the oil plug, filling, is facing upwards.	
2  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
3  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	

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### 3 Maintenance

#### 3.4.6 Changing oil, axis-5 gearbox

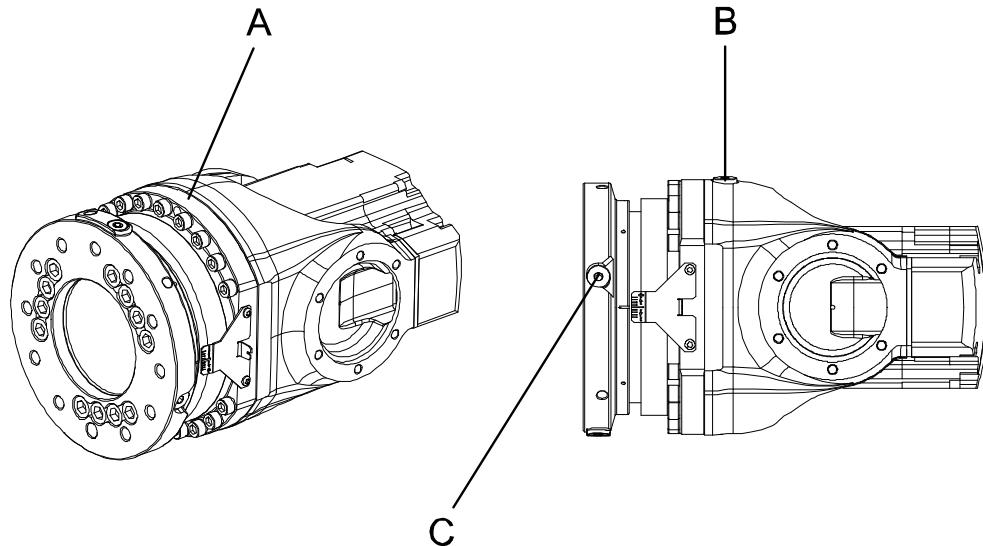
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	Action	Note
4	Refill the gearbox with clean <i>lubricating oil</i> . The correct oil level is detailed in section <a href="#">Inspecting the oil level in axis-5 gearbox on page 149</a> .	Shown in the figure <a href="#">Location of gearbox on page 192</a> . Where to find type of oil and total amount is detailed in <a href="#">Type and amount of oil in gearboxes on page 178</a> .
5	 <b>WARNING</b>  Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <i>Technical reference manual - Lubrication in gearboxes</i> .	
6	Refit the oil plug, filling.	Tightening torque: 24 Nm.

### 3.4.7 Changing oil, axis-6 gearbox

#### Location of gearbox

The axis 6 gearbox is located in the center of the wrist unit as shown in the figure below.



xx0400001092

-	The figure above shows the wrist unit .
A	Gearbox, axis 6
B	Oil plug, filling
C	Oil plug, draining

#### Required equipment

Equipment, etc.	Art. no.	Amount	Note
Lubricating oil	See <a href="#">Type and amount of oil in gearboxes on page 178.</a>	See <a href="#">Type and amount of oil in gearboxes on page 178.</a>	 Note Do not mix with other oils!
Oil exchange equipment	3HAC021745-001		Content is defined in section <a href="#">Special tools on page 436.</a>
Oil collecting vessel	-		Vessel capacity: 500 ml
Standard toolkit	-		Content is defined in section <a href="#">Standard tools on page 435.</a>

Continues on next page

### 3 Maintenance

#### 3.4.7 Changing oil, axis-6 gearbox

Continued

##### Draining, oil, axis 6

The procedure below details how to drain oil from the gearbox, axis 6.

When using the oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 195](#).

Action	Note
1 Run the robot to a position where the <i>oil plug, filling</i> of axis 6 gearbox is facing downwards.	Shown in the figure <a href="#">Location of gearbox on page 195</a> .
2  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
3  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
4 Drain the oil from the gearbox into a vessel by removing the oil plug.	Vessel capacity is specified in <a href="#">Required equipment on page 195</a> .
Measure the amount of oil drained.	The amount of oil to be refilled depends on the amount previously drained.
5 Refit the <i>oil plug, draining</i> .	Tightening torque: 24 Nm.

##### Filling, oil, axis 6

The procedure below details how to fill oil into the gearbox, axis 6.

When using the oil exchange equipment, follow the instructions enclosed with the kit. Art. no. for the kit is specified in [Required equipment on page 195](#).

Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	

Continues on next page

Action	Note
2  <b>WARNING</b> Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section <a href="#">WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 57</a> .	
3 Remove the <i>oil plug, filling.</i>	Shown in the figure <a href="#">Location of gearbox on page 195</a> .
4 Refill the gearbox with clean <i>lubricating oil</i> . The correct oil level is detailed in section <a href="#">Inspecting the oil level in axis-6 gearbox on page 151</a> .	Where to find type of oil and total amount is detailed in <a href="#">Type and amount of oil in gearboxes on page 178</a> .
5  <b>WARNING</b> Do not mix oil types! If wrong oil is refilled, the gearbox must be rinsed as detailed in <i>Technical reference manual - Lubrication in gearboxes</i> .	
6 Refit the oil plug.	Tightening torque: 24 Nm.
Inspect the oil level.	Detailed in the section <a href="#">Inspecting the oil level in axis-6 gearbox on page 151</a> .

### 3 Maintenance

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#### 3.4.8 Replacing the SMB battery



##### Note

The battery low alert (38213 **Battery charge low**) is displayed when the battery needs to be replaced. The recommendation to avoid an unsynchronized robot is to keep the power to the controller turned on until the battery is to be replaced.

For a SMB board with 3-pole battery contact (RMU101 3HAC044168-001 or RMU102 3HAC043904-001), the lifetime of a new battery is typically 36 months.

For a SMB board with 2-pole battery contact (DSQC), the typical lifetime of a new battery is 36 months if the robot is powered off 2 days/week or 18 months if the robot is powered off 16 h/day. The lifetime can be extended for longer production breaks with a battery shutdown service routine. See *Operating manual - IRC5 with FlexPendant* for instructions.



##### WARNING

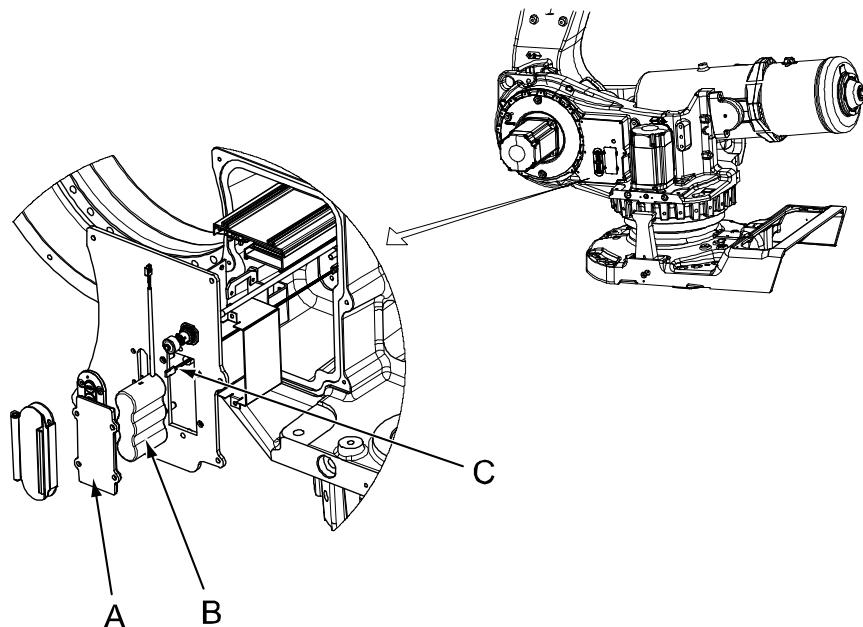
See instructions for batteries, [WARNING - Safety risks during handling of batteries on page 56](#).

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##### Location of SMB battery

The SMB battery (SMB = serial measurement board) is located on the left hand side of the frame as shown in the figure.

Battery pack with a 2-pole battery contact (DSQC)



xx0300000559

A	SMB Battery cover
B	SMB battery pack with 2-pole battery contact.
C	Battery cable

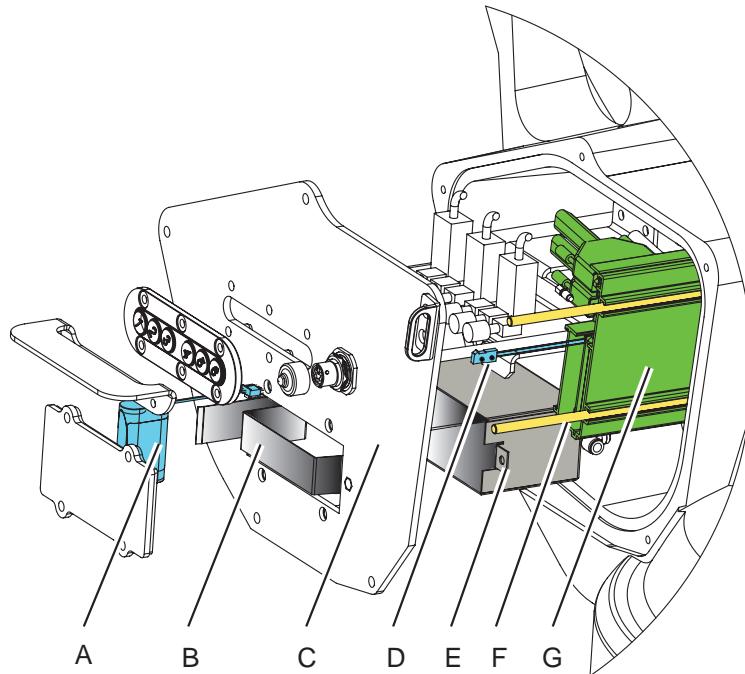
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### 3 Maintenance

#### 3.4.8 Replacing the SMB battery

*Continued*

Battery pack with a 3-pole battery contact (RMU)



xx1400002574

A	Battery pack RMU
B	Holder for battery
C	SMB cover
D	Battery cable
E	Battery holder
F	Guide pin (2 pcs)
G	SMB unit

#### Required equipment



##### Note

There are two variants of SMB units and batteries. One with 2-pole battery contact (DSQC) and one with 3-pole battery contact (RMU). The variant with the 3-pole battery contact has longer lifetime for the battery.

It is important that the SMB unit uses the correct battery. Make sure to order the correct spare parts. Do not exchange battery contacts!

Equipment, etc.	Spare part no.	Note
Battery unit	For spare part no. see: <ul style="list-style-type: none"><li><a href="#">Spare part lists on page 425</a></li></ul>	Battery includes protection circuits. Only replace with a specified spare part or an ABB-approved equivalent.
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .

*Continues on next page*

Equipment, etc.	Spare part no.	Note
Circuit diagram	-	See chapter <a href="#">Circuit diagram on page 441</a> .

**Removing, battery**

Use this procedure to remove the SMB battery.

	Action	Note
1	Move the robot to its calibration position.	This is done in order to facilitate updating of the revolution counter.
2	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply</li> <li>• hydraulic pressure supply</li> <li>• air pressure supply</li> </ul> to the robot, before entering the robot working area.	
3	 <b>ELECTROSTATIC DISCHARGE (ESD)</b> The unit is sensitive to ESD. Before handling the unit please read the safety information in the section <a href="#">WARNING - The unit is sensitive to ESD! on page 54</a>	
4	Remove the <i>SMB battery cover</i> by unscrewing the attachment screws.	Shown in figure <a href="#">Location of SMB battery on page 199</a> .
5	Pull out the battery and disconnect the <i>battery cable</i> .	Shown in figure <a href="#">Location of SMB battery on page 199</a> .
6	Remove the <i>SMB battery</i> . Battery includes protection circuits. Only replace with a specified spare part or with an ABB- approved equivalent.	Shown in figure <a href="#">Location of SMB battery on page 199</a> .

**Refitting, battery**

Use this procedure to refit the SMB battery.

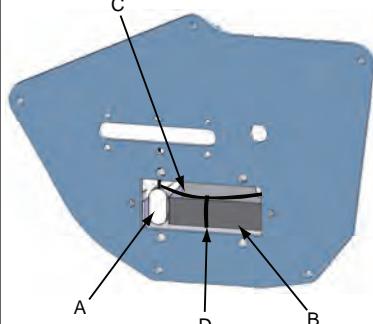
	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply</li> <li>• hydraulic pressure supply</li> <li>• air pressure supply</li> </ul> to the robot, before entering the robot working area.	

*Continues on next page*

### 3 Maintenance

#### 3.4.8 Replacing the SMB battery

*Continued*

Action	Note
<p>2  <b>ELECTROSTATIC DISCHARGE (ESD)</b> The unit is sensitive to ESD. Before handling the unit please read the safety information in the section <a href="#">WARNING - The unit is sensitive to ESD! on page 54</a></p>	
<p>3 Reconnect the <i>battery cable</i> and install the battery pack into the SMB/battery recess.</p> <p> <b>Note</b> RMU batteries are installed together with a battery holder to be properly secured inside the recess. See figure. Strap the battery cable to the holder.</p>	<p>Art. no. is specified in <a href="#">Required equipment on page 200</a>. Shown in figure <a href="#">Location of SMB battery on page 199</a>.</p>  <p>xx1300000307</p> <p>A Battery pack RMU B Battery holder C Battery cable D Strap</p>
4 Secure the <i>SMB battery cover</i> with its attachment screws.	Shown in figure <a href="#">Location of SMB battery on page 199</a> .
5 Update the revolution counters.	Detailed in chapter Calibration - section <a href="#">Updating revolution counters on page 401</a> .
<p>6  <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a>.</p>	

## 3.5.1 Lubrication of spherical roller bearing, balancing device

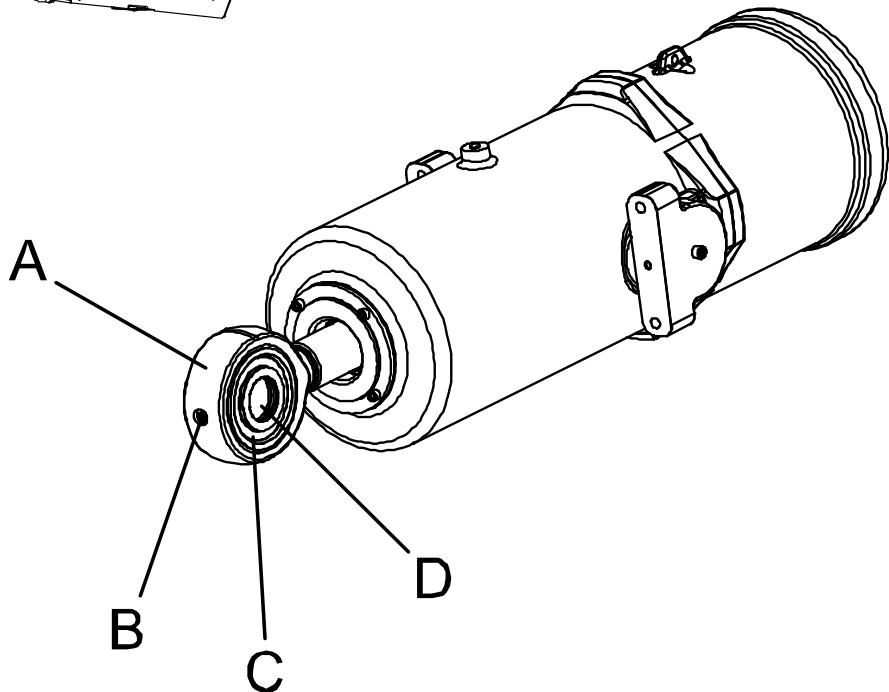
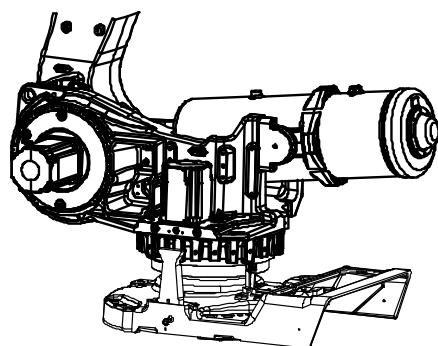
## 3.5 Lubrication activities

## 3.5.1 Lubrication of spherical roller bearing, balancing device

## Location of bearing

The spherical roller bearing is located at the front ear of the balancing device, as shown in the figure below.

**Note!** The balancing device must be mounted on the robot when lubricating the bearing!



xx0400000721

A	Ear (spherical roller bearing located inside)
B	Lubrication nipple
C	Sealing spacer
D	Hole through which the shaft is pressed

Continues on next page

### 3 Maintenance

#### 3.5.1 Lubrication of spherical roller bearing, balancing device

*Continued*

##### Required equipment

Equipment, etc.	Art. no.	Note
Grease	3HAC042534-001	Optimol PDO, 150 ml
Lubrication nipple		M6. Normally fitted to the link ear at delivery.
Grease pump	-	

##### Lubrication, balancing device bearing (Design 1)

The procedure below details how to lubricate the spherical roller bearing.

	Action	Note
1	 <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2	Lubricate the spherical roller bearing through the lubrication nipple in the ear with <i>grease</i> . Fill until excessive grease is forced out between the shaft and the sealing spacer.	Art. no. and amount is specified in <a href="#">Required equipment on page 204!</a> Shown in the figure <a href="#">Location of bearing on page 203!</a> The balancing device must be mounted on the robot when lubricating the bearing!
3	Clean the area from any excessive grease and check the area once again after operation of the robot, in order to make sure there is no incorrect leakage from the o-rings.	Read more about the inspection in section Inspection, balancing device - <a href="#">Check for leakage on page 158.</a>

##### Lubrication, balancing device bearing (Design 2)

The procedure below details how to lubricate the spherical roller bearing.

	Action	Note
1	 <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2	Lubricate the spherical roller bearing through the lubrication nipple in the ear with <i>grease</i> . Fill until excessive grease is forced out through the hole of the lower securing screw.	Art. no. and amount is specified in <a href="#">Required equipment on page 204!</a> Shown in the figure <a href="#">Location of bearing on page 203!</a> The balancing device must be mounted on the robot when lubricating the bearing!

*Continues on next page*

#### 3.5.1 Lubrication of spherical roller bearing, balancing device

*Continued*

Action	Note
Refit the lower securing screw and washer.	M6 x 10, washer: D=6,4/12 T=1,6 Tightening torque: 6 Nm.
3 Clean the area from any excessive grease and check the area once again after operation of the robot, in order to make sure there is no incorrect leakage from the o-rings.	Read more about the inspection in section Inspection, balancing device - <a href="#"><i>Check for leakage on page 158.</i></a>

## 3 Maintenance

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### 3.6.1 Cleaning the IRB 6650S

## 3.6 Cleaning activities

### 3.6.1 Cleaning the IRB 6650S



#### WARNING

Turn off all electrical power supplies to the manipulator before entering its work space.

---

#### General

To secure high uptime it is important that the IRB 6650S is cleaned regularly. The frequency of cleaning depends on the environment in which the manipulator works. Different cleaning methods are allowed depending on the type of protection of the IRB 6650S.



#### Note

Always verify the protection type of the robot before cleaning.

---

#### Oil spills

##### Oil spills from gearboxes

Use the following procedure if any oil spills are detected that can be suspected to originate from a gearbox.

- 1 Inspect that the oil level in the suspected gearbox is according to the recommendations, see [Inspection activities on page 139](#).
- 2 Write down the oil level.
- 3 Inspect the oil level again after, for example, 6 months.
- 4 If the oil level is decreased then replace the gearbox.

##### Oil spills discolors painted surfaces

Oil spills on painted surfaces of the robot can result in discoloration.



#### Note

After all repair and maintenance work involving oil, always wipe the robot clean from all surplus oil.

---

#### Dos and don'ts!

This section specifies some special considerations when cleaning the robot.

##### Always!

- Always use cleaning equipment as specified! Any other cleaning equipment may shorten the life of the robot.
- Always check that all protective covers are fitted to the robot before cleaning!

*Continues on next page*

**Never!**

- Never point the water jet at connectors, joints, sealings, or gaskets!
- Never use compressed air to clean the robot!
- Never use solvents that are not approved by ABB to clean the robot!
- Never spray from a distance closer than 0.4 meters!
- Never remove any covers or other protective devices before cleaning the robot!

**Cleaning methods**

These following table defines what cleaning methods are allowed for ABB manipulators depending on the protection type.

Protection type	Cleaning method			
	Vacuum cleaner	Wipe with cloth	Rinse with water	High pressure water or steam
<b>Standard</b>	Yes	Yes. With light cleaning detergent.	Yes. It is highly recommended that the water contains a rust-prevention solution and that the manipulator is dried afterwards.	No
<b>Foundry Plus</b>	Yes	Yes. With light cleaning detergent or spirit.	Yes. It is highly recommended that the water contains a rust-prevention solution.	Yes <sup>i</sup> . It is highly recommended that the water and steam contains rust preventive, without cleaning detergents.

<sup>i</sup> Perform according to section [Cleaning with water and steam on page 207](#).

**Cleaning with water and steam****Instructions for rinsing with water**

ABB robots with protection types *Standard*, *Foundry Plus*, *Wash*, or *Foundry Prime* can be cleaned by rinsing with water (water cleaner).<sup>1</sup>

The following list defines the prerequisites:

- Maximum water pressure at the nozzle: 700 kN/m<sup>2</sup> (7 bar)<sup>1</sup>
- Fan jet nozzle should be used, min. 45° spread
- Minimum distance from nozzle to encapsulation: 0.4 meters
- Maximum flow: 20 liters/min<sup>1</sup>

<sup>1</sup> Typical tap water pressure and flow

**Instructions for steam or high pressure water cleaning**

ABB robots with protection types *Foundry Plus*, *Wash*, or *Foundry Prime* can be cleaned using a steam cleaner or high pressure water cleaner.<sup>2</sup>

<sup>1</sup> See [Cleaning methods on page 207](#) for exceptions.

<sup>2</sup> See [Cleaning methods on page 207](#) for exceptions.

*Continues on next page*

## **3 Maintenance**

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### **3.6.1 Cleaning the IRB 6650S**

*Continued*

The following list defines the prerequisites:

- Maximum water pressure at the nozzle: 2500 kN/m<sup>2</sup> (25 bar)
  - Fan jet nozzle should be used, min. 45° spread
  - Minimum distance from nozzle to encapsulation: 0.4 meters
  - Maximum water temperature: 80° C
- 

#### **Cables**

Movable cables need to be able to move freely:

- Remove waste material, such as sand, dust and chips, if it prevents cable movement.
- Clean the cables if they have a crusty surface, for example from dry release agents.

## 3.7 Service Information System, M2000

### 3.7.1 Using the SIS system

#### General

This is a brief description of how to use the Service Information System, SIS for M2000 robot systems. Details may be found in:

- Service Information System, SIS
- Defining the SIS input parameters
- Setting the SIS parameters
- Importing/exporting SIS data
- Reading the SIS output logs

The section is only valid for M2000 systems. For information regarding M2004 robot systems, see additional documentation, *Operating manual - Service Information System*. Article number is specified in section [References on page 10](#).

#### Basic procedure

	Action	Reference
1	Determine which of the system functions you require.	These are described in <a href="#">Description of Service Information System (SIS) on page 210</a> .
2	Define what values are adequate and suitable for your application in your production environment.	Recommendations on how to define these are given in <a href="#">SIS system parameters on page 213</a> . Maintenance intervals recommended by ABB are specified in section <a href="#">Maintenance schedule and expected component life on page 134</a> .
3	Enter these parameters in the system.	How to do this is detailed in <a href="#">Setting the SIS parameters on page 214</a> .
4	Run the robot in normal operation.	
5	Reset the counter if a repair is made, or if a counter for any other reason is restarted.	The TPU displays for resetting any SIS value are shown in <a href="#">Description of Service Information System (SIS) on page 210</a> .
6	When a time limit, set in the parameters, is exceeded, a message may be read on the Tech Pendant Unit (TPU).	How to access this is detailed in <a href="#">Reading the SIS output logs on page 215</a> .
7	If the log containing the message is to be available from an external PC, or if the SIS parameters are to be entered from an external PC, a set of software tools are available to build such an application.	These are described in <a href="#">Exporting the SIS data on page 216</a> .

### 3 Maintenance

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#### 3.7.2 Description of Service Information System (SIS)

#### 3.7.2 Description of Service Information System (SIS)

---

##### General

Service Information System (SIS) is a software function within the robot controller, which simplifies maintenance of the robot system. It supervises the operating time and mode of the robot, and alerts the operator when a maintenance activity is scheduled.

Maintenance is scheduled by setting the system parameters of the type SIS Parameters, see section [Setting the SIS parameters on page 214](#). All system parameters are described in *User's Guide - System Parameters*.

---

##### Supervised functions

The following counters are available:

- Calendar time counter, a general alarm based on calendar time
- Operation time counter, a general alarm based on operational time
- Gearbox 1 operation time counter, based on percentage of the axis 1 gearbox service interval
- Gearbox 2 operation time counter, based on percentage of the axis 2 gearbox service interval
- Gearbox 3 operation time counter, based on percentage of the axis 3 gearbox service interval
- Gearbox 6 operation time counter, based on percentage of the axis 6 gearbox service interval

Counters are reset when maintenance has been performed.

The counter status is displayed after running the service routine for maintenance. Status "OK" indicates that no service interval limit has been exceeded by that counter.

---

##### Calendar time

This is a clock within the control system that keeps track of the service interval, based on calendar time.

When the calendar time limit for maintenance is reached, a message is displayed on the TPU. How to access this is detailed in section [Reading the SIS output logs on page 215](#).

The following information is available about the calendar time in the service routine.

Prev service	Date when the counter was reset last time, i.e. after the last service.
Elapsed time	Elapsed time since the counter was reset the last time.
Next service	Date when next scheduled service is planned. This date is calculated using system parameters, as detailed in section <a href="#">Setting the SIS parameters on page 214</a> .
Remaining time	Remaining time to next scheduled service date.

*Continues on next page*

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##### Operation time

This is a function within the control system that keeps track of the amount of time the "MOTORS ON" signal is active, i.e. the amount of time the robot is in the operating mode.

When the operation time limit for maintenance is reached, a message is displayed on the TPU. How to access this is detailed in section [Reading the SIS output logs on page 215](#).

The following information is available about the operation time in the service routine.

Service interval	The specified service interval until another service will be required. This parameter was entered manually as detailed in section <a href="#">Setting the SIS parameters on page 214</a> .
Elapsed time	Operation time since the service interval was set the last time.
Remaining time	Remaining operation time until the time set in service interval has expired.

---

##### Gearbox

Based on measurements, torque and RPM, for example, the system calculates an expected service interval for each gearbox. When service is due, a message will be shown on the TPU. How to access this is detailed in section [Reading the SIS output logs on page 215](#).

The following information is available about the joint service status in the service routine.

Joint x OK	Service status for axis x, i.e. the automatically calculated time parameter has not been exceeded.
Joint x NOK	The service interval for the axis in question has been reached.
Joint x N/A	No service time parameter calculation available. Applies to axes 4 and 5 (IRB 6600 and IRB 7600).

The following information is available for the axis service status in the service routine.

Consumed time	The consumed time as a percentage of the total amount of time.
Elapsed time	Operation time for axis x since calculation began.
Remaining time	Remaining operation time for axis x until the service time parameter value has been reached.

---

##### Reset values

Counters may be reset at any time by running the service routine.

When resetting, the counter variables are reset. The variables are described in section [Exporting the SIS data on page 216](#)!

---

##### Service interval exceeded

When the service time has been exceeded for the selection made, an error message (Service interval exceeded!) is displayed.

*Continues on next page*

### **3 Maintenance**

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#### **3.7.2 Description of Service Information System (SIS)**

*Continued*

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##### **No data available**

When no data is available for the selection made, a message (No data available!) is displayed when trying to display the data.

### 3.7.3 SIS system parameters

#### General

This section details the system parameters that may be set with estimated values. The values can be defined by the operating organization as knowledge of the robot's working conditions are accumulated.

Since the counters are to be used for purposes defined by the user, ABB cannot give any recommendations regarding their definitions.

#### Operation time limit (service level)

The number of operation hours selected as service interval.

E.g. by setting the value "20,000", the SIS will save this as the nominal time for activating the alarm, not counting the percentage described below.

#### Operation time warning

A percentage of the "Operation time limit" specified above.

E.g. by setting the value "90", the SIS will alert the operator 18,000 hours after an operation time "Reset" was made the last time.

#### Calendar time limit (service level)

The number of calendar years selected as service interval.

E.g. by setting the value "2", the SIS will save this as the nominal time for activating the alarm, not counting the percentage described below.

#### Calendar time warning

A percentage of the "Calendar time limit" specified above.

E.g. by setting the value "90", the SIS will alert the operator after 90% of two years, i.e. 657 days after a calendar time "Reset" was made the last time.

#### Gearbox warning

A percentage of the gearbox service interval as calculated by the system. E.g. by setting the value "90", the SIS will alert the operator after 90% of the expected service interval of *each* gearbox.

The robot system automatically detects and stores all required variables to calculate the expected service interval (estimated remaining lifetime) of each gearbox. This is done by extrapolating data from earlier operation into a function of time, using a formula including:

- input and output torque
- gearbox spindle speed
- other variables

### 3 Maintenance

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#### 3.7.4 Setting the SIS parameters

#### 3.7.4 Setting the SIS parameters

---

##### General

If the SIS system is to function properly, a number of parameters must be set. This is detailed below.

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##### Procedure M2000

This is an instruction of how to enter SIS parameters to the M2000 robot system.

Action	Note
1 Open "System parameters" using the TPU.	Detailed in the User's Guide.
2 Go to "System parameters/Manipulator/types 2".	
3 Select "0 SIS parameters" and press "Enter".	
4 Select the required system The parameter list is displayed.	
5 Select the required parameters by stepping up and down through the parameter list.	Available parameters are described in section <a href="#">SIS system parameters on page 213</a> .

### 3.7.5 Reading the SIS output logs

#### General

Whenever a set condition has expired (e.g. max allowed operation time before service), a message to this effect will be shown in the Operational log.

#### Access to logs

How to open a log and show its contents is detailed in the User's Guide, chapter *Service*.

#### Available messages

The following messages may be shown:

Available in:	SIS message in the log:	Meaning:
Calendar time	Service Message Service is due! X calendar days since last service.	The manually set calendar time limit has expired. How to set the limit is detailed in section <a href="#">Setting the SIS parameters on page 214</a> .  Proceed with the required service as detailed in chapter <a href="#">Repair on page 217</a> or chapter <a href="#">Maintenance on page 133</a> depending on which type of service.
Calendar time	Service Message X calendar days to next service.	X number of calendar days remain until the manually set calendar time limit expires. How to set the value determining when the message is to be shown, is detailed in section <a href="#">Setting the SIS parameters on page 214</a> .
Operation time	Service Message Service is due! X production hours since last service.	The manually set operation time limit has expired. How to set the limit is detailed in section <a href="#">Setting the SIS parameters on page 214</a> .  Proceed with the required service as detailed in chapter <a href="#">Repair on page 217</a> or chapter <a href="#">Maintenance on page 133</a> depending on which type of service.
Operation time	Service Message X production hours to next service.	X number of operation hours remain until the manually set operation time limit expires. How to set the value determining when the message is to be shown, is detailed in section <a href="#">Setting the SIS parameters on page 214</a> .
Gearbox time	Service Message Gearbox x requires service!	The automatically calculated gearbox time limit has expired.  Proceed with the required service as detailed in chapter <a href="#">Repair on page 217</a> or chapter <a href="#">Maintenance on page 133</a> depending on which type of service.
Gearbox time	Service Message X% of the service interval has expired for gearbox x!	X percent of gearbox hours remain until the automatically calculated gearbox time limit expires. How to set the value determining when the message is to be shown, is detailed in section <a href="#">Setting the SIS parameters on page 214</a> .

### 3 Maintenance

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#### 3.7.6 Exporting the SIS data

#### 3.7.6 Exporting the SIS data

---

##### General

This section describes the available variables for entering SIS parameters as well as showing any values of exceeded time limits as detected by the SIS counters.

In a M2000 robot system, the values can be read on a PC using "Webware SDK". How to access these variables and how to perform the actual programming sequences are detailed in the robot system User's Guide.

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##### Definitions

The table below defines the names and functions of all software variables available for communication between the SIS and an external computer.

Signal	Unit	Counter type	Function
sisRestartDate	seconds	Calendar time	The date on which the supervision was started/reset last time.
sisCalendarT	seconds	Calendar time	The number of hours since start/last reset.
sisTotRunT	seconds	Operation time	Total number of operation hours since the system was started. Corresponds to the operating time counter on the control cabinet.
sisRunT	seconds	Operation time	The number of operation hours since start/last reset of the operation time counter. Corresponds to the operating time counter on the control cabinet.
sisL10h_1	hours	Gearbox time	Estimated life of gearbox axis 1
sisL10h_Time_1	seconds	Gearbox time	Operation time of gearbox axis 1
sisL10h_2	hours	Gearbox time	Estimated life of gearbox axis 2
sisL10h_Time_2	seconds	Gearbox time	Operation time of gearbox axis 2
sisL10h_3	hours	Gearbox time	Estimated life of gearbox axis 3
sisL10h_Time_3	seconds	Gearbox time	Operation time of gearbox axis 3
sisL10h_6	hours	Gearbox time	Estimated life of gearbox axis 6
sisL10h_Time_6	hours	Gearbox time	Operation time of gearbox axis 6

# 4 Repair

## 4.1 Introduction

### Structure of this chapter

This chapter describes all repair activities recommended for the IRB 6650S and any external unit.

It is made up of separate procedures, each describing a specific repair activity. Each procedure contains all the information required to perform the activity, for example spare parts numbers, required special tools, and materials.



### WARNING

Repair activities not described in this chapter must only be carried out by ABB. Otherwise damage to the mechanics and electronics may occur.

### Required equipment

The details of the equipment required to perform a specific repair activity are listed in the respective procedures.

The details of equipment are also available in different lists in the chapter [Reference information on page 427](#).

### Safety information

There are general safety information and specific safety information. The specific safety information describes the danger and safety risks while performing specific steps in a procedure. Make sure to read through the chapter [Safety on page 19](#) before commencing any service work.



### Note

If the IRB 6650S is connected to power, always make sure that the IRB 6650S is connected to earth before starting any repair work.

For more information see:

- *Product manual - IRC5*

## 4 Repair

### 4.2.1 Performing a leak-down test

## 4.2 General procedures

### 4.2.1 Performing a leak-down test

#### When to perform a leak-down test

After refitting any motor and gearbox, the integrity of all seals enclosing the gearbox oil must be tested. This is done in a leak-down test.

#### Required equipment

Equipment, etc.	Article number	Note
Leak-down tester	-	
Leak detection spray	-	

#### Performing a leak-down test

Action	Note
1 Finish the refitting procedure of the motor or gear in question.	
2 Remove the topmost oil plug on the gear and replace it with the <i>leak-down tester</i> . Regulators, which are included in the leak-down test, may be required.	
3 Use caution, apply compressed air and raise the pressure with the knob until the correct value is shown on the manometer.   <b>CAUTION</b>  The pressure must under no circumstance be higher than 0.25 bar (20-25 kPa). Also during the time when the pressure is raised.	Correct value: 0.2-0.25 bar (20-25 kPa)
4 Disconnect the compressed air supply.	
5 Wait for approximately 8-10 minutes and make sure that no pressure loss occurs.	If the compressed air is significantly colder or warmer than the gearbox to be tested, a slight pressure increase or decrease may occur. This is quite normal.
6 If any pressure drop occurred, then localize the leak as described in step 7. If no pressure drop occurred, then remove the leak-down tester and refit the oil plug. The test is complete.	
7 Spray any suspected leak areas with the leak detection spray. Bubbles indicate a leak.	
8 When the leak has been localized, take the necessary measures to correct the leak.	

## 4.2.2 Mounting instructions for bearings

### General

This section describes how to mount and grease different types of bearings on the robot.

### Equipment

Equipment, etc.	Article number	Note
Grease	3HAB3537-1	Used to grease the bearings, if not specified otherwise.

### Assembly of all bearings

Follow the following instructions while mounting a bearing on the robot.

Action	Note
1 To avoid contamination, let a new bearing remain in its wrapping until it is time for fitting.	
2 Ensure that the parts included in the bearing fitting are free from burrs, grinding waste, and other contamination. Cast components must be free of foundry sand.	
3 Bearing rings, inner rings, and roller elements must not be subjected to direct impact. The roller elements must not be exposed to any stresses during the assembly work.	

### Assembly of tapered bearings

Follow the preceding instructions for the assembly of the bearings when mounting a tapered bearing on the robot.

In addition to those instructions, the following procedure must be carried out to enable the roller elements to adjust to the correct position against the race flange.

Action	Note
1 Tension the bearing gradually until the recommended pre-tension is achieved.   Note  The roller elements must be rotated a specified number of turns before pre-tensioning is carried out and also rotated during the pre-tensioning sequence.	
2 Make sure the bearing is properly aligned as this will directly affect the durability of the bearing.	

### Greasing of bearings

The bearings must be greased after assembly according to the following instructions:

- The bearings must not be completely filled with grease. However, if space is available beside the bearing fitting, the bearing may be totally filled with grease when mounted, as excessive grease will be pressed out from the bearing when the robot is started.

*Continues on next page*

## 4 Repair

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### 4.2.2 Mounting instructions for bearings

*Continued*

- During operation, the bearing should be filled to 70-80% of the available volume.
- Ensure that grease is handled and stored properly to avoid contamination.

Grease the different types of bearings as following description:

- *Grooved ball bearings* must be filled with grease from both sides.
- *Tapered roller bearings* and axial needle bearings must be greased in the split condition.

## 4.2.3 Mounting instructions for seals

### General

This section describes how to mount different types of seals onto the robot.

### Equipment

Equipment, etc.	Article number	Note
Grease	3HAB3537-1	Used to lubricate the seals.

### Rotating seals

The procedure below describes how to fit rotating seals.



#### CAUTION

Please observe the following before commencing any assembly of seals:

- Protect the sealing surfaces during transport and mounting.
- Keep the seal in its original wrappings or protect it well before actual mounting.
- The fitting of seals and gears must be carried out on clean workbenches.
- Use a protective sleeve for the sealing lip during mounting, when sliding over threads, keyways, etc.

	Action	Note
1	Check the seal to ensure that: <ul style="list-style-type: none"> <li>• The seal is of the correct type (provided with cutting edge).</li> <li>• There is no damage to the sealing edge (feel with a fingernail).</li> </ul>	
2	Inspect the sealing surface before mounting. If scratches or damage are found, the seal must be replaced since it may result in future leakage.	
3	Lubricate the seal with grease just before fitting. (Not too early - there is a risk of dirt and foreign particles adhering to the seal.)  Fill 2/3 of the space between the dust tongue and sealing lip with grease. The rubber coated external diameter must also be greased, unless otherwise specified.	Article number is specified in <a href="#">Equipment on page 221</a> .
4	Mount the seal correctly with a mounting tool. Never hammer directly on the seal as this may result in leakage.	

*Continues on next page*

## 4 Repair

### 4.2.3 Mounting instructions for seals

*Continued*

#### Flange seals and static seals

The following procedure describes how to fit flange seals and static seals.

Action	
1	Check the flange surfaces. They must be even and free from pores. It is easy to check flatness using a gauge on the fastened joint (without sealing compound). If the flange surfaces are defective, the parts may not be used because leakage could occur.
2	Clean the surfaces properly in accordance with the recommendations of ABB.
3	Distribute the sealing compound evenly over the surface, preferably with a brush.
4	Tighten the screws evenly when fastening the flange joint.

#### O-rings

The following procedure describes how to fit o-rings.

Action	Note
1 Ensure that the correct o-ring size is used.	
2 Check the o-ring for surface defects, burrs, shape accuracy, and so on.	Defective o-rings may not be used.
3 Check the o-ring grooves. The grooves must be geometrically correct and should be free of pores and contamination.	Defective o-rings may not be used.
4 Lubricate the o-ring with grease.	
5 Tighten the screws evenly while assembling.	

## 4.3 Complete robot

## 4.3.1 Replacing cable harness, axes 1-6

**General**

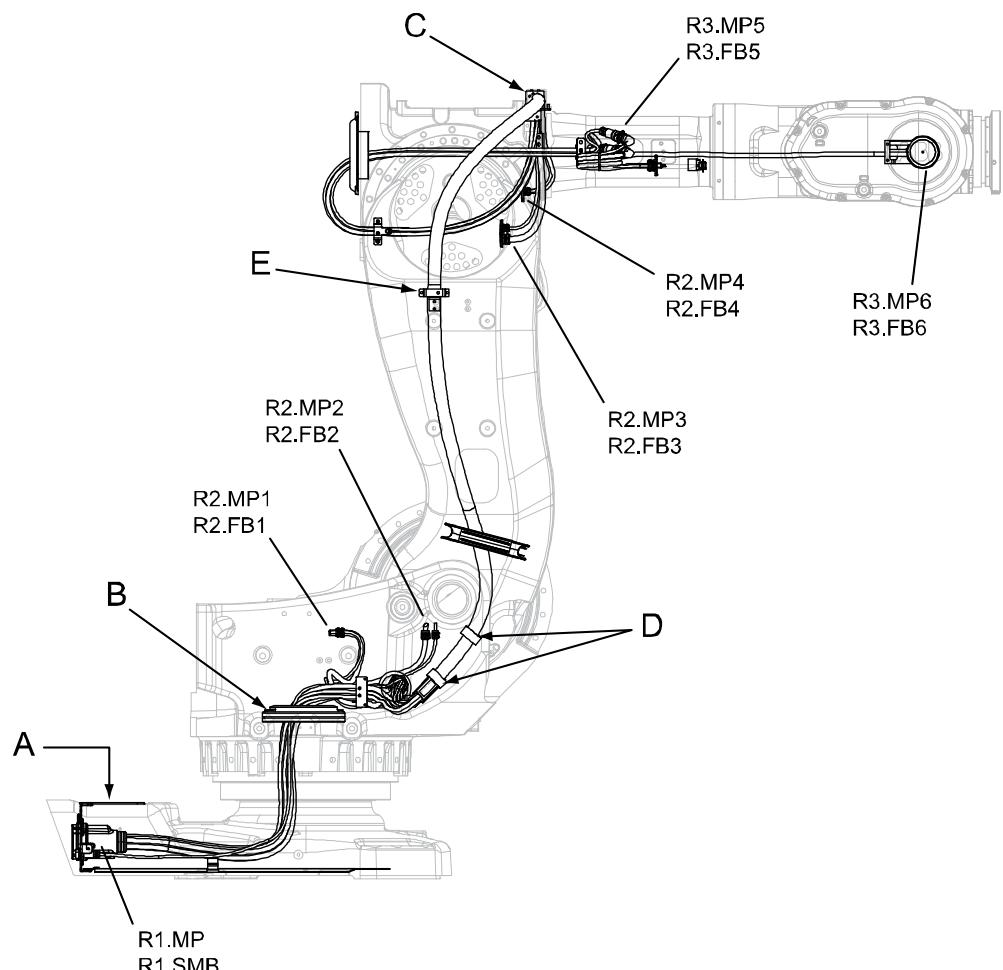
Use this section to replace the cable harness that runs undivided from axis 1 to axis 6.

If the cabling has a division point at the upper arm, see:

- [Replacement of cable harness, axes 1-4 on page 236](#)
- [Replacement of cable harness, axes 5-6 on page 245.](#)

**Location of cable harness**

The cable harness of axes 1-6 is run throughout the robot as shown in the figure below.



xx0500002176

A	Rear cover plate
B	Cable guide, inside the frame
C	Cable gland, upper arm house

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## 4 Repair

### 4.3.1 Replacing cable harness, axes 1-6

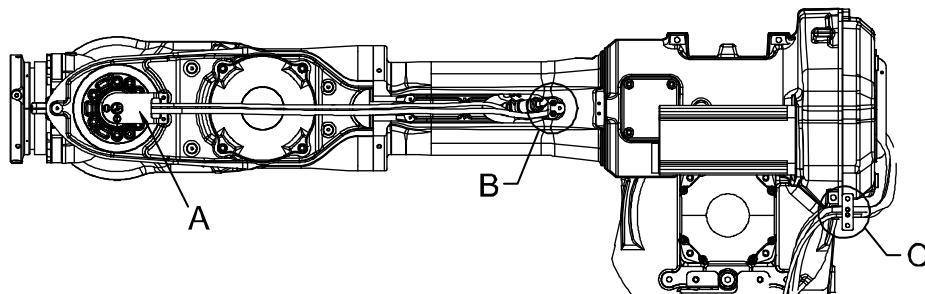
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D	Velcro straps
E	Cable gland, lower arm

#### Required equipment

Equipment	Spare part no.	Note
Cable harness axes 1-6	3HAC038800-001	
Gasket	3HAC12877-1	Motor axis 6
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.
Circuit diagram		See chapter <a href="#">Circuit diagram on page 441</a> .

#### Cable brackets of the upper arm



xx0500002293

A	Cable bracket, wrist unit
B	Cable bracket, upper arm tube
C	Cable attachment, rear

#### Removing the cable harness - upper arm

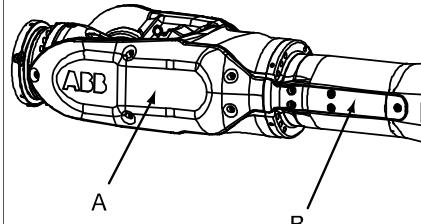
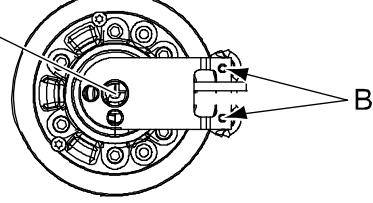
Use this procedure to remove the cable harness from the upper arm of the robot.

	Action	Note
1	In order to facilitate refitting of the cable harness, run the robot to the specified position: <ul style="list-style-type: none"><li>• Axis 1: 0 °</li><li>• Axis 2: 0 °</li><li>• Axis 3: 0 °</li><li>• Axis 4: 0 °</li><li>• Axis 5: +90 °</li><li>• Axis 6: no significance</li></ul>	Axes 2 and 3 may be tilted slightly to improve access.

*Continues on next page*

## 4.3.1 Replacing cable harness, axes 1-6

Continued

Action	Note
<p>2  <b>DANGER</b> Turn off all:<ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul>Before entering the robot working area.</p>	
3 Remove the <i>cover, wrist unit</i> and the <i>cover, upper arm tube</i> .	 xx0200000214 <p>A Cover, wrist unit B Cover, upper arm tube</p>
4  <b>Note</b> Axis 5 must be oriented in the correct position (+90°) to allow the motor 6 cover to open!	
5 Remove the cover of motor, axis 6 and disconnect all connectors beneath.	
6 Loosen the <i>cable bracket, wrist unit</i> by unscrewing its attachment screws.  Two of the attachment screws are visibly located at the rear of the bracket and the third is located at the bottom of the cable bracket, in the center.	<p>Shown in the figure <a href="#">Cable brackets of the upper arm on page 224</a>.</p>  xx0200000254 <ul style="list-style-type: none"> <li>• B: Attachment screws, rear of cable bracket (2 pcs)</li> <li>• C: Attachment screw, bottom of cable bracket</li> </ul>
7 Pick out the cabling from motor, axis 6.	
8 Loosen the <i>cable bracket, upper arm tube</i> by unscrewing the two screws on top of the tube.	Shown in the figure <a href="#">Cable brackets of the upper arm on page 224</a> .
9 Disconnect the two connectors (R3.FB5 and R3.MP5) inside the tube.	Shown in the figure <a href="#">Location of cable harness on page 223</a> .
10 Remove cable straps from the harness, if any.	
11 Remove the <i>cable attachment, rear</i> .	Shown in the figure <a href="#">Cable brackets of the upper arm on page 224</a> .

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## 4 Repair

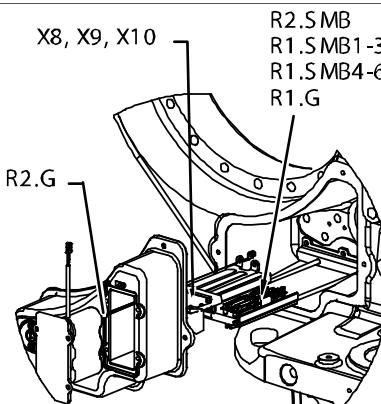
### 4.3.1 Replacing cable harness, axes 1-6

*Continued*

Action	Note
12 Remove the covers of motors axes 3 and 4 and disconnect all connectors beneath. Pick out the cabling from the motors.	
13 Gently pull the cable harness out from the upper arm tube.	
14 Tie the connectors into bundles, to avoid damaging them during further removal.	
15 Continue removing the cable harness in lower arm, frame and base.	

#### Removing the cable harness - frame and base

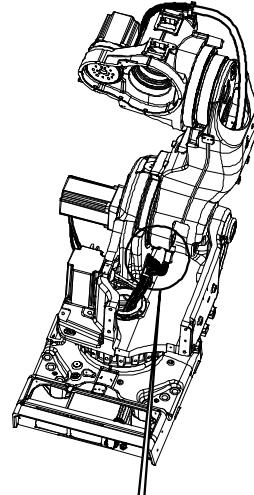
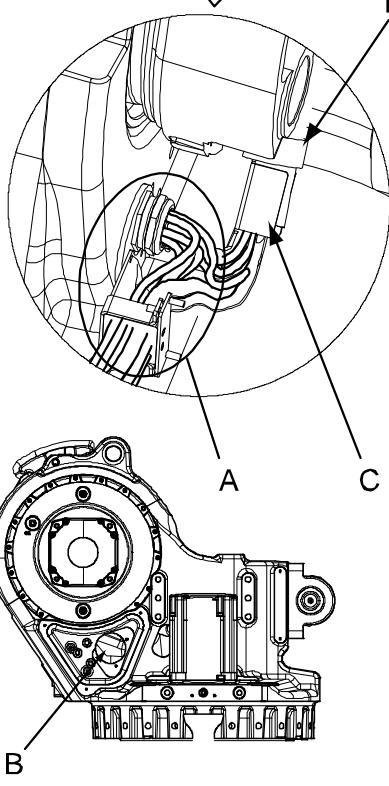
Use this procedure to remove the cable harness from the frame and base.

Action	Note
1 Remove the <i>rear cover plate</i> from the robot by removing its attachment screws.	Shown in the figure <a href="#">Location of cable harness on page 223</a> .
2 Disconnect the <i>earth cable</i> beneath the rear cover plate.	
3 Disconnect connectors <i>R1.MP</i> and <i>R1.SMB</i> .	Shown in the figure <a href="#">Location of cable harness on page 223</a> .
4 Pull the cable and connectors up through the cable guide in the center of the frame.	
5 Disconnect all connectors at motors 1 and 2.	
6 Open the SMB cover carefully. The cable between the battery and the SMB-unit can stay connected, in order to avoid an update of the revolution counter. Be careful not to let the weight of the cover strain the cable!	
<p> Note</p> <p>In order to remove the cover completely, the connector R1.G must be disconnected! This causes a necessary updating of the revolution counter!</p>	
7 Disconnect connectors <i>R2.SMB</i> , <i>R1.SMB1-3</i> , <i>R1.SMB4-6</i> from the SMB unit. Disconnect X8, X9 and X10 from the brake release unit.	 <p>X8, X9, X10 R2.G R2.SMB R1.SMB1-3 R1.SMB4-6 R1.G</p> <p>xx0200000118</p>

*Continues on next page*

## 4.3.1 Replacing cable harness, axes 1-6

Continued

Action	Note
8 Remove <ul style="list-style-type: none"> <li>• the <i>cable gland</i>, by removing the four <i>attachment screws</i> from inside the SMB recess</li> <li>• the <i>attachment plate</i>, by removing the attachment screws and the <i>velcro strap</i>.</li> </ul>	 <p><b>Note</b></p> <p>Different robot versions are fitted with different versions of the attachment plate. When replacing the cable harness, make sure the correct one is used to avoid cable failure.</p>  <p>xx0300000560</p> <p>A Cable gland B Attachment screws, cable gland C Attachment plate D Velcro strap</p>
9 Remove the cable gland securing the cables inside the lower arm.	
10 Remove the velcro strap and cable gland.	

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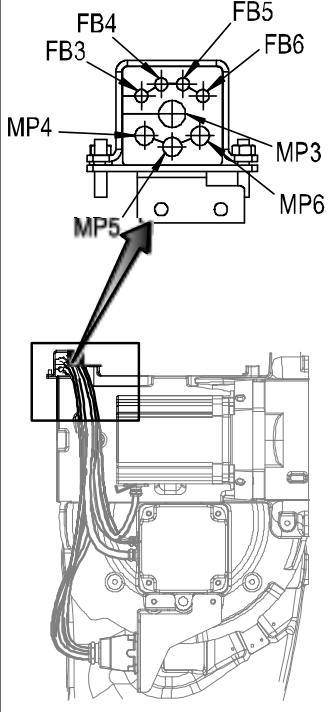
## 4 Repair

### 4.3.1 Replacing cable harness, axes 1-6

Continued

#### Removing the cable harness - lower arm

Use this procedure to remove the cable harness from the lower arm.

Action	Note
1 Remove the cable gland that secures the cables to the arm house.	 xx0100000143
2 Remove the <i>velcro strap</i> from the harness at the cable fixing bracket at the arm house.	Shown in the figure <a href="#">Location of cable harness on page 223</a> .
3 Disconnect all connectors at the axis-3 and axis-4 motors.	
4 Gently pull the cable harness out.	

#### Refitting the cable harness - lower arm, frame and base

Use this procedure to refit the cable harness on the lower arm, frame and base of the robot.

How to refit on the upper arm is described in section [Refitting the cable harness - upper arm on page 233](#).

Action	Note
1 Push the cable and connectors down through the <b>cable guide</b> in the center of the frame. <ul style="list-style-type: none"><li>• Make sure the cables are not twisted with each other or with customer harnesses if any</li><li>• Make a note of the correct positions of the connectors.</li></ul>	Shown in the figure <a href="#">Location of cable harness on page 223</a> .
2 Reconnect connectors <i>R1.MP</i> and <i>R1.SMB</i> at the base.	Tightening torque for R1.SMB: 10 Nm. Shown in the figure <a href="#">Location of cable harness on page 223</a> . Make a note of the correct positions of the connectors!

Continues on next page

## 4.3.1 Replacing cable harness, axes 1-6

*Continued*

	Action	Note
3	Reconnect the <i>earth cable</i> .	
4	Refit the <i>rear cover plate</i> to the robot with its attachment screws.	Shown in the figure <a href="#">Location of cable harness on page 223</a> .
5	Reconnect all connectors at motors axes 1 and 2.	

*Continues on next page*

## 4 Repair

### 4.3.1 Replacing cable harness, axes 1-6

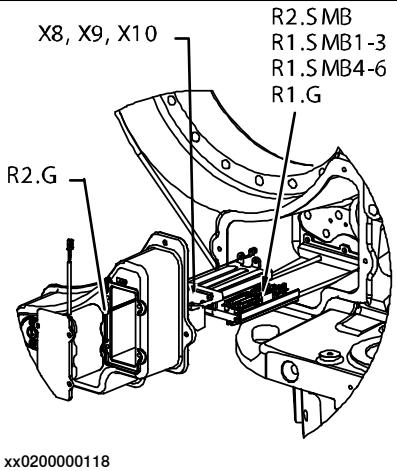
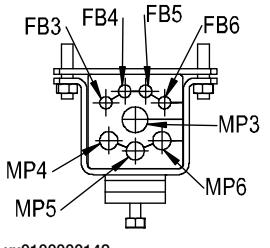
Continued

Action	Note
<p>6 Secure the <i>cable gland</i> with four <i>attachment screws</i> from inside the SMB recess.</p> <p>Secure the correct <i>attachment plate</i> to the cable gland with its two attachment screws, using locking liquid.</p> <p>Refit the <i>velcro strap</i>. Shown in the figure <a href="#">Location of cable harness on page 223</a>.</p> <p><b>Note</b></p> <p>Different robot versions are fitted with different versions of the attachment plate. Make sure the correct one is used to avoid cable failure.</p>	<p>Locking liquid is specified in <a href="#">Required equipment on page 224</a>.</p> <p>xx0300000560</p> <p>A Cable gland B Attachment screws, cable gland C Attachment plate D Velcro strap</p>

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## 4.3.1 Replacing cable harness, axes 1-6

Continued

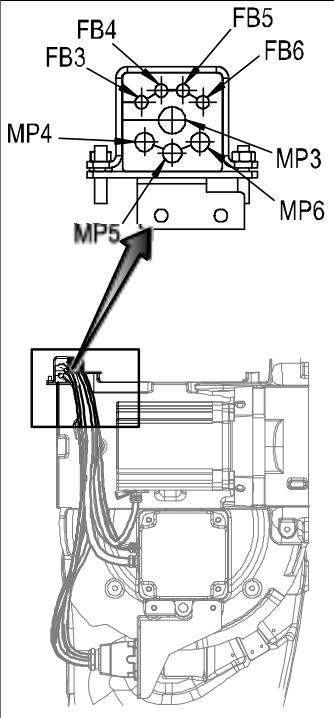
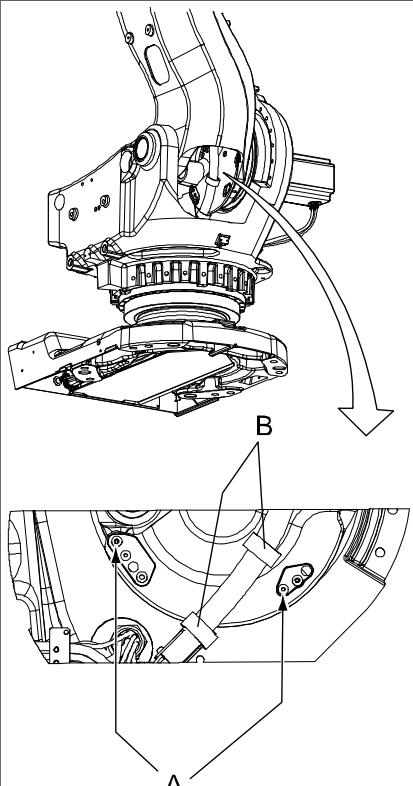
Action	Note
<p>7   Reconnect connectors to the SMB unit:</p> <ul style="list-style-type: none"> <li>• R2.SMB</li> <li>• R1.SMB1-3</li> <li>• R1.SMB4-6</li> </ul> <p>Reconnect connectors to the Brake release unit:</p> <ul style="list-style-type: none"> <li>• X8</li> <li>• X9</li> <li>• X10</li> </ul> <p>Reconnect R1.G if it has been disconnected.</p>	 xx0200000118
<p>8   Secure the SMB cover with its attachment screws.</p> <p>If cabling is used for 7th axis (option), refit the connector R2.FB7 to the SMB cover and tighten with 6 Nm.</p>	
<p>9    <b>WARNING</b></p> <p>Before continuing any service work, please observe the safety information in section <b>WARNING - The brake release buttons may be jammed after service work on page 51!</b></p>	
<p>10   Push the cable harness gently through the lower arm.</p>	
<p>11   Refit the <i>cable gland</i> securing the cables inside the lower arm.</p>	 xx0100000142

Continues on next page

## 4 Repair

### 4.3.1 Replacing cable harness, axes 1-6

*Continued*

Action	Note
12 Refit the cable gland securing the cables to the arm house.	<p><b>Note</b></p> <p>The cable harness is delivered in a pretwisted state. Make sure not to affect this by twisting the cable harness further in any direction.</p>  <p>xx0100000143</p>
13 Fit a cable protection to the lower arm, if not already mounted, with two <i>securing screws</i> , M6x16. Secure the cable harness with two <i>velcro straps</i> , with a distance of approximately 180 mm. Fix the strap by wrapping it two turns around the largest cable before wrapping around the complete harness.	 <p>xx0500002320</p> <p><b>Parts:</b></p> <ul style="list-style-type: none"> <li>A: Securing screws, M6x16 (2 pcs)</li> <li>B: Velcro straps (2 pcs)</li> </ul>

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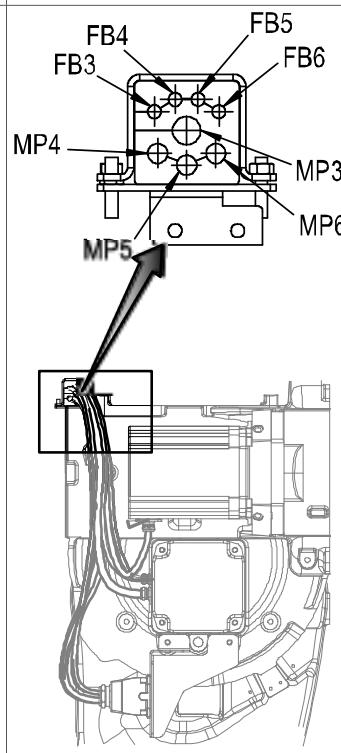
## 4.3.1 Replacing cable harness, axes 1-6

Continued

**Refitting the cable harness - upper arm**

Use this procedure to refit the cable harness on the upper arm of the robot.

How to refit the cable harness on lower arm, frame and base is described in section [Refitting the cable harness - lower arm, frame and base on page 228](#).

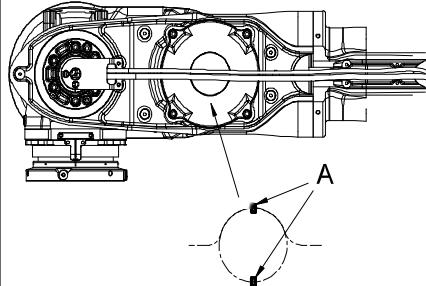
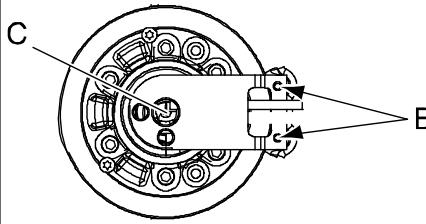
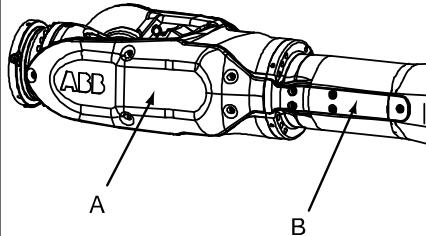
Action	Note
1 Before refitting the upper end of the cable harness, the lower end must first be refitted.	How to refit see section <a href="#">Refitting the cable harness - lower arm, frame and base on page 228</a> .
2 Refit the <i>cable gland</i> securing the cables in the armhouse.   <b>Note</b>  The cable harness is delivered pretwisted. Make sure not to affect this by twisting the cable harness further in any direction.	 xx0100000143
3 Reconnect all connectors on motors axes 3 and 4.	
4 Secure the cable harness to the upper armhouse by refitting the <i>velcro strap</i> to the cable bracket at the upper armhouse.  Refit the <i>velcro strap</i> at the guide plate axis 2.	Shown in the figure <a href="#">Location of cable harness on page 223</a> .
5 Gently insert the cable harness from the rear into the upper arm.	
6 Connect the two connectors inside the upper arm tube, R2.FB5 and R3.MP5 and secure the <i>cable bracket</i> with its two attachment screws to the tube.	Shown in the figure <a href="#">Cable brackets of the upper arm on page 224</a> .
7  <b>Note</b>  The position of axis 6 must be +90° for a correct installation of the cable harness.	

Continues on next page

## 4 Repair

### 4.3.1 Replacing cable harness, axes 1-6

*Continued*

Action	Note
8 Place the cabling to motor axis 6 correctly on the upper arm and gently pull the connectors through the hole on top of the wrist unit to motor axis 6.  In case of excess of cable length: <ul style="list-style-type: none"><li>• put the excess cable in a loop in the area shown in the figure and secure with cable straps. Cables are longer in order to fit different upper arm lengths.</li></ul>	 xx020000185 • A: Cable straps
9 Fasten the cable bracket, wrist unit with its <i>attachment screws</i> . Two screws are visible at the <i>rear attachment point</i> of the bracket and the third is located at the <i>bottom of the cable bracket</i> , in the center.   <b>Note</b>  Do not use stainless attachment screws! There is a potential risk of galvanic corrosion.	 xx020000254 • B: Attachment screws, rear attachment point of cable bracket (2 pcs) • C: Attachment screw, bottom of cable bracket (1 pc)
10 Reconnect the connectors to motor, axis 6 and refit the motor cover.	<b>Foundry robots:</b> It is recommended to use a new gasket on cover.
11 Refit the cover, upper arm tube and the cover, wrist unit.  Make sure the cabling is placed correctly when refitting the covers, and does not get jammed.	 xx020000214 <b>Parts:</b> <ul style="list-style-type: none"><li>• A: Cover, wrist unit</li><li>• B: Cover, upper arm tube</li></ul>
12 If any cable straps have been removed, refit them to the harness.	
13 Refit the <i>cable attachment, rear</i> .	Shown in the figure <a href="#">Cable brackets of the upper arm on page 224</a> .
14 If the connection between the SMB battery and the SMB unit has been broken, the revolution counters now must be updated!	Detailed in section <a href="#">Updating revolution counters on page 401</a> .

*Continues on next page*

## 4.3.1 Replacing cable harness, axes 1-6

*Continued*

Action	Note
15  <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <i>DANGER - First test run may cause injury or damage!</i> on page 50.	

## 4 Repair

### 4.3.2 Replacement of cable harness, axes 1-4

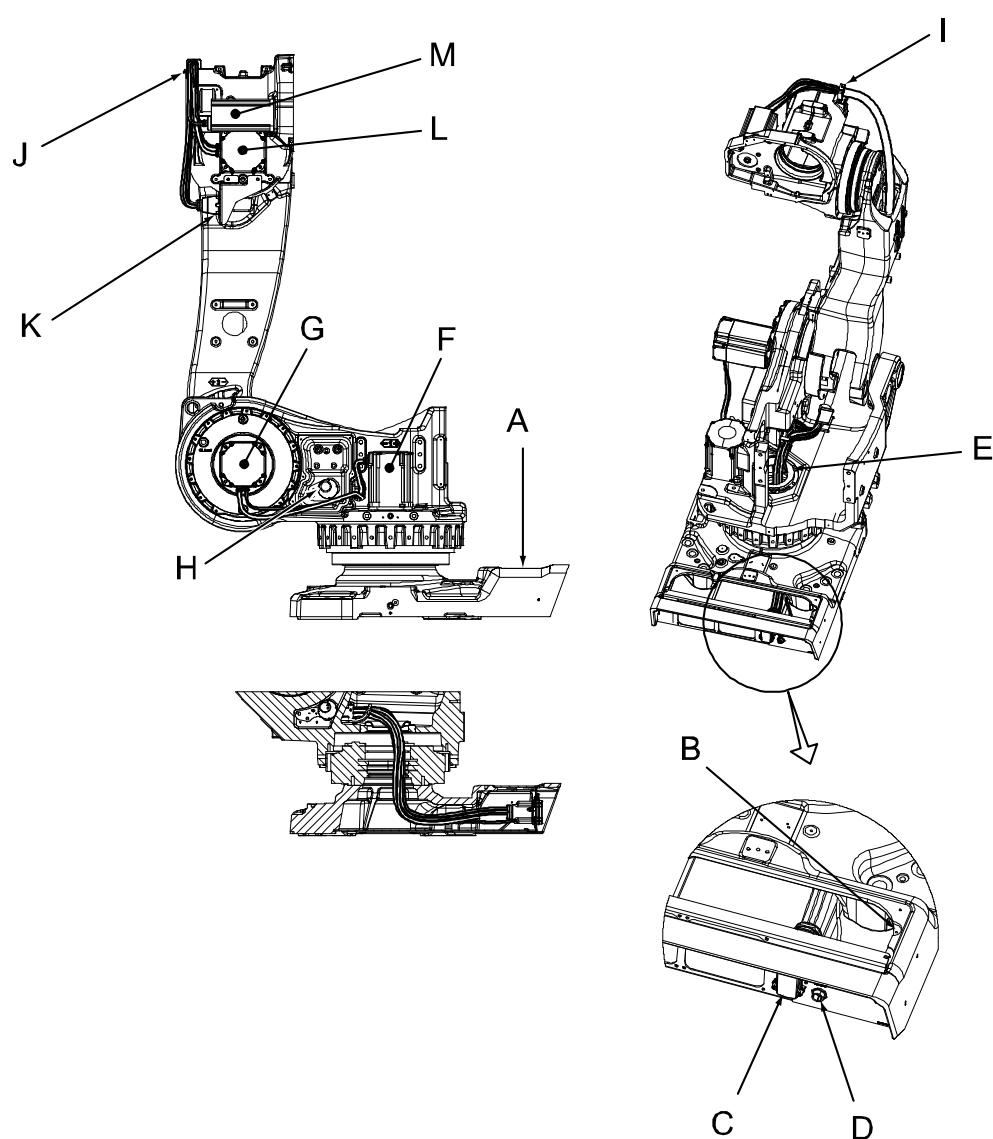
#### General

This section details how to replace the cable harness that runs from axis 1 to axis 4. If the robot is equipped with an undivided cable harness, it is instead replaced as detailed in section [Replacing cable harness, axes 1-6 on page 223](#).

(The divided cable for axes 1-4 is not applicable for robot model IRB 6650S - 90/3.9.)

#### Location of cable harness

The cable harness for axes 1-4 is run throughout the base, frame and lower arm as shown in the figure below.



xx0300000589

A	Rear cover plate
B	Attachment point for earth lug

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## 4.3.2 Replacement of cable harness, axes 1-4

*Continued*

C	Connector R1.MP
D	Connector R1.SMB
E	Cable guide in the center of the frame
F	Connectors at motor 1: R2.FB1 and R2.MP1
G	Connectors at motor 2: R2.FB2 and R2.MP2
H	SMB recess
I	Cable gland, upper arm house
J	Cable fixing bracket + velcro strap
K	Connector R2.M5/6 at the cable division point
L	Connectors at motor 3: R2.FB3 and R2.MP3 (optional signal lamp: R2.H1 and R2.H2)
M	Connectors at motor 4: R2.FB4 and R2.MP4

**Required equipment**

Equipment, etc.	Spare part no.	Art. no.	Note
Cable harness axes 1-4	3HAC033389-001		
Locking liquid			Loctite 638 Used to secure the attachment screws for the attachment plate inside the frame.
Standard toolkit		-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.
Circuit diagram			See chapter <a href="#">Circuit diagram on page 441</a> .

**Removal, cable harness, axes 1-4**

The procedure below details how to remove the cable harness, axes 1-4.

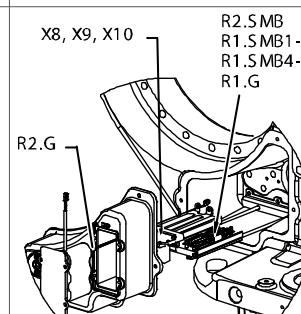
	Action	Note
1	In order to facilitate refitting of cable harness, run the robot to the specified position: <ul style="list-style-type: none"> <li>• Axis 1: 0 °</li> <li>• Axis 2: 0 °</li> <li>• Axis 3: 0 °</li> <li>• Axis 4: 0 °</li> <li>• Axis 5: +90 °</li> <li>• Axis 6: no significance</li> </ul>	Axes 2 and 3 may be tilted slightly to improve access.

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## 4 Repair

### 4.3.2 Replacement of cable harness, axes 1-4

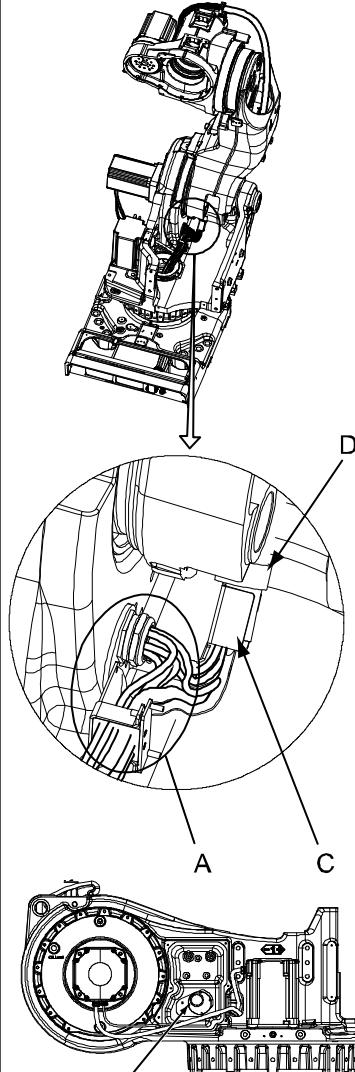
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Action	Note
<p>2  <b>DANGER</b></p> <p>Turn off all:</p> <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> <p>Before entering the robot working area.</p>	
3 Remove the <i>rear cover plate</i> from the robot by removing its attachment screws.	Shown in the figure <a href="#">Location of cable harness on page 236</a> .
4 Disconnect the <i>earth cable</i> .	Attachment point is shown in the figure <a href="#">Location of cable harness on page 236</a> !
5 Disconnect connectors <i>R1.MP</i> and <i>R1.SMB</i> .	Attachment points are shown in the figure <a href="#">Location of cable harness on page 236</a> .
6 Pull the cable and connectors up through the cable guide in the center of the frame.	
7 Disconnect all connectors at motors 1 and 2.	Specified and shown in the figure <a href="#">Location of cable harness on page 236</a> !
8 Open the SMB cover carefully. The cable between the battery and the SMB-unit may stay connected, in order to avoid an update of the revolution counter. Be careful not to let the weight of the cover strain the cable!  In order to remove the cover completely, the connector R1.G must be disconnected! This causes a necessary updating of the revolution counter!	
9 Disconnect connectors <i>R2.SMB</i> , <i>R1.SMB1-3</i> , <i>R1.SMB4-6</i> from the SMB unit. Disconnect X8, X9 and X10 from the brake release unit.	 xx0200000118

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## 4.3.2 Replacement of cable harness, axes 1-4

Continued

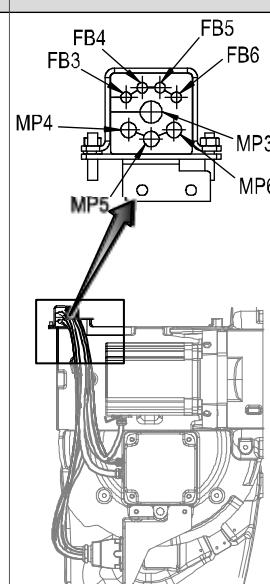
Action	Note
10 Remove <ul style="list-style-type: none"> <li>• the <i>cable gland</i> (A), by removing the four attachment screws from inside the SMB recess (B)</li> <li>• the <i>attachment plate</i> (C), by removing the attachment screws and the velcro strap (D).</li> </ul> <p><b>Note</b></p> <p>Different robot versions are fitted with different versions of the attachment plate. When replacing the cable harness, make sure the correct one is used to avoid cable failure.</p>	 <p>xx0400001069</p> <ul style="list-style-type: none"> <li>• A: Cable gland</li> <li>• B: Attachment screws, cable gland</li> <li>• C: Attachment plate</li> <li>• D: Velcro strap</li> </ul>
11 Remove the cable gland securing the cables inside the lower arm.	

Continues on next page

## 4 Repair

### 4.3.2 Replacement of cable harness, axes 1-4

*Continued*

Action	Note
12 Remove the cable gland securing the cables to the arm house.	 xx010000143
13 Remove the <i>velcro strap</i> from the harness at the cable fixing bracket at the arm house.	Shown in the figure <a href="#">Location of cable harness on page 236</a> .
14 Disconnect connector R2.M5/6 at the cable division point.	Shown in the figure <a href="#">Location of cable harness on page 236</a> !
15 Disconnect all connectors at motor 3 and motor 4.	Specified and shown in the figure <a href="#">Location of cable harness on page 236</a> !
16 Gently pull the cable harness out.	

### Refitting, cable harness, axes 1-4

The procedure below details how to refit the cable harness, axes 1-4.

Action	Note
<b>1</b>  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
<b>2</b> In order to facilitate refitting of cable harness, move the robot to the specified position: <ul style="list-style-type: none"> <li>• Axis 1: 0 degrees</li> <li>• Axis 2: 0 degrees</li> <li>• Axis 3: 0 degrees</li> <li>• Axis 4: 0 degrees</li> <li>• Axis 5: +90 degrees</li> <li>• Axis 6: no significance</li> </ul>	Axes 2 and 3 may be tilted slightly to improve access.

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## 4.3.2 Replacement of cable harness, axes 1-4

Continued

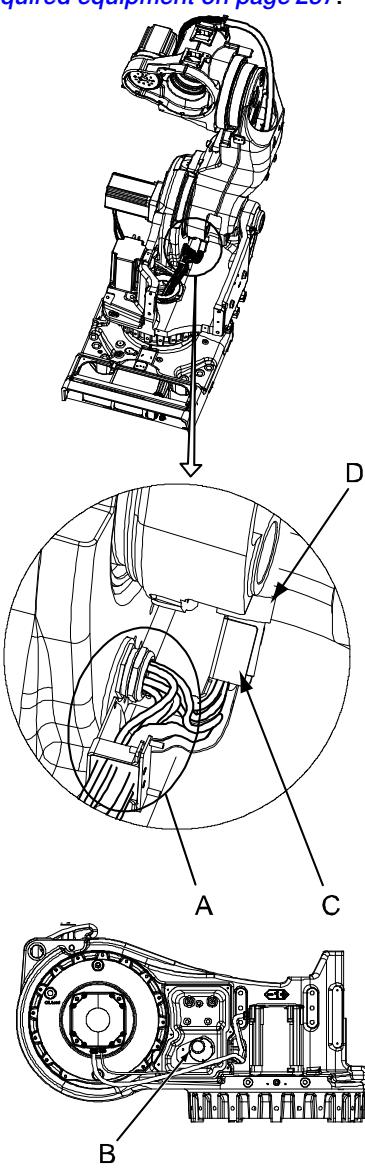
	Action	Note
3	Pull the cable and connectors down through the cable guide in the center of the frame.	Make sure the cables are not twisted with each other or with eventual customer harnesses! Make a note of the correct positions of the connectors!
4	Reconnect connectors <i>R1.MP</i> and <i>R1.SMB</i> at the rear cover plate.	Tightening torque for R1.SMB: 10 Nm. Make a note of the correct positions of the connectors! Attachment point is shown in the figure <a href="#">Location of cable harness on page 236</a> .
5	Reconnect the earth cable.	Attachment point is shown in the figure <a href="#">Location of cable harness on page 236</a> !
6	Refit the <i>rear cover plate</i> to the robot with its attachment screws.	Shown in the figure <a href="#">Location of cable harness on page 236</a> .
7	Reconnect all connectors at motors 1 and 2.	Specified and shown in the figure <a href="#">Location of cable harness on page 236</a> !

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## 4 Repair

### 4.3.2 Replacement of cable harness, axes 1-4

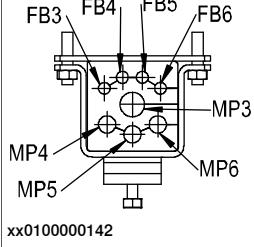
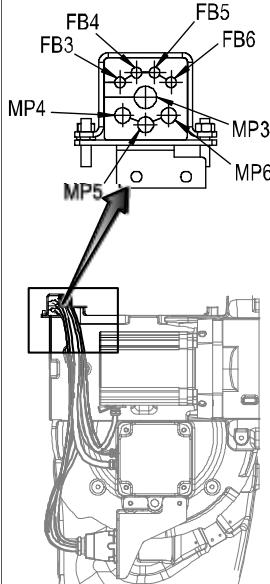
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Action	Note
<p>8 Secure the cable gland (A) with four attachment screws (B) from inside the SMB recess.</p> <p>Secure the correct attachment plate (C) to the cable gland with its two attachment screws, using locking liquid.</p> <p>Refit the velcro strap (D).</p> <p><b>Note</b></p> <p>Different robot versions are fitted with different versions of the attachment plate. Make sure the correct one is used to avoid cable failure.</p>	<p>Locking liquid is specified in <a href="#">Required equipment on page 237</a>.</p>  <p>xx0400001069</p> <ul style="list-style-type: none"> <li>• A: Cable gland</li> <li>• B: Attachment screws, cable gland</li> <li>• C: Attachment plate</li> <li>• D: Velcro strap</li> </ul>
<p>9 Reconnect connectors R2.SMB, R1.SMB1-3, R1.SMB4-6 to the SMB unit.</p> <p>Reconnect X8, X9 and X10 to the brake release unit.</p> <p>Reconnect R1.G if it has been disconnected.</p>	
<p>10 Secure the SMB cover with its attachment screws.</p> <p>If cabling is used for 7th axis (option), refit the connector R2.FB7 to the SMB cover and tighten with 6 Nm.</p>	

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## 4.3.2 Replacement of cable harness, axes 1-4

Continued

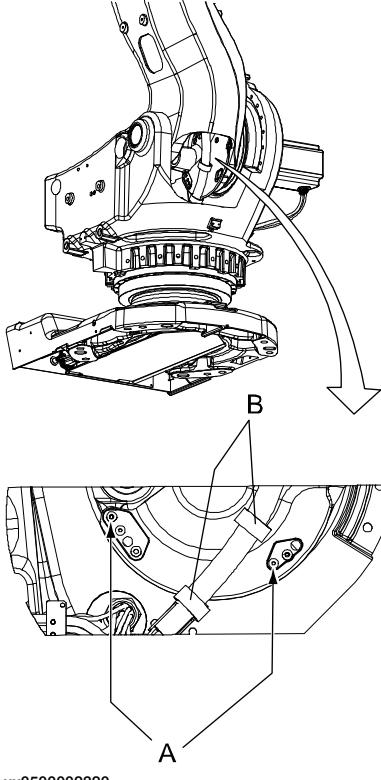
Action	Note
11  <b>WARNING</b> Before continuing any service work, please observe the safety information in section <b>WARNING - The brake release buttons may be jammed after service work on page 51!</b>	
12 Pull the cable harness through the lower arm.	
13 Refit the cable gland securing the cables inside the lower arm.	
14 Refit the cable gland securing the cables to the arm house.  Make sure not to twist the harness!	
15 Reconnect all connectors at motor 3 and motor 4.	Specified and shown in the figure <a href="#">Location of cable harness on page 236!</a>
16 Reconnect the connector R2.M5/6 gently at the cable division point.  Be careful not to bend the attachment plate when fastening the screws!	Shown in the figure <a href="#">Location of cable harness on page 236!</a> M6, 2 pcs.
17 Secure the cable harness to the upper arm house by refitting the velcro strap to the cable bracket at the upper arm house.	Shown in the figure <a href="#">Location of cable harness on page 236!</a>

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## 4 Repair

### 4.3.2 Replacement of cable harness, axes 1-4

*Continued*

Action	Note
18 Fit a cable protection to the lower arm, if not already mounted, with two securing screws (A), M6x16.  Secure the cable harness with two velcro straps (B), with a distance of approximately 180 mm. Fix the strap by wrapping it two turns around the largest cable before wrapping around the complete harness.	Both the protection and the strap are included in the spare part no., specified in <a href="#">Required equipment on page 237</a> .   xx0500002320
19 Refit the cable harness to the <i>guide plate axis 2</i> .	Shown in the figure <a href="#">Location of cable harness on page 236</a> .
20 Refit the <i>velcro strap</i> at the <i>guide plate axis 2</i> .	Shown in the figure <a href="#">Location of cable harness on page 236</a> .
21 If the connection between the SMB battery and the SMB unit has been broken, the revolution counters must now be updated!	Detailed in the Calibration chapter - section <a href="#">Updating revolution counters on page 401</a> .
22  <b>DANGER</b>  Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

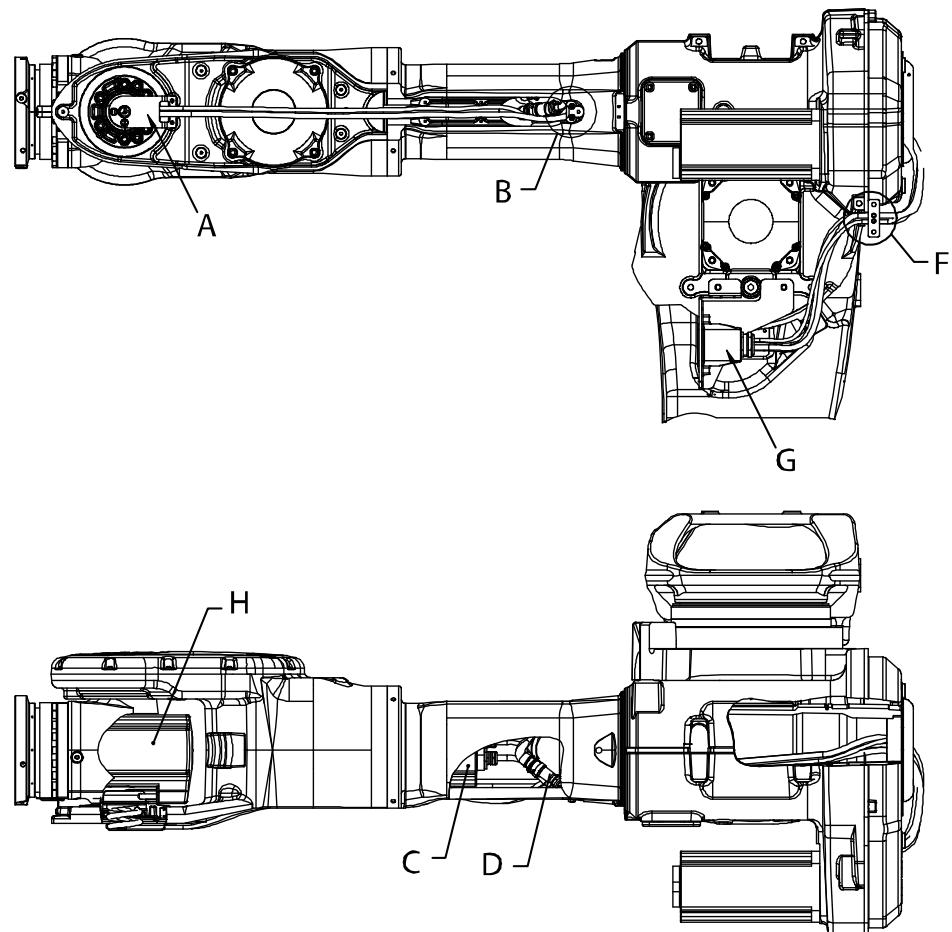
## 4.3.3 Replacement of cable harness, axes 5-6

**4.3.3 Replacement of cable harness, axes 5-6****General**

This cable is not applicable for robot model IRB 6650S - 90/3.9.

**Location of cable harness ax 5-6**

The location of the cable harness, axes 5-6, is shown in the figure below.



xx0200000213

<b>A</b>	Cable bracket, wrist unit
<b>B</b>	Cable bracket, upper arm tube
<b>C</b>	Connectors at motor axis 5; R4.FB5 and R4.MP5
<b>D</b>	Connectors in upper arm tube; R3.FB5 and R3.MP5
<b>F</b>	Cable attachment, rear
<b>G</b>	Connector at cable harness division point; R2.M5/6
<b>H</b>	Connectors at motor, axis 6; R3.FB6 and R3.MP6

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## 4 Repair

### 4.3.3 Replacement of cable harness, axes 5-6

*Continued*

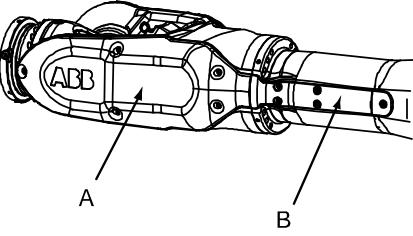
#### Required equipment

Equipment, etc.	Spare part no.	Note
Cable harness axes 5-6	3HAC14140-1	Not applicable for IRB 6650S - 90/3.9.
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.
Circuit diagram		See chapter <a href="#">Circuit diagram on page 441</a> .

#### Removal, cable harness, axes 5-6

The procedure below details how to remove the upper cable harness.

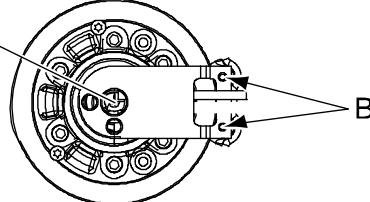
The separate cable that goes from the connection point inside of the upper arm tube to the motor, axis 5, is not included in this procedure. The removal of that cable is described in section [Removal, cabling axis 5 motor on page 249](#).

	Action	Note/Illustration
1	 <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2	Remove the cover, wrist unit and the cover, upper arm tube.	 xx0200000214 <ul style="list-style-type: none"><li>• A: cover, wrist unit</li><li>• B: cover, upper arm tube</li></ul>
3	 <b>Note</b>  Axis 5 must be oriented in the correct position (+90°) to allow the motor 6 cover to open!	
4	Remove the cover of motor, axis 6 and disconnect all connectors beneath.	Specified in the figure <a href="#">Location of cable harness ax 5-6 on page 245</a> .

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## 4.3.3 Replacement of cable harness, axes 5-6

Continued

Action	Note/Illustration
5 Loosen the <i>cable bracket</i> on top of the wrist unit by undoing the three attachment screws. Two of the attachment screws are visibly located at the rear attachment and the third is located at the bottom of the cable bracket, in the center.	Shown in the figure <a href="#">Location of cable harness ax 5-6 on page 245</a> .  xx0200000254 <ul style="list-style-type: none"> <li>B: Attachment screws, rear of cable bracket, 2 pcs</li> <li>C: Attachment screw, bottom of cable bracket, 1 pc</li> </ul>
6 Pick out the cabling from motor, axis 6.	
7 Loosen the <i>cable bracket in the upper arm tube</i> by undoing the two screws on top of the tube.	Shown in the figure <a href="#">Location of cable harness ax 5-6 on page 245</a> .
8 Disconnect the two <i>connectors (R3.FB5 and R3.MP5)</i> in the tube.	Shown in the figure <a href="#">Location of cable harness ax 5-6 on page 245</a> .
9 Remove eventual cable straps from the harness.	
10 Remove the <i>cable attachment, rear</i> .	Shown in the figure <a href="#">Location of cable harness ax 5-6 on page 245</a> .
11 Disconnect connector <i>R2.M5/6</i> at the cable harness division point.	Shown in the figure <a href="#">Location of cable harness ax 5-6 on page 245</a> .
12 Gently pull the cable harness out.	

**Refitting, cable harness, axes 5-6**

The procedure below details how to refit the upper arm cable harness. The separate cable that goes from the connection point inside of the upper arm tube to the motor, axis 5, is not included in this procedure. The refitting of that cable is described further down in section [Refitting, cabling axis 5 motor on page 250](#).

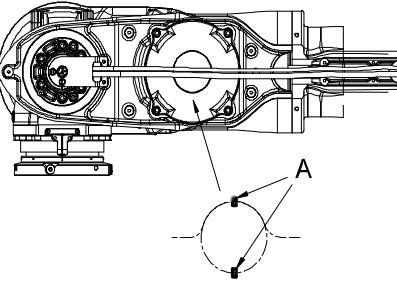
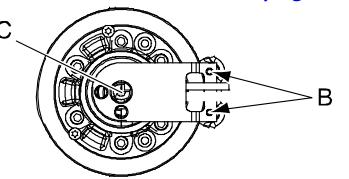
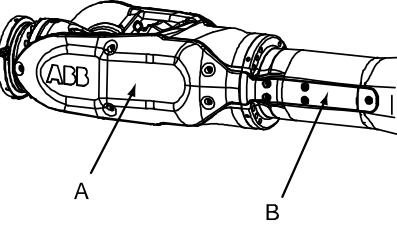
Action	Note/Illustration
1 Position the upper arm as follows: <ul style="list-style-type: none"> <li>Axis 4: 0 degrees</li> <li>Axis 5: +90 degrees</li> <li>Axis 6: no significance</li> </ul>	
2 Gently insert the cable harness from the rear into the upper arm.	
3 Connect the two <i>connectors inside the upper arm tube, R3.FB5 and R3.MP5</i> and secure the <i>cable bracket</i> with the two attachment screws to the tube.	Shown in the figure <a href="#">Location of cable harness ax 5-6 on page 245</a> .

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## 4 Repair

### 4.3.3 Replacement of cable harness, axes 5-6

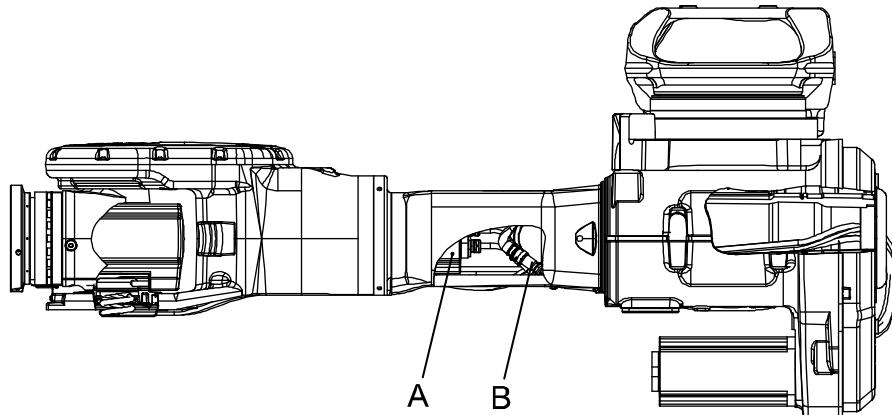
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Action	Note/Illustration
4 Place the cabling to motor, axis 6, correctly on the upper arm and gently pull the connectors through the hole on top of wrist unit to motor, axis 6.	 xx0200000185 <ul style="list-style-type: none"> <li>In case of excess cable length: put a loop of cable in this area with cable straps (A). The cables are longer in order to fit different upper arm lengths.</li> </ul>
5 Fasten the <i>cable bracket, wrist unit</i> with three attachment screws, two of them visible at the rear attachment point and the third located on the bottom of the cable bracket, in the center.	Also shown in the figure <a href="#">Location of cable harness ax 5-6 on page 245</a> .  xx0200000254 <ul style="list-style-type: none"> <li>B: Attachment screws, rear of cable bracket.</li> <li>C: Attachment screw, bottom of cable bracket.</li> </ul>
6 Reconnect the connectors to motor, axis 6 and refit the motor cover.	
7 Refit the cover, upper arm and the cover, wrist unit. Make sure the cabling is placed correctly when refitting the covers, and does not get jammed.	 xx0200000214 <ul style="list-style-type: none"> <li>A: cover, wrist unit</li> <li>B: cover, upper arm tube</li> </ul>
8 If any cable straps have been removed, refit them to the harness.	
9 Refit the <i>cable attachment, rear</i> .	Shown in the figure <a href="#">Location of cable harness ax 5-6 on page 245</a> .
10 Reconnect connector R2.M5/6 gently at the rear cable division point with two screws, M6. Be careful not to bend the attachment plate when fastening the screws!	Shown in the figure <a href="#">Location of cable harness ax 5-6 on page 245</a> .
11 Update the revolution counter!	Detailed in section <a href="#">Updating revolution counters on page 401</a> .

### 4.3.4 Replacement of cabling, axis 5 motor

#### Location of cabling

The separate cables for the axis 5 motor are located inside the upper arm tube, as shown in the figure below.



xx0500002294

A	Motor axis 5 with connectors R4.FB5 and R4.MP5
B	Connectors R3.FB5 and R3.MP5

#### Required equipment

Equipment	Spare part no.	Note
Cable harness axis 5	See <a href="#">Spare part lists on page 425</a> .	
Circuit diagram	3HAC025744-001	
Standard toolkit		Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

#### Removal, cabling axis 5 motor

The procedure below details how to remove the cabling from the axis 5 motor.

	Action	Note
1	<p> <b>DANGER</b></p> <p>Turn off all:</p> <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> <p>Before entering the robot working area.</p>	
2	Remove the complete wrist unit.	<p>Detailed in section:</p> <ul style="list-style-type: none"> <li>• <a href="#">Removal, wrist unit on page 263</a>.</li> </ul>

*Continues on next page*

## 4 Repair

### 4.3.4 Replacement of cabling, axis 5 motor

Continued

	Action	Note
3	Remove the cover of motor, axis 5.	
4	Disconnect all connectors at motor, axis 5.	
5	Remove the cable gland cover at the cable exit by unscrewing its two attachment screws.	
6	Remove the cable, axis 5.	

#### Refitting, cabling axis 5 motor

The procedure below details how to refit the cabling to the motor of axis 5.

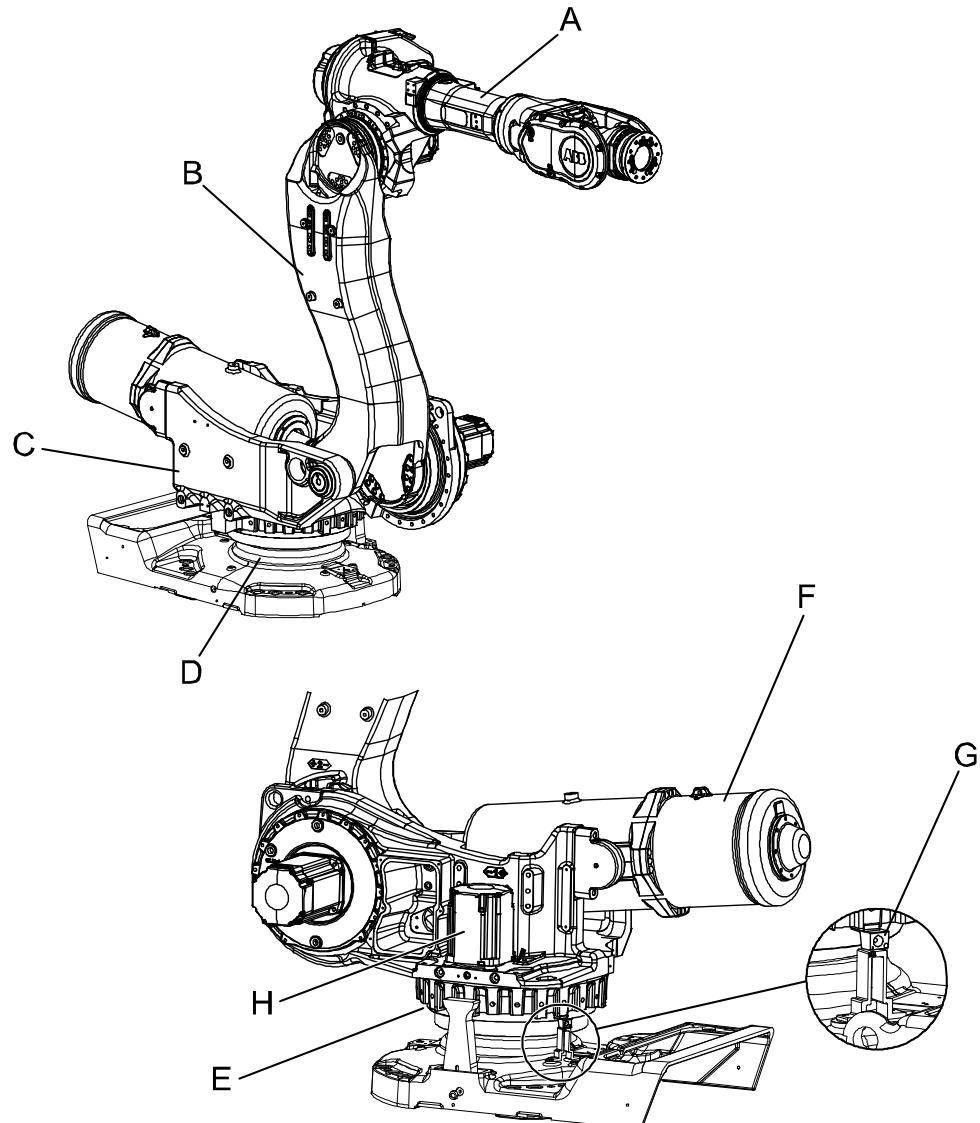
	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2	Reconnect all connectors at motor, axis 5.	
3	Refit the cable gland cover at the cable exit with its two attachment screws.	
4	Refit the cover of motor, axis 5.	
5	Refit the complete wrist unit.	Detailed in section: <ul style="list-style-type: none"><li>• <a href="#">Refitting, wrist unit on page 264</a>.</li></ul>
6	Recalibrate the robot.	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in section <a href="#">Calibration on page 393</a> .
7	 <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

### 4.3.5 Replacement of complete arm system

#### Location of arm system

The complete arm system is defined as the complete robot except for the base and axis-1 gearbox. This is shown in the figure below.

A more detailed view of the component and its position may be found in [Spare part lists on page 425](#).



xx0300000465

A	Upper arm
B	Lower arm
C	Frame
D	Gearbox, axis 1
E	Base attachment screws
F	Balancing device

*Continues on next page*

## 4 Repair

### 4.3.5 Replacement of complete arm system

*Continued*

G	Block for calibration
H	Motor axis 1

#### Required equipment

Equipment, etc.	Art. no.	Note
Lifting accessory, robot	3HAC15607-1	Instruction 3HAC15971-2 is enclosed!
Guide pins M12 x 130	3HAC022637-001	Used to guide the complete arm system when lifting it. Always use the guide pins in pairs! In order to make the refitting easier, it is recommended to use two guide pins of different lengths. Notice that longer guide pins than 140 mm will not be possible to remove from the frame because lack of space after refitting!
Roundsling 1,5 m		Lifting capacity 1,000 kg
Hoisting block	-	Used to adjust the length of the lifting chain.
Isopropanol	-	Used for cleaning mounting surfaces.
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

#### Deciding calibration routine

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

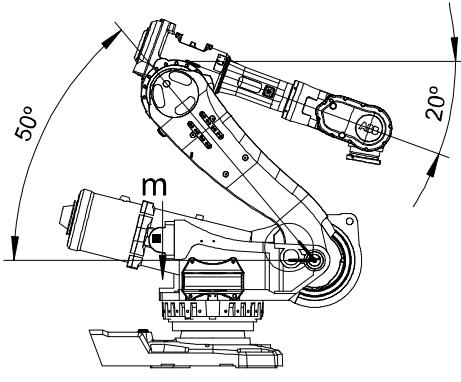
Action	Note
1 Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"><li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li><li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li></ul>	
If the robot is to be calibrated with reference calibration: Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot. If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.	Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a> . Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a> .

*Continues on next page*

Action	Note
If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

**Removal, arm system**

Use this procedure to lift and remove the complete arm system.

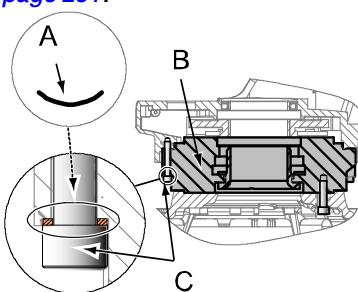
Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2 Run the robot to the position shown in the figure to the right.	Release the brakes if necessary, as detailed in section <a href="#">Manually releasing the brakes on page 78</a> .   xx0300000632
3 Run the overhead crane to a position above the robot.	
4 Fit the <i>lifting accessory</i> and adjust it as detailed in the enclosed <i>instructions</i> .	Art. no. is specified in <a href="#">Required equipment on page 252</a> . Make sure the lift is done completely level! How to adjust the lift is described in the enclosed instruction to the lifting accessory! <b>Read the instructions before lifting!</b>
5  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
6 Drain the oil from gearbox axis 1.	Detailed in section <a href="#">Changing oil, axis-1 gearbox on page 180</a> .

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## 4 Repair

### 4.3.5 Replacement of complete arm system

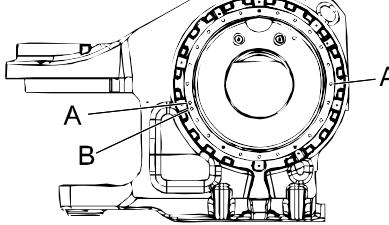
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Action	Note
7 Disconnect the cabling in the rear of the robot base and remove the cable support plate inside the base.	
8 Pull the disconnected cabling up through the center of the axis-1 gearbox.	How to replace the cabling is detailed in <a href="#">Replacing cable harness, axes 1-6 on page 223</a> .
9 Remove the motor, axis 1.	Detailed in section <a href="#">Removal, motor axis 1 on page 325</a> .
10 Remove the <i>block for calibration</i> from the bottom of the frame.	Shown in the figure <a href="#">Location of arm system on page 251</a> .
11 Unfasten the arm system from the base by unscrewing its 24 attachment screws.	Shown in the figure <a href="#">Location of arm system on page 251</a> .   <b>Parts:</b> <ul style="list-style-type: none"> <li>A: Serrated lock washer</li> <li>B: Gearbox axis 1</li> <li>C: Attachment screws M12x110</li> </ul>
12 Fit two <i>guide pins</i> in two opposite screw holes.	Art. no. is specified in section <a href="#">Required equipment on page 252</a> .
13  <b>CAUTION</b>  The complete arm system weighs 1250 kg! All lifting equipment used must be sized accordingly!	
14 Lift the arm system carefully and secure it in a safe area. Always move the robot at very low speeds, making sure it does not tip.  Continue lifting even if the arm system turns out to be unbalanced despite earlier adjustments! The risk of damaging the interfaces is bigger if the load is lowered unbalanced!	Make sure all hooks and attachments stay in the correct position while lifting the arm system and that the lifting accessory does not wear against sharp edges.

*Continues on next page*

**Refitting, arm system**

The procedure describes how to lift and refit the complete arm system.

	Action	Note
1	 <b>DANGER</b> <b>Turn off all:</b> <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> <b>Before entering the robot working area.</b>	
2	<b>Fit the <i>lifting accessory</i> as detailed in enclosed instruction.</b> <b>Also fit a <i>hoisting block</i> to the front chain.</b> <b>(Used to adjust the balance of the arm system in order to lift it completely level!)</b>	Art. no. is specified in <a href="#">Required equipment on page 252</a> . Make sure the lift is done completely level! How to adjust the lift is described in the enclosed instruction to the lifting accessory! <b>Follow the instructions before lifting!</b> Releasing the brakes are detailed in section <a href="#">Manually releasing the brakes on page 78</a> .
3	 <b>CAUTION</b> <b>The complete arm system weighs 1250 kg!</b> <b>All lifting equipment used must be sized accordingly!</b>	
4	<b>Lift the complete arm system and move it at very low speed, making sure it does not tip!</b> <b>Make sure the lift is done completely level.</b> <b>Adjust the length of the chains as detailed in enclosed instruction or with a hoisting block.</b>	
5	<b>Clean the mounting surfaces with isopropanol.</b>	
6	<b>Fit the two <i>guide pins</i> to the frame attachment holes, as shown in the figure to the right.</b> <b>Fit one guide pin next to the guiding hole (for the spring pin in the gearbox) and the other guide pin straight across the frame.</b> <p> <b>Note</b></p> <p>Lubricate the guide pins for easier fitting of the arm system.</p>	Dimension is specified in <a href="#">Required equipment on page 252</a> .  xx0600003441 The figure above shows the frame, view from below. A Attachment holes for the guide pins, M12. B Guiding hole for the spring pin located in the gearbox, axis 1.

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## 4 Repair

### 4.3.5 Replacement of complete arm system

*Continued*

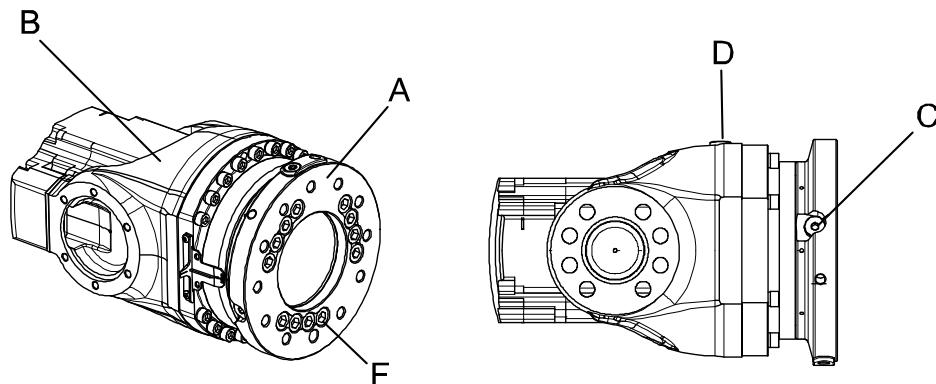
Action	Note
7 Lubricate the outer surface of the gearbox for easier mating of the gearbox and arm system.	
8 Look through the empty mounting hole of motor 1 to assist in aligning the assembly during refitting of the arm system.  The spring pin in the gearbox must be fitted to the guiding hole of the frame (B).  Lower the arm system with guidance from the guide pins previously fitted to the frame.	This is a complex task to be performed with utmost care in order to avoid injury or damage!
 <b>Note</b>  The refitting must be made completely level! Make sure the lifting accessory is adjusted prior to refitting of arm system.	
9 Refit 22 of the 24 attachment screws before the arm system is completely lowered.	
10 Remove the guide pins and secure the arm system to the base with its 24 <i>attachment screws and washers</i> .	Shown in the figure <a href="#">Location of arm system on page 251</a> .  M12 x 110, 12.9 quality UNBRAKO. Tightening torque: 110 Nm.  Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.
11 Refit the <i>block for calibration</i> at the bottom of the frame.	Shown in the figure <a href="#">Location of arm system on page 251</a> .
12 Refit the <i>axis-1 motor</i> .	Detailed in section <a href="#">Refitting, motor axis 1 on page 326</a> .
13 Perform a <i>leak-down test</i> of the axis-1 gearbox.	Detailed in section <a href="#">Performing a leak-down test on page 218</a> .
14 Refit the <i>cabling</i> in the base.	
15 Refill the gearbox with lubricating oil.	Detailed in section <a href="#">Changing oil, axis-1 gearbox on page 180</a> .
16 Recalibrate the robot.	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools.  Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> .  General calibration information is included in section <a href="#">Calibration on page 393</a> .
17  <b>DANGER</b>  Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

## 4.4 Upper and lower arm

### 4.4.1 Replacing the turning disk

#### Location of turning disk

The turning disk is located in the front of the wrist housing as shown in the figure below.



xx0200000217

A	Turning disk
B	Wrist unit
C	Oil plug, draining
D	Oil plug, filling
F	Attachment screws (12 pcs)

#### Required equipment

Equipment, etc.	Art. no.	Note
Turning disk	For spare part no. see: <a href="#">Spare part lists on page 425</a> .	
O-ring Wrist, type 2	3HAB3772-64 (1 pc) 3HAB3772-61 (12 pcs)	Must be replaced when replacing the turning disk!
Grease	3HAB3537-1	Used to lubricate the o-rings.
Flange sealant	3HAC034903-001	Loctite 574
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

*Continues on next page*

## 4 Repair

### 4.4.1 Replacing the turning disk

*Continued*

#### Removing, turning disk

Use this procedure to remove the turning disk.

Action	Note
1 Run the robot to a position where the <i>oil plug, draining</i> of axis 6 gearbox faces downwards.	Shown in the figure <a href="#">Location of turning disk on page 257</a> .
2  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply</li><li>• hydraulic pressure supply</li><li>• air pressure supply</li></ul> to the robot, before entering the robot working area.	
3 Remove any equipment fitted to the turning disk.	
4 Drain the axis 6 gearbox.	See section <ul style="list-style-type: none"><li>• <a href="#">Changing oil, axis-6 gearbox on page 195</a></li></ul>
5 Remove the <i>attachment screws</i> that secure the turning disk.	Shown in the figure <a href="#">Location of turning disk on page 257</a> .
6 Remove the <i>turning disk</i> .	
7 <i>Foundry Plus:</i> Remove old flange sealant residues and other contamination from the contact surfaces.	

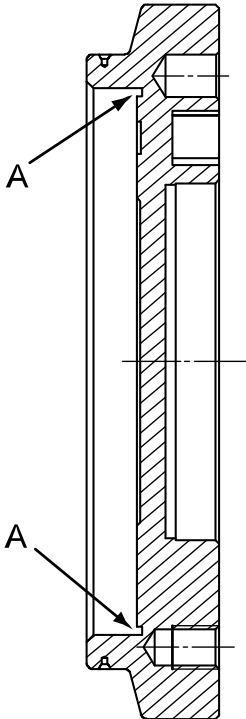
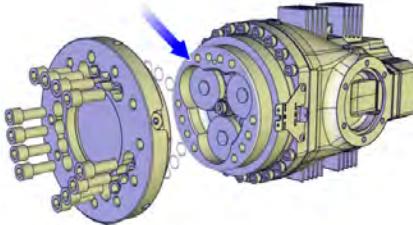
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## 4.4.1 Replacing the turning disk

Continued

## Refitting, turning disk

Use this procedure to refit the turning disk.

	Action	Note
1	Lubricate the <i>o-ring</i> of the turning disk with grease and fit it to the turning disk. Also fit the 12 o-rings, when refitting the attachment screws.	Art. no. is specified in <a href="#">Required equipment on page 257</a> .   xx0200000218 <ul style="list-style-type: none"> <li>• A: Sealing surface, o-ring</li> </ul>
2	<b>Foundry Plus:</b> Apply Loctite 574 flange sealant on the contact surface.	 xx1400000995
3	Secure the turning disk with its <i>attachment screws</i> .	12 pcs, M12 x 30, 12.9 quality Gleitmo. <b>Tightening torque: 100 Nm.</b> Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.
4	Perform a <i>leak-down test</i> of the gearbox axis 6.	Detailed in the section <a href="#">Performing a leak-down test on page 218</a> .
5	Refill the axis 6 gearbox with oil.	See section <ul style="list-style-type: none"> <li>• <a href="#">Changing oil, axis-6 gearbox on page 195</a></li> </ul>
6	Refit any equipment removed during disassembly to the turning disk.	

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## 4 Repair

### 4.4.1 Replacing the turning disk

*Continued*

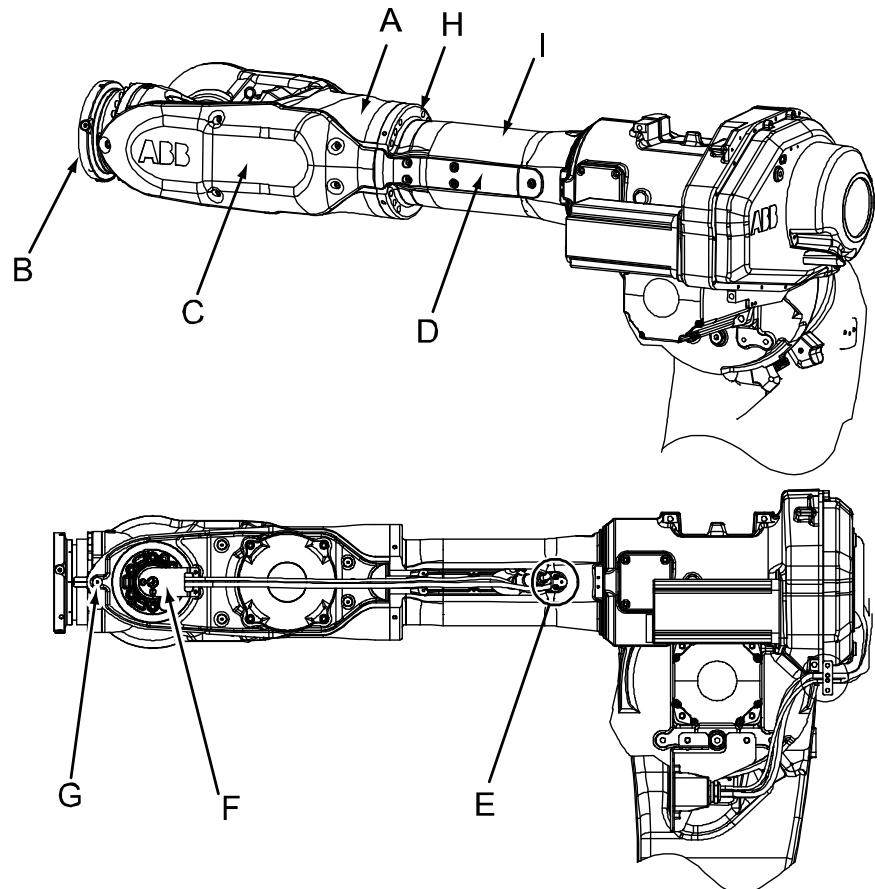
Action	Note
7  <b>DANGER</b>  Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <i>DANGER - First test run may cause injury or damage!</i> on page 50.	

## 4.4.2 Replacement of complete wrist unit

### Location of wrist unit

The wrist unit is located in the frontmost part of the upper arm as shown in the figure below.

A more detailed view of the component and its position may be found in [Spare part lists on page 425](#).



xx0200000184

<b>A</b>	Wrist unit
<b>B</b>	Turning disk
<b>C</b>	Cover, wrist unit
<b>D</b>	Cover, upper arm tube
<b>E</b>	Connectors, upper arm tube, with cable bracket (R3.FB5, R3.MP5)
<b>F</b>	Cable bracket
<b>G</b>	Attachment point for lifting tool, wrist unit
<b>H</b>	Wrist unit attachment screws and washers
<b>I</b>	Upper arm tube

*Continues on next page*

## 4 Repair

### 4.4.2 Replacement of complete wrist unit

*Continued*

#### Required equipment

Equipment etc.	Art. no.	Note
Wrist unit	For spare part number, see <a href="#">Spare part lists on page 425</a> .	
Cover for wrist unit	For spare part number, see <a href="#">Spare part lists on page 425</a> .	
Guide pins M12 x 200	3HAC13056-3	Always use guide pins in pairs!
Lifting accessory, wrist unit	3HAC13605-1	
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.
Circuit diagram		See chapter <a href="#">Circuit diagram on page 441</a> .

#### Deciding calibration routine

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

Action	Note
1 Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"><li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li><li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li></ul>	
If the robot is to be calibrated with reference calibration: Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot. If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.	Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a> . Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a> .
If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

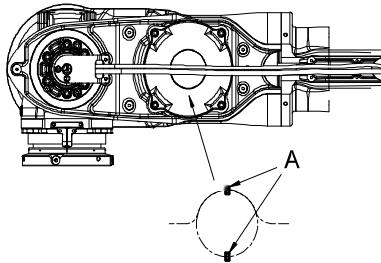
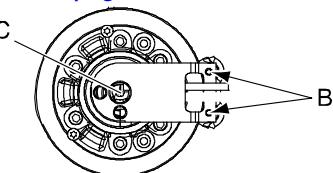
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## 4.4.2 Replacement of complete wrist unit

Continued

**Removal, wrist unit**

The procedure below details how to remove the complete wrist unit.

	Action	Note
1	Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2	Remove all equipment fitted to the turning disk.	
3	Turn axis 4 to a position where the <i>cover, upper arm tube and wrist unit</i> , faces upwards. Turn axis 5 to +90°.	 xx0200000185
4	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
5	Remove the <i>cover, wrist unit</i> .	Shown in the figure <a href="#">Location of wrist unit on page 261</a> .
6	Remove the <i>cover, upper arm tube</i> .	Shown in the figure <a href="#">Location of wrist unit on page 261</a> .
7	Remove the cover of motor, axis 6 and disconnect all connectors beneath.	
8	Loosen the <i>cable bracket, wrist unit</i> on top of the wrist by undoing the three attachment screws. Two of the <i>attachment screws</i> are visibly located at the rear of the bracket and the third located at the bottom of the cable bracket, in the center.	Shown in the figure <a href="#">Location of wrist unit on page 261</a> .  xx0200000254 <ul style="list-style-type: none"> <li>• B: Attachment screws, rear of cable bracket (2 pcs)</li> <li>• C: Attachment screw, bottom of cable bracket</li> </ul>
9	Pick out the cabling from motor, axis 6 and place it safely on the tube.	
10	Fit the <i>lifting accessory</i> to the wrist unit.	Art. no. is specified in <a href="#">Required equipment on page 262</a> .

Continues on next page

## 4 Repair

### 4.4.2 Replacement of complete wrist unit

*Continued*

Action	Note
11  <b>CAUTION</b> The complete wrist unit weighs 130 kg! All lifting equipment used must be sized accordingly!	
12 Slightly raise the wrist unit to unload the screw joint, facilitating removing the attachment screws.	
13 Remove the <i>wrist unit attachment screws and washers</i> .	Shown in the figure <a href="#">Location of wrist unit on page 261</a> .
14 Pull the wrist unit out, lift it away and place it on a secure surface.	
15 Disconnect the <i>motor axis 5</i> by disconnecting the two connectors in the upper arm tube (R3.FB5, R3.MP5).	Shown in the figure <a href="#">Location of wrist unit on page 261</a> .

### Refitting, wrist unit

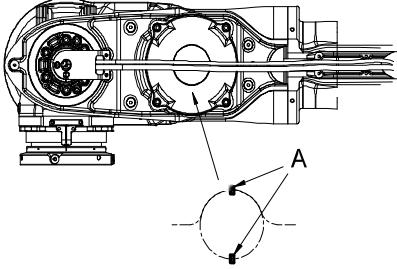
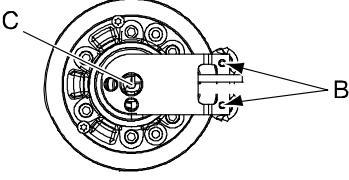
The procedure below details how to refit the complete wrist unit.

Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2 Fit two <i>guide pins, M12</i> in the upper arm tube, in two of the holes for the <i>wrist unit attachment screws</i> .	Art. no. is specified in <a href="#">Required equipment on page 262</a> . Shown in the figure <a href="#">Location of wrist unit on page 261</a> .
3 Fit the <i>lifting tool</i> to the wrist unit.	Art. no. is specified <a href="#">Location of wrist unit on page 261</a> .
4  <b>CAUTION</b> The complete wrist unit weighs 130 kg! All lifting equipment used must be sized accordingly!	
5 Lift the wrist unit and guide it to the upper arm tube with help of the guide pins. Make sure the cabling from motor, axis 5 is safely run into the arm tube and does not get jammed.	
6 Reconnect the motor axis 5 by connecting the two <i>connectors inside the upper arm tube</i> (R3.FB5, R3.MP5) and secure the cable bracket with the two attachment screws to the tube.	Shown in the figure <a href="#">Location of wrist unit on page 261</a> .

*Continues on next page*

## 4.4.2 Replacement of complete wrist unit

Continued

Action	Note
7 Secure the wrist unit with 10 of the 12 attachment screws and washers.	Shown in the figure <a href="#">Location of wrist unit on page 261</a> . 12 pcs: M12 x 50, 12.9 quality Gleitmo. Tightening torque: 115 Nm. Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.
8 Remove the guide pins and secure the two remaining attachment screws as detailed above.	
9 Remove the lifting tool from the wrist unit.	
10  Note  Axis 5 must be oriented in the correct position (+90°) to allow the motor 6 cover to open!	
11 Place the cabling to motor axis 6 correctly on the upper arm and gently pull the connectors through the hole on top of wrist unit to motor, axis 6.  In case of excess of cable length: <ul style="list-style-type: none"><li>put the excess cable in a loop in the area shown in the figure and secure with with <b>cable straps</b>. Cables are longer in order to fit different upper arm lengths.</li></ul>	 xx0200000185 Parts: <ul style="list-style-type: none"><li>A: Cable straps</li></ul>
12 Fasten the <b>cable bracket</b> at top of the wrist unit with three attachment screws. Two of them are visible at the <b>rear attachment point</b> and the third is located on the <b>bottom</b> of the cable bracket, in the center.	 xx0200000254 <ul style="list-style-type: none"><li>B: Attachment screws, rear attachment point of cable bracket (2 pcs)</li><li>C: Attachment screw, bottom of cable bracket</li></ul>
13 Reconnect the connectors to the axis-6 motor and refit the motor cover.	
14 Refit the <b>cover, upper arm tube</b> .	Shown in the figure <a href="#">Location of wrist unit on page 261</a> .
15 Refit the <b>cover, wrist unit</b> .	Shown in the figure <a href="#">Location of wrist unit on page 261</a> .

Continues on next page

## 4 Repair

### 4.4.2 Replacement of complete wrist unit

*Continued*

	Action	Note
16	Recalibrate the robot!	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> . General calibration information is included in section <a href="#">Calibration on page 393</a> .
17	Refit any equipment previously removed from the turning disk.	
18	 <b>DANGER</b>  Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

### 4.4.3 Replacement of upper arm

#### Location of upper arm

The upper arm is located on top of the robot as shown in the following figure. The complete upper arm includes the wrist unit but this section also describes how to remove the upper arm when there is no wrist unit mounted.



#### Note

The lifting accessory is attached differently depending on whether the wrist unit is mounted on the upper arm or not. The attachment points are shown in the following figure.

*Continues on next page*

## **4 Repair**

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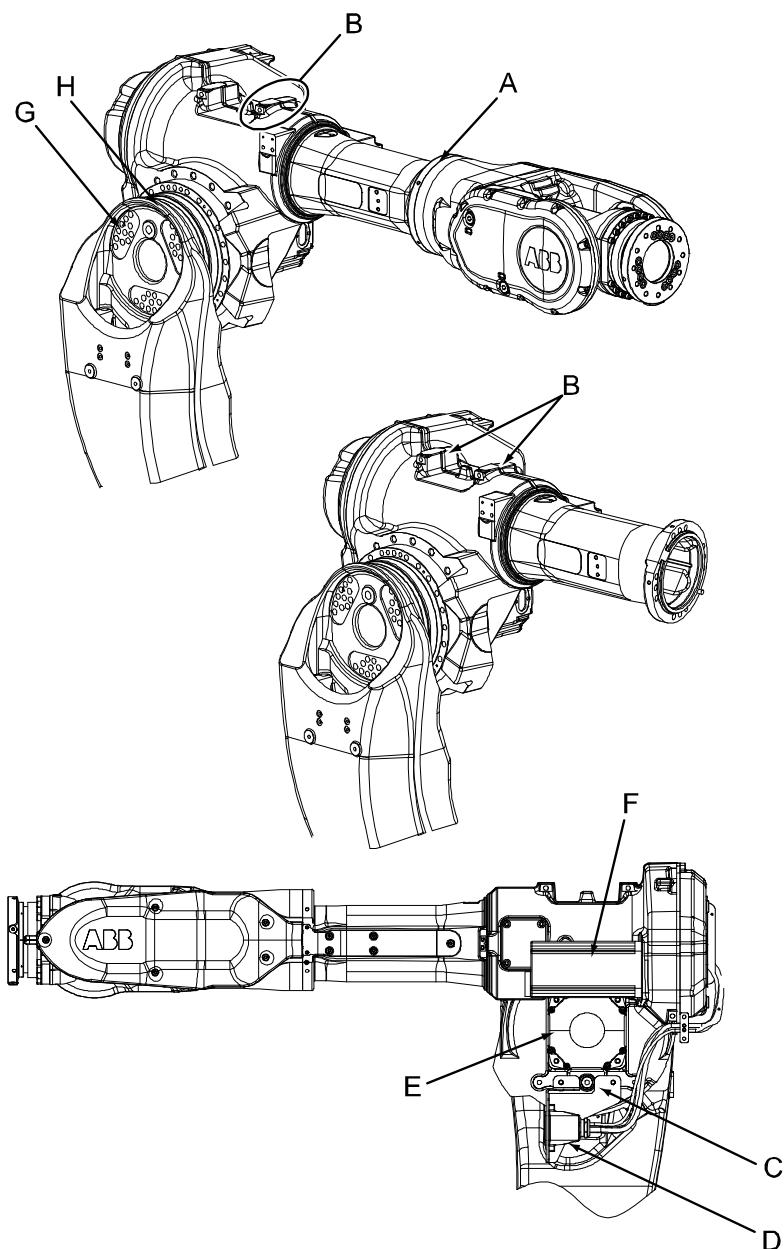
### **4.4.3 Replacement of upper arm**

*Continued*

A more detailed view of the component and its position may be found in [\*Spare part lists on page 425.\*](#)

*Continues on next page*

## 4.4.3 Replacement of upper arm

*Continued*

xx0200000163

A	Attachment hole for lifting eye, M12 (if wrist unit is mounted)
B	Attachment for lifting accessory, upper arm (2 pcs if there is no wrist unit mounted)
C	Oil plug, draining, gearbox axis 3
D	Cable harness division; connector R2.M5/6
E	Motor, axis 3
F	Motor, axis 4
G	Attachment screws and washers, upper arm
H	Sealing, axis 2/3 (between lower arm and gearbox axis 3)

*Continues on next page*

## 4 Repair

### 4.4.3 Replacement of upper arm

*Continued*

#### Required equipment

Equipment	Art. no.	Note
Sealing, axis 3	3HAC17212-1	Always use a new sealing when refitting the upper arm!
Foundry Prime (grey)	3HAC038648-001	To be replaced if damaged.
Washer, axis 3 (3 pcs) Standard and Foundry Plus (ABB Orange)	3HAC038648-002	To be replaced if damaged.
Washer, axis 3 (3 pcs) Standard and Foundry Plus (Graphite White)	3HAC038648-003	To be replaced if damaged.
Guide pins, sealing axis 2/3 80 mm	3HAC14628-1	For guiding the axis-3 sealing.
Guide pins, sealing axis 2/3 100 mm	3HAC14628-2	For guiding the axis-3 sealing.
Power supply	-	24 VDC, max 1,5A For releasing the brakes.
Rotation tool	3HAC17105-1	Used to rotate the motor shaft beneath the motor cover, when brakes are released with 24 VDC power supply.
Lifting eye VLBG M12	3HAC16131-1	
Lifting accessory, upper arm	3HAC15994-1	
Lifting tool (chain)	3HAC15556-1	To be used together with lifting eye, M12 and lifting accessory, upper arm.
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

#### Deciding calibration routine

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

	Action	Note
1	Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"><li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li><li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li></ul>	

*Continues on next page*

## 4.4.3 Replacement of upper arm

Continued

Action	Note
<p><b>If the robot is to be calibrated with reference calibration:</b> Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot.</p> <p>If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.</p>	<p>Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a>. Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a>.</p>
<p><b>If the robot is to be calibrated with fine calibration:</b> Remove all external cable packages (DressPack) and tools from the robot.</p>	

**Removal, upper arm**

The procedure below details how to remove the upper arm.

Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2 Remove all equipment fitted to turning disk.	
3 Move the upper arm to a horizontal position. Rotate axis 4 so that the <i>attachment hole for lifting eye</i> is faced upwards!	Shown in the figure <a href="#">Location of upper arm on page 267</a> .
4 Rotate axis 5 to position +90°.	
5  <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
6 <b>Upper arm including wrist unit:</b> Fit the <i>lifting eye, VLBG M12</i> to the <i>attachment hole for lifting eye</i> on the upper arm tube.	Art. no. is specified in <a href="#">Required equipment on page 270</a> . Shown in the figure <a href="#">Location of upper arm on page 267</a> .
7 <b>Upper arm including wrist unit:</b> Fit one of the pieces included in <i>lifting accessory, upper arm</i> to the front <i>attachment for lifting accessory</i> on the upper arm. <b>Upper arm without wrist unit:</b> Fit the <i>lifting accessory, upper arm</i> to both <i>attachments for lifting accessory</i> .	Art. no. is specified in <a href="#">Required equipment on page 270</a> . Attachment point is shown in the figure <a href="#">Location of upper arm on page 267</a> .   <b>Note</b>  The different attachment points, depends on whether the wrist unit is mounted or not!

Continues on next page

## 4 Repair

### 4.4.3 Replacement of upper arm

Continued

Action	Note
8 Fasten the <i>lifting tool (chain)</i> onto the lifting eye, the lifting accessory and an overhead crane.	Art. no. is specified in <a href="#">Required equipment on page 270</a> .
9 Drain the oil from gearbox axis 3.	Detailed in section <a href="#">Changing oil, axis-3 gearbox on page 186</a> .
10 Disconnect connector R2.M5/6 at the <i>cable harness division</i> as well as all remaining connections between upper and lower arm.	Shown in the figure <a href="#">Location of upper arm on page 267</a> .
11 Remove the cover on top of the motors, axis 3 and 4 and disconnect all connectors inside the motors.	
12 Remove all brackets securing the cabling to the upper arm by removing their attachment screws respectively.	
13  <b>CAUTION</b> The complete upper arm weighs 380 kg without any additional equipment fitted! Use a suitable lifting accessory to avoid injury to personnel!	
14 Raise the lifting equipment to take the weight of the upper arm.	
15 In order to release the brake of the axis 3 motor, connect the 24 VDC power supply.  <b>Note</b> When releasing the brake, the position of the upper arm is adjusted to the position given by the lifting equipment.	Connect to connector R2.MP3 • +: pin 2 • -: pin 5
16 Remove the axis-3 motor.	See <a href="#">Replacement of motor, axis 3 on page 334</a> .
17 Carefully remove the <i>attachment screws and washers, upper arm</i> .	Shown in the figure <a href="#">Location of upper arm on page 267</a> .
18 Lift the upper arm and place it on a secure surface. Make sure the lift is done completely level! In case of necessary adjustments, use the shortening loops on the lifting tool (chain), but make sure to place the chain the right way through the loops!	
19 Remove the <i>sealing, axis 2/3</i> from the lower arm.	Shown in the figure <a href="#">Location of upper arm on page 267</a> .

Continues on next page

#### 4.4.3 Replacement of upper arm

*Continued*

##### Refitting, upper arm

The procedure below details how to refit the upper arm.

Action	Note
1 Fit the new <i>sealing, axis 2/3</i> onto the axis-3 gearbox and keep it in place by also fitting the two <i>guide pins, sealing axis 2/3</i> in two of the attachment screw holes on the gearbox, see figure to the right.	Always use a new sealing when reassembling! Art. no. is specified in <a href="#">Required equipment on page 270</a> .   xx0200000166  A Holes for the guide pins (sealing axis 2/3). B Holes for the upper arm attachment screws (33 pcs). C Holes for the gearbox attachment screws (not affected in this instruction).
2 Upper arm including wrist unit: Fit the <i>lifting eye, VLBG M12</i> to the <i>attachment hole, lifting eye</i> on the wrist unit.	Art. no. is specified in <a href="#">Required equipment on page 270</a> . Shown in the figure <a href="#">Location of upper arm on page 267</a> .
3 Upper arm including wrist unit: Fit one of the pieces included in the <i>lifting accessory, upper arm</i> to the front <i>attachment for the lifting accessory</i> on the upper arm.  Upper arm without wrist unit: Fit the <i>lifting accessory, upper arm</i> to the both <i>attachments for the lifting accessory</i> on the upper arm.	Art. no. is specified in <a href="#">Required equipment on page 270</a> . Attachment points are shown in the figure <a href="#">Location of upper arm on page 267</a> .   <b>Note</b> The different attachment points, depends on whether the wrist unit is mounted or not!
4 Fasten the <i>lifting tool (chain)</i> onto the lifting eye, the lifting accessory and an overhead crane.	Art. no. is specified in <a href="#">Required equipment on page 270</a> .
5  <b>CAUTION</b>  The complete upper arm weighs 380 kg without any additional equipment fitted! Use a suitable lifting accessory to avoid injury to personnel!	

*Continues on next page*

## 4 Repair

### 4.4.3 Replacement of upper arm

Continued

Action	Note
6 Lift the upper arm and move to its mounting position.   <b>CAUTION</b> Make sure the lift is done completely level!	
7 Fit in the gearbox attachment holes with the attachment holes on the lower arm with the guide pins.	Art. no. is specified in <a href="#">Required equipment on page 270</a> .
8 Fit the three <i>washers</i> to be placed beneath the attachment screws.	Shown in the figure <a href="#">Location of upper arm on page 267</a> .
9 Insert 31 of the 33 <i>attachment screws, upper arm</i> into the attachment holes in the lower arm. Do not remove the guide pins until the attachment screws are tightened as detailed below.	Shown in the figure <a href="#">Location of upper arm on page 267</a> . Removing the plastic mechanical stops may be required before fitting the upper arm. If guide pins are removed before the screws are tightened, the sealing can be involuntarily moved into wrong position.
10 Secure the lower arm to gearbox axis 3, with the attachment screws.	33 pcs: M12 x 50; 12.9 quality UN-BRAKO, tightening torque: 120 Nm. Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.
11 Remove the guide pins and fit the two remaining attachment screws. Tighten them as detailed above!	
12 Refit the axis-3 motor.	See <a href="#">Replacement of motor, axis 3 on page 334</a> .
13 Remove the lifting accessories.	
14 Refit any cabling removed during the removal process.	
15 Reconnect all connectors inside motors, axis 3 and 4. Refit the motor covers.	
16 Reconnect connector R2.M5/6 gently at the cable harness division point, with 2 screws, M6. Be careful not to bend the attachment plate when fastening the screws!	
17 Perform a leakdown test.	Detailed in section <a href="#">Performing a leakdown test on page 218</a> .
18 Refill the gearbox with oil.	Detailed in section <a href="#">Changing oil, axis-3 gearbox on page 186</a> .

Continues on next page

## 4.4.3 Replacement of upper arm

*Continued*

Action	Note
19 Recalibrate the robot.	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> . General calibration information is included in section <a href="#">Calibration on page 393</a> .
20  <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

## 4 Repair

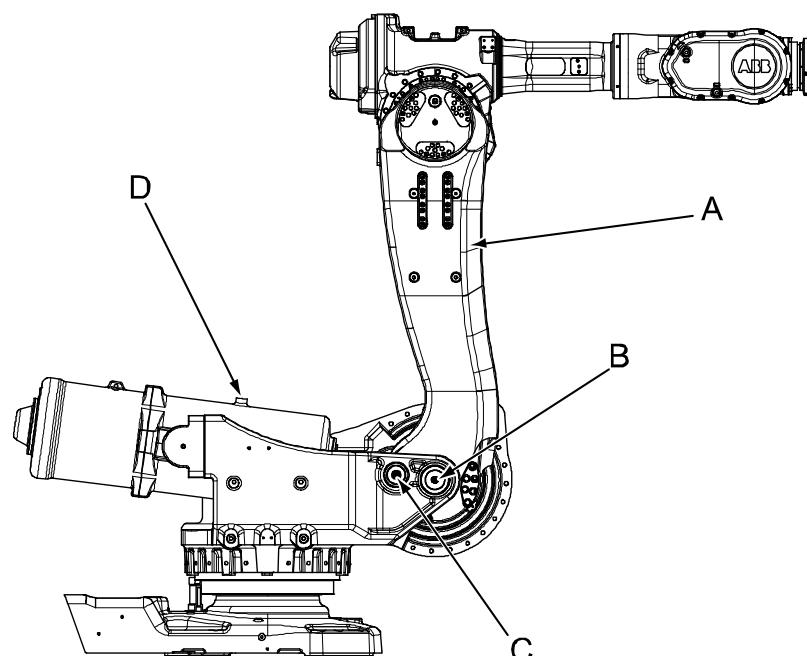
### 4.4.4 Replacement of complete lower arm

#### 4.4.4 Replacement of complete lower arm

##### Location of lower arm

The lower arm is located as shown in the figure below.

A more detailed view of the component and its position may be found in [Spare part lists on page 425](#).



A	Lower arm
B	Pivot point, axis 2
C	Front shaft, balancing device, including securing screw
D	Attachment for lifting equipment, balancing device

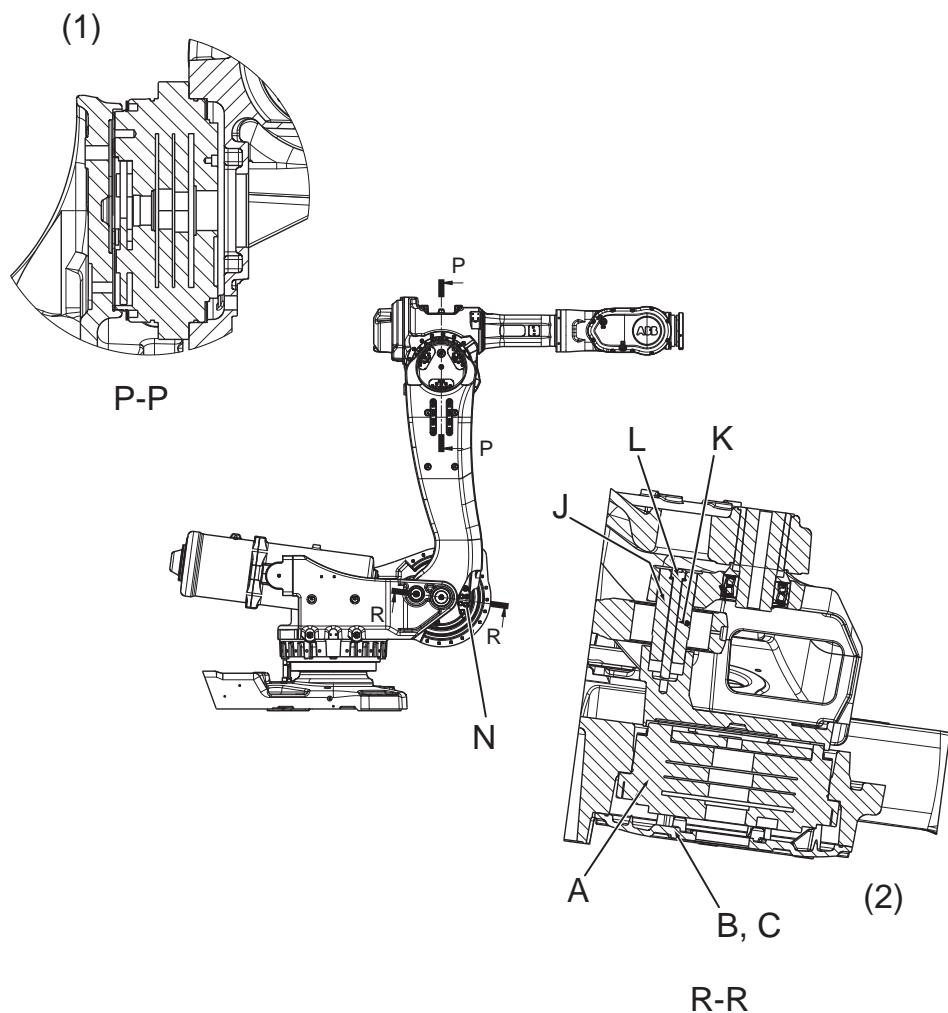
##### Internal components, lower arm

The internal components of the lower arm are located as shown in the figure below:

- The figure (1) shows a cut between the lower arm and the gearbox axis 3. The location of the sealing axis 2/3 is identical between the lower arm and the axis 2.
- The figure (2) shows a cut through the lower arm pivot point in axis 2 (item B in the figure above!).

*Continues on next page*

4.4.4 Replacement of complete lower arm  
*Continued*



xx0300000475

A	Gearbox
B	Cover axis 2
C	O-ring
J	Shaft, balancing device
K	Grease
L	Securing screw and washer, balancing device shaft
N	Attachment screws and washers

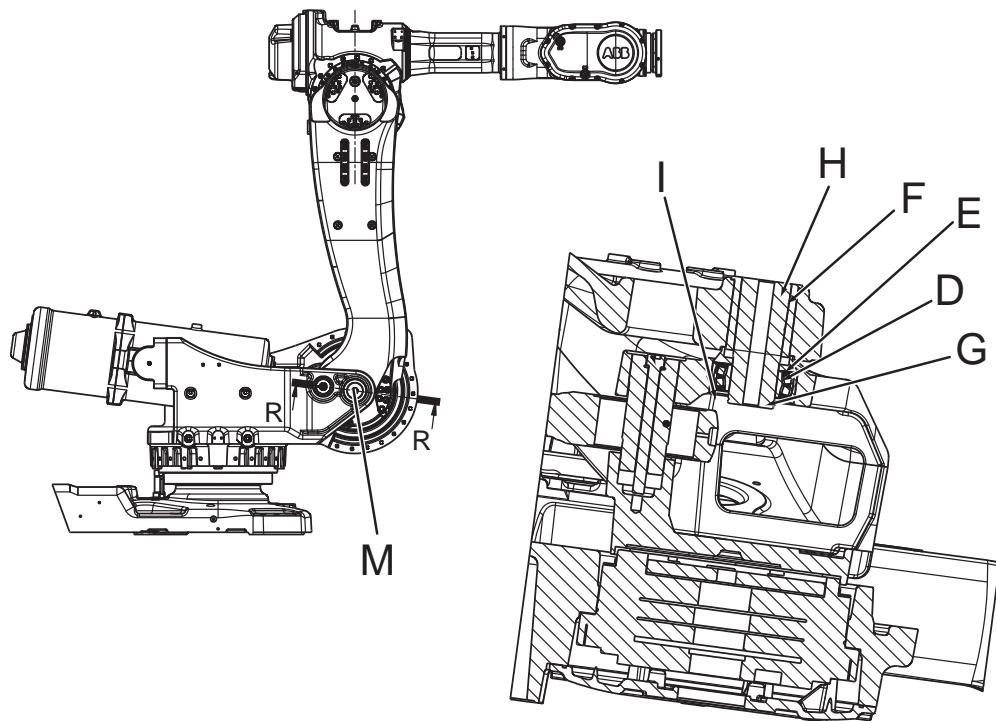
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## 4 Repair

### 4.4.4 Replacement of complete lower arm

*Continued*

Internal components for robots with protection Standard



R-R

xx1100000955

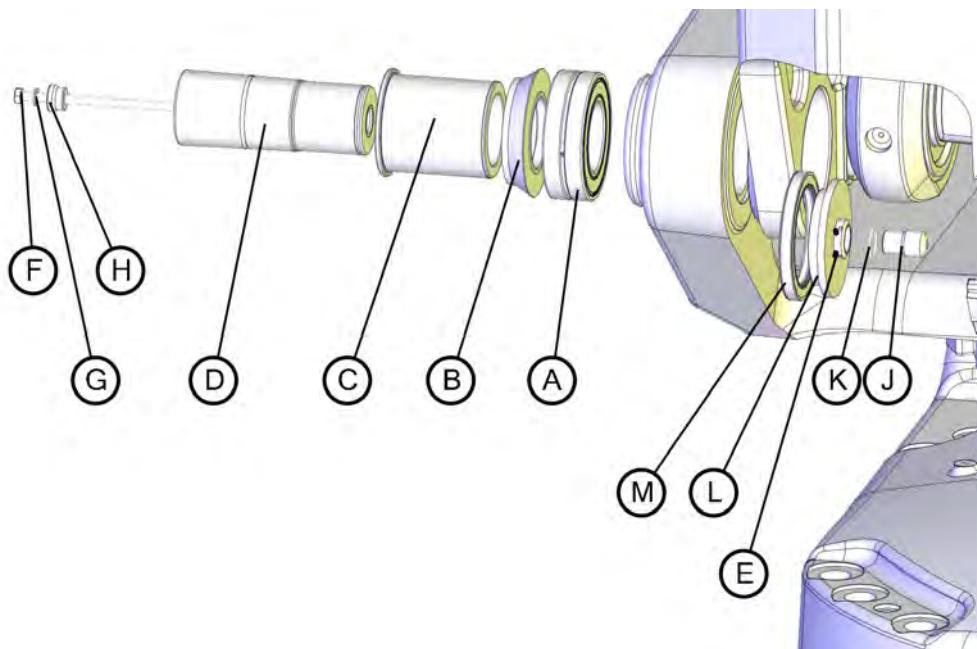
D	Bearing
E	Thrust washer
F	Bushing
G	Retaining ring, shaft
H	Shaft, lower arm
I	Protection washer
M	Protection plug

*Continues on next page*

## 4.4.4 Replacement of complete lower arm

*Continued*

Internal components for robots with protection Foundry Plus



xx1100000954

A	Bearing
B	Thrust washer
C	Bushing
D	Shaft, lower arm
E	Set screw with cup point, M4x6 (2 pcs)
F	Hexagon bolt M8x190
G	Conical spring washer
H	Shaft tap
J	Short shaft sealing cover
K	O-ring
L	Sealing cover
M	Radial sealing with dust lip

## Required equipment

Equipment, etc.	Art. no.	Note
Bearing	For spare part number see: • <a href="#">Spare part lists on page 425.</a>	Always use a new bearing when reassembling!
Sealing, axis 2	For spare part number see: • <a href="#">Spare part lists on page 425.</a>	Always use a new sealing when reassembling!

*Continues on next page*

## 4 Repair

### 4.4.4 Replacement of complete lower arm

*Continued*

Equipment, etc.	Art. no.	Note
VK-Cover VK 120x12	For spare part number see: <ul style="list-style-type: none"><li>• <a href="#">Spare part lists on page 425</a>.</li></ul>	Mount on new lower arm or replace if damaged.
Lifting eye M12	3HAC14457-3	Used to lift the balancing device, if it is equipped with a threaded hole.
Shackle, balancing device	3HAC 020997-1	
Puller tool, balancing device shaft	3HAC12475-1	
Lifting accessory, lower arm	3HAC14691-1	Tool that may be rented from ABB Robotics. Includes: <ul style="list-style-type: none"><li>• two guidings, 3HAC 14445-1, must be used for guiding the sealing, axis 2/3.</li></ul>
Rotation tool	3HAC17105-1	Used to rotate the motor pinion and gear if necessary, when brakes are released.
Hydraulic pump, 80 MPa	3HAC13086-1	
Hydraulic pump, 150 MPa (Glycerin)	3HAC021563-012	
Puller device, axis 2 shaft	3HAC021563-001	The use of the tool is detailed in section <a href="#">Replacement of lower arm shaft on page 286</a> .
Press device, axis 2 shaft	3HAC021600-001	
Press tool, axis 2 bearing	3HAC13527-1	
Retaining ring plier	-	
Grease	3HAB3537-1	For lubrication of the shaft hole.
Isopropanol	11771012-208	For cleaning of the shaft.
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

*Continues on next page*

**Deciding calibration routine**

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

Action	Note
1 Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"> <li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li> <li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li> </ul>	
If the robot is to be calibrated with reference calibration: Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot. If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.	Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a> . Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a> .
If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

**Removal, lower arm**

The procedure below details how to remove the complete lower arm.

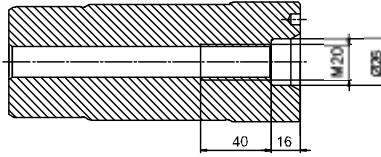
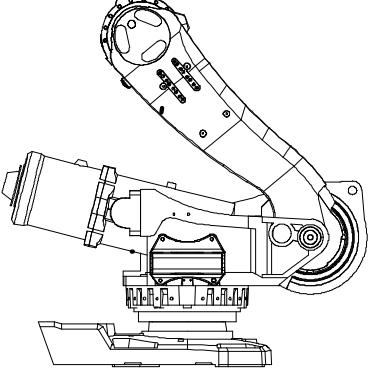
Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
3 Remove the <i>upper arm</i> .	Detailed in section <a href="#">Removal, upper arm on page 271</a> .
4 Disconnect and remove the <i>cables</i> from inside the lower arm. Release any cable attachments.	Detailed in section <a href="#">Replacing cable harness, axes 1-6 on page 223</a> .

*Continues on next page*

## 4 Repair

### 4.4.4 Replacement of complete lower arm

*Continued*

Action	Note
5 Apply the <i>lifting eye, M12</i> to the balancing device and raise to unload the weight of the device.	Art. no. is specified in <a href="#">Required equipment on page 279</a> . Attachment is shown in the figure <a href="#">Location of lower arm on page 276</a> .
6 Unload the balancing device in order to make the piston rod and front ear adjustable when pulling the front shaft out.	Method 1 detailed in section <a href="#">Unloading the balancing device using hydraulic press tool on page 316</a>
7 Remove the securing screw from the balancing device <i>front shaft</i> .	Shown in the figure <a href="#">Location of lower arm on page 276</a> .
8 Apply the <i>puller tool, balancing device shaft</i> to the shaft of the balancing device, through the hole in the frame. The shaft has a M20 thread diameter, as shown in the figure to the right. Pull the shaft out using the puller tool and the <i>hydraulic pump</i> .	Art. no. is specified in <a href="#">Required equipment on page 279</a> .  xx0300000060  <b>Note</b> The dimension of the shaft puller tool is M20. Do not mix up with the shaft press tool used when mounting the shaft.
9 Lower the balancing device until it rests safely against the bottom of the frame.	
10 Move the lower arm backwards to the lowest position possible.	 xx0400001028
11 Apply the <i>lifting accessory</i> to the lower arm.	Art. no. is specified in <a href="#">Required equipment on page 279</a> .
12 Drain the oil from gearbox 2.	Detailed in section <a href="#">Changing oil, axis-2 gearbox on page 183</a> .
13  <b>CAUTION</b> The lower arm weighs 160 kg! All lifting equipment used must be sized accordingly!	
14 Raise the tool to unload the lower arm.	

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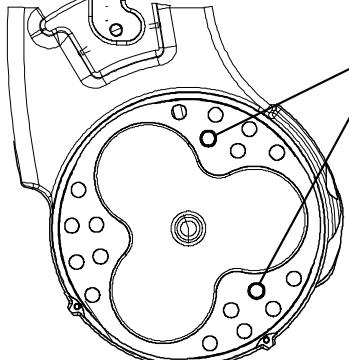
## 4.4.4 Replacement of complete lower arm

Continued

Action	Note
15 Remove the lower arm shaft and all additional components, as detailed in section <a href="#">Replacement of lower arm shaft on page 286</a> .	
16 Remove the <i>attachment screws and washers</i> that attach the lower arm to the gearbox axis 2.	Shown in the figure <a href="#">Internal components, lower arm on page 276</a> .
17 Lift the lower arm and place it on a secure surface.	

**Refitting, lower arm**

The procedure below details how to refit the lower arm.

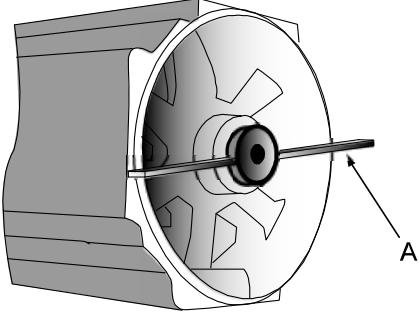
Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2 Fit a new <i>VK-cover</i> on a new lower arm or replace the existing if damaged.	Part no. is specified in <a href="#">Required equipment on page 279</a> .
3 Fit two <i>guidings</i> in the attachment holes of the lower arm.	Art. no. is specified in <a href="#">Required equipment on page 279</a> .  xx0300000548 A: Attachment holes for the two guidings
4 Fit the new <i>sealing, axis 2/3</i> on the guidings.	Always use a new sealing when reassembling! Art. no. is specified in <a href="#">Required equipment on page 279</a> .
5 Apply the <i>lifting tool</i> to the lower arm.	Art. no. is specified in <a href="#">Required equipment on page 279</a> .
6  <b>CAUTION</b> The lower arm weighs 160 kg! All lifting equipment used must be sized accordingly!	

Continues on next page

## 4 Repair

### 4.4.4 Replacement of complete lower arm

*Continued*

Action	Note
7 Lift the lower arm and move it to its mounting position.	
8 In case the hole pattern of the lower arm and the gearbox axis 2 does not match, use power supply to release the motor axis 2 brakes and rotate the pinion and gear with the <i>rotational tool</i> .	<p>Connect power supply to connector R2.MP2</p> <ul style="list-style-type: none"> <li>• +: pin 2</li> <li>• -: pin 5</li> </ul>  <p>xx0200000165</p> <p>The rotation tool (A) is used beneath the motor cover, directly on the motor shaft as shown in figure above. Art. no. is specified in <a href="#">Required equipment on page 279</a>.</p>
9 Disconnect the power supply, if used.	
10 Secure the lower arm with 16 of the <i>18attachment screws and washers</i> in gearbox, axis 2.	<p>18 pcs: M16 x 50, tightening torque: 300 Nm.</p> <p>Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.</p> <p>Shown in the figure <a href="#">Internal components, lower arm on page 276</a>.</p>
11 Remove the guidings and secure the two remaining screws as detailed above!	
12 Refit the lower arm shaft and all additional components, as detailed in section <a href="#">Replacement of lower arm shaft on page 286</a> .	
13 Remove the lifting tool from the lower arm.	
14 Refit and restore the balancing device.	See section <a href="#">Replacing the balancing device on page 309</a> .
15 Refit the upper arm.	See section <a href="#">Refitting, upper arm on page 273</a> .
16 Perform a leak-down test.	See section <a href="#">Performing a leak-down test on page 218</a> .
17 Refill the gearbox with oil.	See section <a href="#">Changing oil, axis-2 gearbox on page 183</a> .
18 Refit and reconnect all cables inside the lower arm. Resecure any cable attachments.	Detailed in section <a href="#">Replacing cable harness, axes 1-6 on page 223</a> .

*Continues on next page*

## 4.4.4 Replacement of complete lower arm

*Continued*

	Action	Note
19	Recalibrate the robot!	<p>Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i>, enclosed with the calibration tools.</p> <p>Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a>.</p> <p>General calibration information is included in section <a href="#">Calibration on page 393</a>.</p>
20	 <b>DANGER</b> <p>Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a>.</p>	

## 4 Repair

### 4.4.5 Replacement of lower arm shaft

#### 4.4.5 Replacement of lower arm shaft

##### Prerequisites

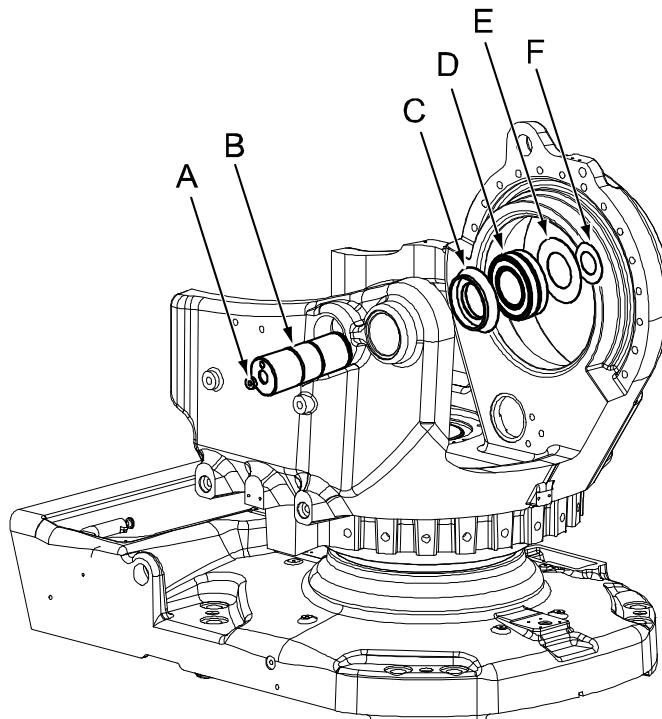
This section details how to remove and refit the lower arm shaft as a step in the procedure of removing/refitting the complete lower arm. To perform the procedure described in this section, it is required that the preceding instructions in section [Replacement of complete lower arm on page 276](#) are followed! These include:

- removing the upper arm
- removing the cabling in the lower arm
- unloading the balancing device and removing the front eye shaft
- draining the oil in gearbox axis 2
- unloading the lower arm with specific lifting equipment.

##### Components, lower arm shaft for robots with protection Standard

The figure shows components fitted to the lower arm shaft when the robot has protection Standard.

The figure shows IRB 6600, but is also valid for IRB 6650S!



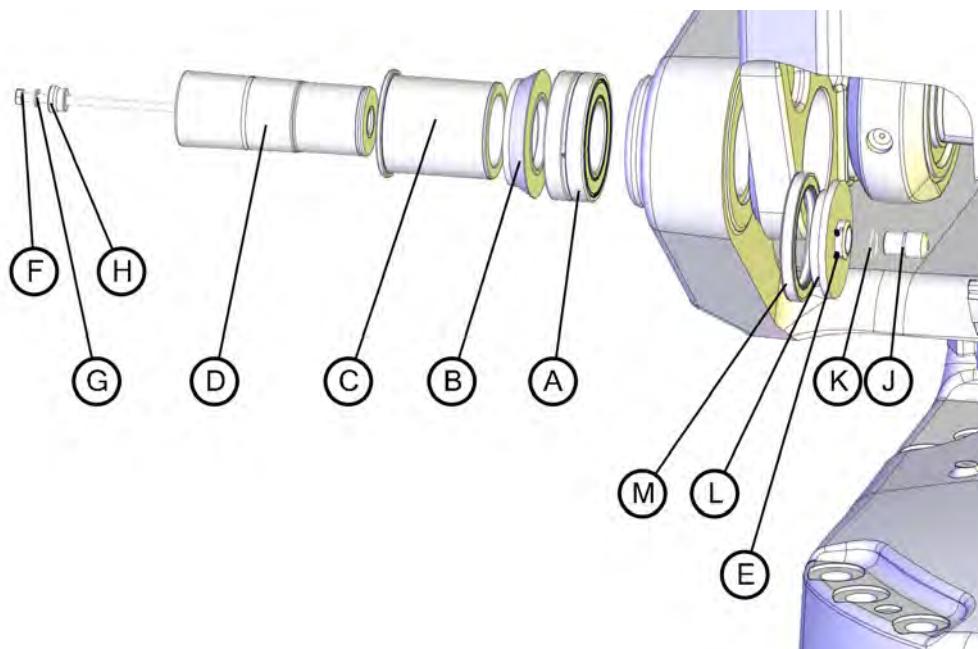
xx030000487

A	Protection plug
B	Lower arm shaft (axis 2 shaft)
C	Thrust washer
D	Bearing
E	Protection washer
F	Retaining ring

Continues on next page

**Components, lower arm shaft for robots with protection Foundry Plus**

The figure shows components fitted to the lower arm shaft when the robot has protection Foundry Plus.



xx1100000954

A	Bearing
B	Thrust washer
C	Bushing
D	Shaft for the lower arm
E	Set screw with cup point, M4x6 (2 pcs)
F	Hexagon bolt M8x190
G	Conical spring washer 8.4x16x1.6
H	Shaft tap
J	Shaft for the sealing cover
K	O-ring
L	Sealing cover
M	Radial sealing with dust lip

**Required equipment**

Equipment	Art. no.	Note
Bearing	For spare part number see: • <i>Spare part lists on page 425.</i>	Always use a new bearing when reassembling!
Puller device, axis 2 shaft	3HAC021563-001	
Press device, axis 2 shaft	3HAC021600-001	

*Continues on next page*

## 4 Repair

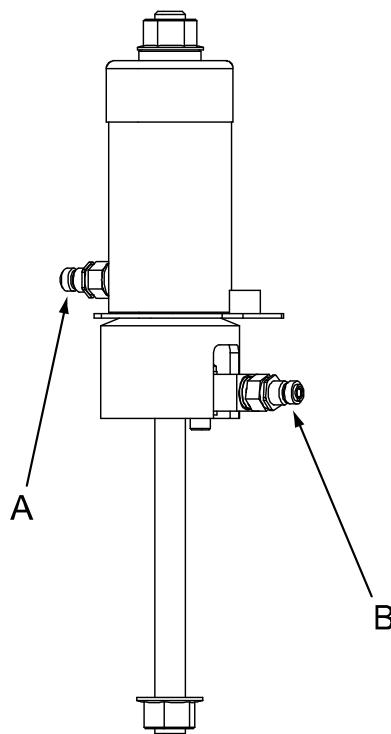
### 4.4.5 Replacement of lower arm shaft

*Continued*

Equipment	Art. no.	Note
Hydraulic pump, 80 MPa	3HAC13086-1	
Hydraulic pump, 150 MPa (Glycerin)	3HAC021563-012	
Press tool, axis 2 bearing	3HAC13527-1	
Retaining ring plier	-	
Isopropanol	11771012-208	For cleaning the shaft.
Grease	3HAB3537-1	For lubrication of the bearing.
Glycerin	-	For lubrication of the shaft.
Rust preventive	3HAC026621-001	Equivalent: • Mercasol 3106
Locking liquid (only for robots with protection Foundry Plus and Foundry Prime)	3HAB7116-1	Loctite 243

#### Puller device for removal of axis 2 shaft

The illustration below shows the puller tool used to remove the lower arm shaft (axis 2 shaft).



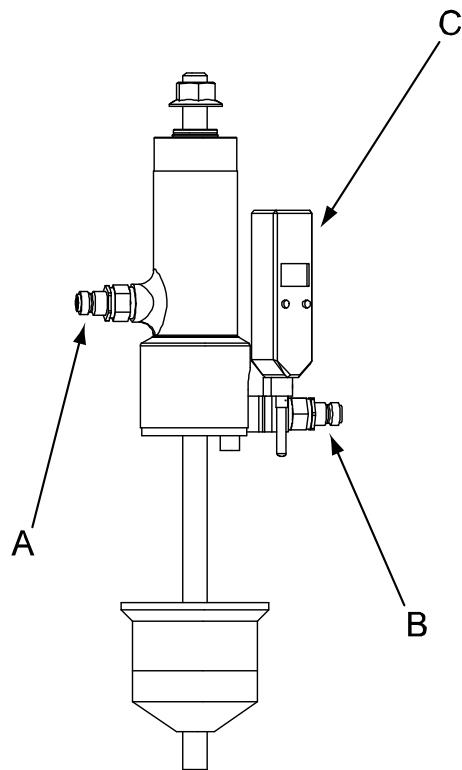
xx0400001029

A	Nipple for the hydraulic pump
B	Nipple for the glycerin pump

*Continues on next page*

**Press device for refitting of axis 2 shaft**

The illustration below shows the press tool used to refit the lower arm shaft (axis 2 shaft).



xx0400001030

A	Nipple for the hydraulic pump
B	Nipple for the glycerin pump
C	Indicator

**Removal, lower arm shaft from robot with protection Standard**

Use this procedure to remove the lower arm shaft if the robot has protection Standard.

If encountering any problems when removing the shaft, contact ABB Robotics!

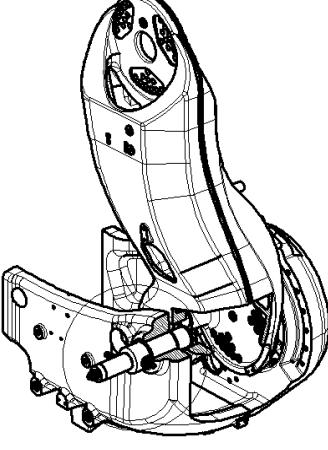
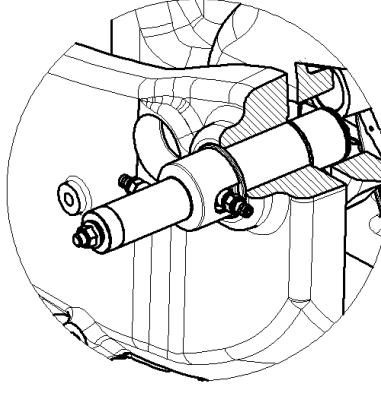
	Action	Note/Illustration
1	 <b>WARNING</b> This procedure is a step in the complete procedure of removing the lower arm! Make sure all the preceding steps specified in <a href="#">Replacement of lower arm shaft on page 286</a> are made before removing the lower arm shaft!	
2	Remove the <i>protection plug</i> .	Shown in the figure <a href="#">Components, lower arm shaft for robots with protection Standard on page 286</a> !

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## 4 Repair

### 4.4.5 Replacement of lower arm shaft

*Continued*

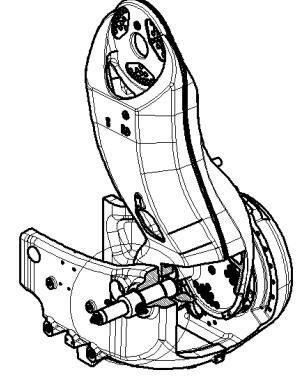
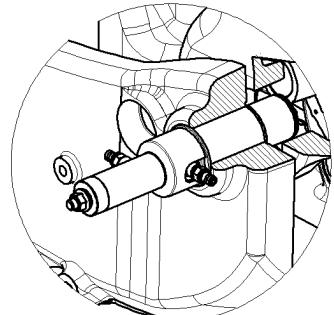
Action	Note/Illustration
3 Remove the <i>protection washer</i> and the <i>retaining ring</i> .	<p>Shown in the figure <a href="#">Components, lower arm shaft for robots with protection Standard on page 286!</a>          Use a plier for the retaining ring.</p>
4 Fit the <i>puller device</i> to the shaft as shown in the figure to the right.	<p>Art. no. is specified in <a href="#">Required equipment on page 287!</a></p> 
	 xx0300000010
5 Fit both the <i>hydraulic pump</i> and the <i>glycerin pump</i> to the puller device.	<p>Art. no. is specified in <a href="#">Required equipment on page 287!</a>          The attachments on the tool are shown in figure <a href="#">Puller device for removal of axis 2 shaft on page 288.</a></p>
6 Increase the pressure of the glycerin pump and, at the same time, pull out the shaft with the puller tool by increasing the pressure of the hydraulic pump.	<p>Note! Do not exceed the limit of maximum pressure classified for the pumps!</p>
7 Remove the <i>bearing</i> and <i>thrust washer</i> from the shaft hole in the lower arm, recommendable after removing the complete lower arm as detailed in section <a href="#">Replacement of complete lower arm on page 276.</a>	

*Continues on next page*

**Removal, lower arm shaft on robot with protection Foundry Plus**

Use this procedure to remove the lower arm shaft if the robot has protection Foundry Plus.

If encountering any problems when removing the shaft, contact ABB Robotics!

Action	Note
1  <b>WARNING</b>  This procedure is a step in the complete procedure of removing the lower arm! Make sure all the preceding steps specified in <a href="#">Replacement of lower arm shaft on page 286</a> are made before removing the lower arm shaft!	
2 Remove the two <i>set screws</i> .	Shown in the figure <a href="#">Components, lower arm shaft for robots with protection Foundry Plus on page 287</a> .
3 Remove the <i>shaft sealing cover</i> .	
4 Remove the <i>sealing cover</i> .	
5 Remove the <i>radial sealing</i> , if the lower arm is to be replaced with a new one.  If the same lower arm is refitted, the radial sealing can be left in the lower arm.	
6 Remove the <i>hexagon bolt</i> with the <i>washer</i> and <i>shaft tap</i> .	
7 Fit the <i>puller device</i> to the shaft as shown in the figure to the right.	Art. no. is specified in <a href="#">Required equipment on page 287</a> !    xx0300000010

Continues on next page

## 4 Repair

### 4.4.5 Replacement of lower arm shaft

*Continued*

Action	Note
8 Fit both the <i>hydraulic pump</i> and the <i>glycerin pump</i> to the puller device.	Art. no. is specified in <a href="#">Required equipment on page 287</a> . The attachments on the tool are shown in figure <a href="#">Puller device for removal of axis 2 shaft on page 288</a> .
9 Increase the pressure of the glycerin pump and, at the same time, pull out the shaft with the puller tool by increasing the pressure of the hydraulic pump.	<b>Note!</b> Do not exceed the limit of maximum pressure classified for the pumps!
10 Remove the <i>bearing</i> and <i>thrust washer</i> from the shaft hole in the lower arm, recommendable after removing the complete lower arm as detailed in section <a href="#">Replacement of complete lower arm on page 276</a> .	

#### Refitting, lower arm shaft on robot with protection Standard

Use this procedure to refit the lower arm shaft if the robot has protection Standard.

Action	Note/Illustration
1 Clean the shaft with <i>isopropanol</i> and lubricate it with <i>glycerin</i> .	Art. no. is specified in <a href="#">Required equipment on page 287</a> !
2 Push the shaft in by hand.	
3 Refit the <i>thrust washer</i> to the shaft.	Also shown in the figure <a href="#">Components, lower arm shaft for robots with protection Standard on page 286</a> !
4 Apply the <i>press device, axis 2 shaft</i> against the shaft.	Art. no. is specified in <a href="#">Required equipment on page 287</a> !
5 Tighten the M16 nut.	Tightening torque: 20 Nm.
6 Fit both the <i>hydraulic pump</i> and the <i>glycerin pump</i> to the press device.	Art. no. is specified in <a href="#">Required equipment on page 287</a> . The attachments on the tool are shown in the figure <a href="#">Press device for refitting of axis 2 shaft on page 289</a> .
7 Set the <i>indicator</i> on the press device to zero.	Shown in the figure <a href="#">Press device for refitting of axis 2 shaft on page 289</a> .
8 Press in the shaft with the hydraulic cylinder by setting the pressure of the hydraulic pump to approximately 35-55 MPa and the pressure of the glycerin pump to 55 MPa.	
9 Increase the pressure of the both pumps alternately until the correct value is reached with the indicator on the press tool.	Correct value: 2.45 mm ± 0.15 mm.  <b>Note</b> Do not exceed the limit of maximum pressure classified for the pumps!

*Continues on next page*

## 4.4.5 Replacement of lower arm shaft

Continued

Action	Note/Illustration
10 When a correct value is reached, release the pressure from the glycerin pump first, then from the hydraulic pump (approximately 1/2 minute after), in order to avoid movement of the shaft.	
11 Remove the press device, axis 2 shaft.	
12 Apply grease to the location of the shaft where the bearing is to be mounted.	Art. no. is specified in <a href="#">Required equipment on page 287</a>
13 Press in the new bearing with the <i>press tool, axis 2 bearing</i> .	Always use a new bearing when reassembling! Art. no. is specified in <a href="#">Required equipment on page 287</a> .
14 Refit the <i>protection washer</i> and the <i>retaining ring</i> .	Shown in the figure <a href="#">Components, lower arm shaft for robots with protection Standard on page 286</a> .
15 Refit the <i>protection plug</i> .	
16 Proceed with the refitting procedure of the lower arm, detailed in section <a href="#">Replacement of complete lower arm on page 276</a> .	

**Refitting, lower arm shaft on robot with protection Foundry Plus**

Use this procedure to refit the lower arm shaft if the robot has protection Foundry Plus.

Action	Note/Illustration
1 Clean the shaft with <i>isopropanol</i> and lubricate it with <i>glycerin</i> .	Art. no. is specified in <a href="#">Required equipment on page 287</a> !
2 Push the shaft in by hand.	
3 Refit the <i>thrust washer</i> to the shaft.	Also shown in the figure <a href="#">Components, lower arm shaft for robots with protection Foundry Plus on page 287</a> !
4 Apply the <i>press device, axis 2 shaft</i> against the shaft.	Art. no. is specified in <a href="#">Required equipment on page 287</a> !
5 Tighten the M16 nut.	Tightening torque: 20 Nm.
6 Fit both the <i>hydraulic pump</i> and the <i>glycerin pump</i> to the press device.	Art. no. is specified in <a href="#">Required equipment on page 287</a> . The attachments on the tool are shown in the figure <a href="#">Press device for refitting of axis 2 shaft on page 289</a> .
7 Set the <i>indicator</i> on the press device to zero.	Shown in the figure <a href="#">Press device for refitting of axis 2 shaft on page 289</a> .
8 Press in the shaft with the hydraulic cylinder by setting the pressure of the hydraulic pump to approximately 35-55 MPa and the pressure of the glycerin pump to 55 MPa.	
9 Increase the pressure of the both pumps alternately until the correct value is reached with the indicator on the press tool.	Correct value: 2.45 mm ± 0.15 mm. <b>Note!</b> Do not exceed the limit of maximum pressure classified for the pumps!

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## 4 Repair

### 4.4.5 Replacement of lower arm shaft

Continued

Action	Note/Illustration
10 When a correct value is reached, release the pressure from the glycerin pump first, then from the hydraulic pump (approximately 1/2 minute after), in order to avoid movement of the shaft.	
11 Remove the press device, axis 2 shaft.	
12 Apply <i>grease</i> to the location of the shaft where the bearing is to be mounted.	Art. no. is specified in <a href="#">Required equipment on page 287</a>
13 Press in the new <i>bearing</i> with the <i>press tool, axis 2 bearing</i> .	Always use a new bearing when reassembling! Art. no. is specified in <a href="#">Required equipment on page 287</a> .
14 Fit a <i>radial sealing</i> to the lower arm, if there is none left during removal of the arm.	Shown in the figure <a href="#">Components, lower arm shaft for robots with protection Foundry Plus on page 287</a> .
15 Refit the <i>hexagon bolt</i> with a <i>spring washer</i> and a <i>shaft tap</i> through the hole in the lower arm shaft.	
16 Fit the <i>shaft for the sealing cover</i> onto the hexagon bolt and tighten the bolt with torque: 24 Nm.	
17 Check the <i>o-ring</i> in the sealing cover. Replace if damaged.	
18 Refit the <i>sealing cover</i> onto the shaft. Press it tightly against the radial sealing while tightening the set screws. Use locking liquid.	
19 Proceed with the refitting procedure of the lower arm, detailed in section <a href="#">Replacement of complete lower arm on page 276</a> .	

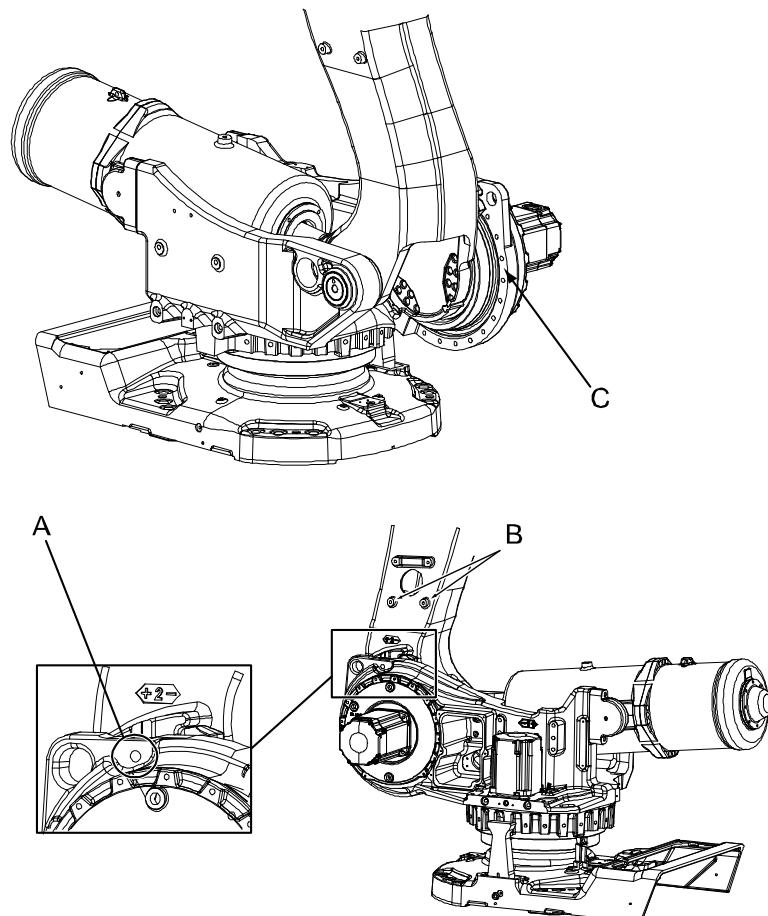
## 4.4.6 Securing the lower arm

### General

This section details how to secure the lower arm with a specific fixture prior to performing certain service activities to the robot.

### Attachment points, robot

The special equipment used to secure the lower arm is fitted to the attachment points shown in the figure below.



xx0300000608

A	Attachment hole, securing screw
B	Holes for M12 bolts
C	Holes for M16 bolts

### Required equipment

Equipment, etc	Art. no.	Note
Fixture lower arm	3HAC020729-001	Includes the locking screw for securing the lower arm.

*Continues on next page*

## 4 Repair

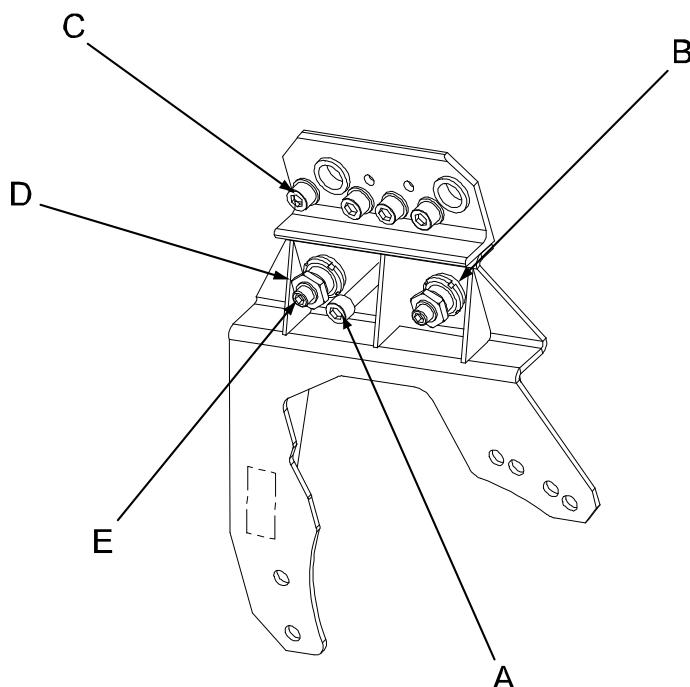
### 4.4.6 Securing the lower arm

*Continued*

Equipment, etc	Art. no.	Note
Standard toolkit	3HAC 15571-1	The contents are defined in section <a href="#">Standard tools on page 435</a> in part 2 of the Product manual.

#### Fixture, lower arm

The attachment bolts, locking screw, adjusters and ring nuts are attached to the fixture tool as shown in the figure below. Move them to the attachment points shown in the instruction.



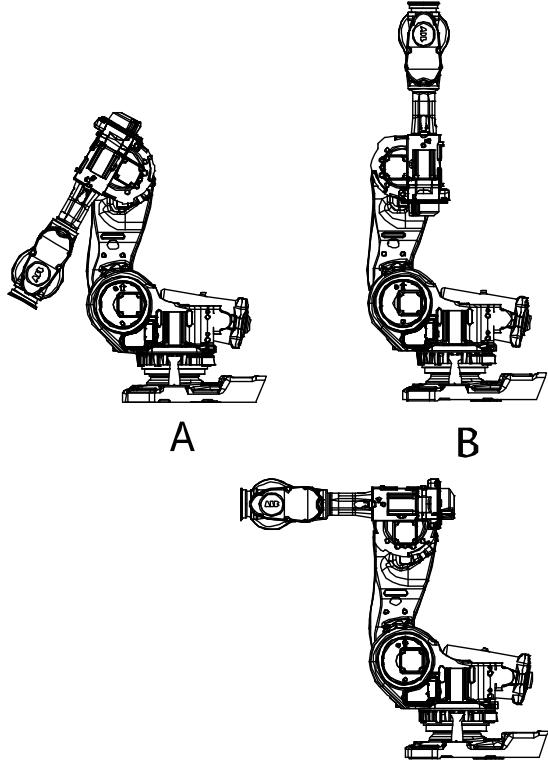
xx0300000609

A	Locking screw
B	Adjusters, 2 pcs
C	M16 bolts, 4 pcs
D	Ring nuts, 2 pcs
E	M12 bolts and washers, 2 pcs

*Continues on next page*

**Securing the lower arm**

The procedure below details how to secure the lower arm by fitting the fixture to the robot.

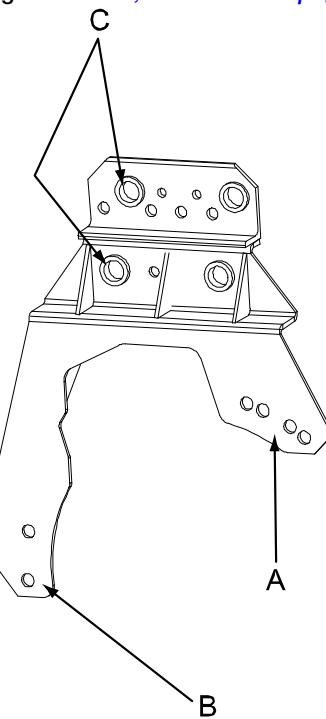
Action	Note/Illustration
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
2 Remove any load or equipment fitted to the upper arm or turning disk.	
3 Move the robot to the calibration position. The upper arm can be directed in three different ways, shown in the figure to the right. The lowered position, as in figure A, is recommended as it gives the least load on the tool.	 xx0200000260
4 If the robot is fitted with moveable mechanical stops on axis 2 (not stock equipment), these must be removed at this point. The attachment holes of the mechanical stops are used to attach the fixture.	

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## 4 Repair

### 4.4.6 Securing the lower arm

*Continued*

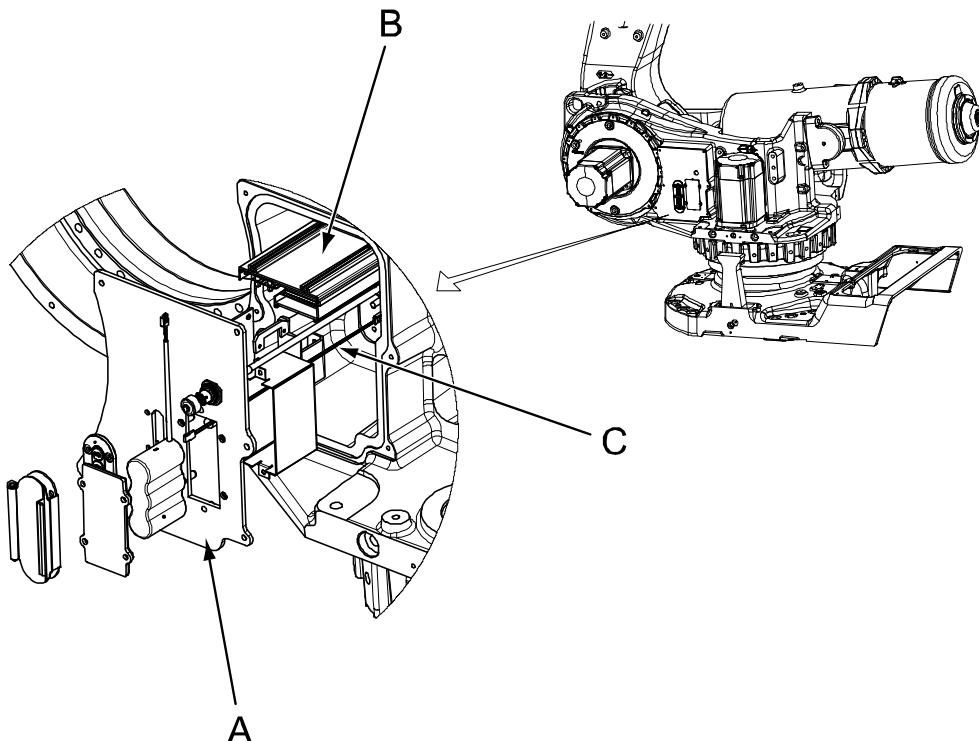
Action	Note/Illustration
5 Remove the <i>locking screw</i> from the fixture, where it is attached.	Shown in the figure <i>Fixture, lower arm on page 296</i> . Art. no. of the fixture is specified in <i>Required equipment on page 295</i> .
6 Secure the lower arm to the frame by inserting the locking screw into a specific <i>attachment hole</i> through the frame, into the lower arm.	Shown in the figure <i>Attachment points, robot on page 295</i> .
7 Fit the <i>fixture, lower arm</i> to the frame and the lower arm, according to following instruction: <ol style="list-style-type: none"> <li>Fit the both adjusters in the correct holes and make sure that they are screwed back (C).</li> <li>Align the fixture with the frame and lower arm.</li> <li>Make sure the fixture is pressed tightly against the lower arm before securing with screws!</li> <li>Fit and tighten the four M16 bolts in the attachment holes on the inside of the frame with tightening torque: 220 Nm (A).</li> <li>Screw in the two adjusters until they rest against the flats on the lower arm. Tighten by hand.</li> <li>Lock, using the two ring nuts.</li> <li>Fit and tighten the two M12 bolts in the attachment holes on the lower arm with tightening torque: 91 Nm (C).</li> </ol>	<p>Art. no. is specified in <i>Required equipment on page 295</i>.</p> <p>Attachment holes on the frame and on the lower arm are shown in the figure <i>Attachment points, robot on page 295</i>!</p> <p>The adjusters, bolts and ring nuts are shown in the figure <i>Fixture, lower arm on page 296</i>.</p>  <p>xx0300000610</p> <ul style="list-style-type: none"> <li>A: Holes for M16 bolts. Choose the 2 suitable holes for current robot model.</li> <li>B: Holes for M16 bolts.</li> <li>C: Holes for M12 bolts (2 pcs), adjusters, ring nuts and washers. Choose the suitable holes for current robot model.</li> </ul>
8 The lower arm is now secured and it is safe to remove the gearbox of axis 2, according to section <i>Removal, gearbox axis 2 on page 373</i> , provided that the balancing device is unloaded.	

## 4.5 Frame and base

### 4.5.1 Replacing the SMB unit

#### Location of SMB unit

The SMB unit (SMB = serial measurement board) is located on the left hand side of the frame as shown in the figure.



xx0300000557

A	SMB cover
B	SMB unit
C	Battery cable

#### Required equipment



##### Note

There are different variants of SMB units and batteries. The variant with the 3-pole battery contact has longer lifetime for the battery.

It is important that the SMB unit uses the correct battery. Make sure to order the correct spare parts. Do not replace the battery contact!

Equipment, etc.	Art. no.	Note
SMB unit	For spare part number, see: <a href="#">Spare part lists on page 425</a> .	

*Continues on next page*

## 4 Repair

### 4.5.1 Replacing the SMB unit

*Continued*

Equipment, etc.	Art. no.	Note
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Circuit diagram	-	See chapter <a href="#">Circuit diagram on page 441</a> .

#### Removing, SMB unit

Use this procedure to remove the SMB unit.

	Action	Note
1	Move the robot to the calibration position.	
2	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply</li><li>• hydraulic pressure supply</li><li>• air pressure supply</li></ul> to the robot, before entering the robot working area.	
3	 xx0200000023 <b>WARNING!</b> The unit is sensitive to ESD. Before handling the unit please read the safety information in the section <a href="#">WARNING - The unit is sensitive to ESD! on page 54</a>	
4	Remove the <i>SMB cover</i> by unscrewing its attachment screws.	Shown in the figure <a href="#">Location of SMB unit on page 299</a> .
5	Use caution and remove the connectors X8, X9 and X10 from the brake release board, if need of more space.	
6	Remove the nuts and washers from the <i>guide pins</i> that secure the board.	Shown in the figure <a href="#">Location of SMB unit on page 299</a> .
7	Use caution and disconnect the connectors from the SMB unit when pulling the board out.	Connectors R1.SMB1-3, R1.SMB4-6 and R2.SMB
8	Disconnect the <i>battery cable</i> from the SMB unit.	Shown in the figure <a href="#">Location of SMB unit on page 299</a> .

*Continues on next page*

## Refitting, SMB unit

Use this procedure to refit the SMB unit.

	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply</li> <li>• hydraulic pressure supply</li> <li>• air pressure supply</li> </ul> to the robot, before entering the robot working area.	
2	 xx0200000023 <b>WARNING!</b> The unit is sensitive to ESD. Before handling the unit please read the safety information in the section <a href="#">WARNING - The unit is sensitive to ESD! on page 54</a> .	
3	Connect the <i>battery cable</i> to the SMB unit.	Shown in the figure <a href="#">Location of SMB unit on page 299</a> .
4	Connect all connectors to the SMB board: R1.SMB1-3, R1.SMB4-6 and R2.SMB	Art. no. is specified in <a href="#">Required equipment on page 299</a> . Shown in the figure <a href="#">Location of SMB unit on page 299</a> .
5	Fit the <i>SMB unit</i> onto the <i>guide pins</i> .	
6	Secure the SMB unit to the pins with the nuts and washers.	
7	If disconnected, reconnect the connectors X8, X9 and X10 to the brake release board.	
8	Secure the <i>SMB cover</i> with its attachment screws. If cabling is used for 7th axis (option), refit the 7th axis connector to the SMB cover and tighten with 6 Nm.	Shown in the figure <a href="#">Location of SMB unit on page 299</a> .
9	Update the revolution counter!	See <a href="#">Updating revolution counters on page 401</a> .
10	 <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

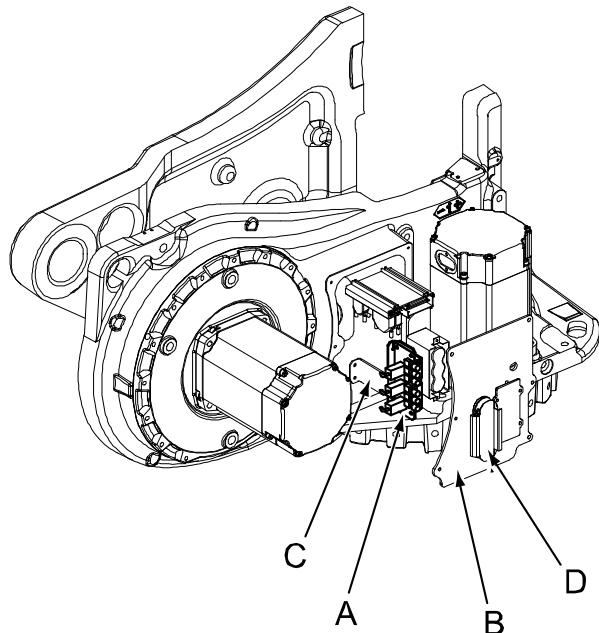
## 4 Repair

### 4.5.2 Replacing the brake release board

#### 4.5.2 Replacing the brake release board

##### Location of brake release board

The brake release unit is located together with the SMB unit on the left hand side of the frame, right next to the gearbox, axis 2, as shown in figure below.



xx0300000558

A	Brake release unit
B	SMB cover
C	Bracket
D	Push button guard

##### Required equipment

Equipment, etc.	Art. no.	Note
Brake release board with buttons	For spare part no. see: • <a href="#">Spare part lists on page 425</a>	
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

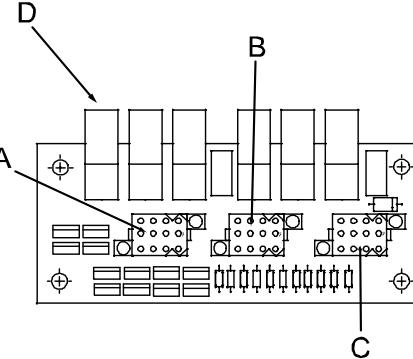
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## 4.5.2 Replacing the brake release board

Continued

**Removing, brake release board**

Use this procedure to remove the brake release board.

	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
2	 <b>ELECTROSTATIC DISCHARGE (ESD)</b> The unit is sensitive to ESD. Before handling the unit read the safety information in section <b>WARNING - The unit is sensitive to ESD! on page 54</b>	
3	Remove the <i>push button guard</i> from the SMB cover.	Shown in the figure <a href="#">Location of brake release board on page 302</a> . The guard must be removed to ensure a correct refitting of the brake release board.
4	Open the <i>SMB cover</i> by unscrewing the attachment screws.  Let the battery stay connected, to avoid the need of synchronization of the robot!	Shown in the figure <a href="#">Location of brake release board on page 302</a> .
5	Remove the complete brake release board (including brake release board and bracket) from the SMB recess, by removing its two attachment screws.	
6	Disconnect the connectors X8, X9 and X10 from the <i>brake release board</i> .	 xx0200000129 <ul style="list-style-type: none"> <li>• A: Connector X8</li> <li>• B: Connector X9</li> <li>• C: Connector X10</li> <li>• D: Push buttons</li> </ul> <p>Location of the brake release unit is shown in the figure <a href="#">Location of brake release board on page 302</a>.</p>

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## 4 Repair

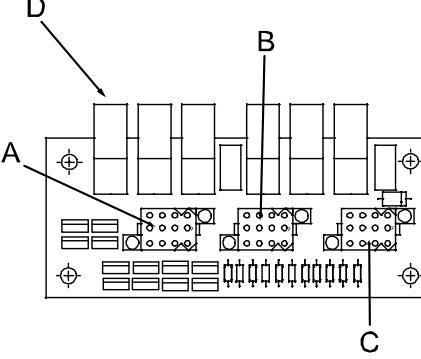
### 4.5.2 Replacing the brake release board

*Continued*

Action	Note
7 Remove the brake release board from the bracket by removing the four attachment screws.	

#### Refitting, brake release board

Use this procedure to refit the brake release board.

Action	Note
1  ELECTROSTATIC DISCHARGE (ESD)  The unit is sensitive to ESD. Before handling the unit read the safety information in section <b>WARNING - The unit is sensitive to ESD! on page 54</b>	
2 Fasten the <i>brake release board</i> on the bracket with the attachment screws. Make sure the board is positioned as straight as possible on the bracket! The push buttons can otherwise get jammed when the SMB cover is refitted.	Shown in the figure <a href="#">Location of brake release board on page 302</a> . Art. no. is specified in <a href="#">Required equipment on page 302</a> .
3 Connect the connectors X8, X9 and X10 to the brake release board.	 xx0200000129 <ul style="list-style-type: none"> <li>• A: Connector X8</li> <li>• B: Connector X9</li> <li>• C: Connector X10</li> <li>• D: Push buttons</li> </ul>
4 Refit the complete brake release board (including brake release board and bracket) to the SMB recess with the two attachment screws.	
5 Refit the <i>SMB cover</i> with its attachment screws. The push button guard must not be mounted on the cover before the check described in following warning is made!	Shown in the figure <a href="#">Location of brake release board on page 302</a> .
6  <b>WARNING</b>  Before continuing any service work, please observe the safety information in section <b>WARNING - The brake release buttons may be jammed after service work on page 51!</b>	

*Continues on next page*

## 4.5.2 Replacing the brake release board

Continued

	Action	Note
7	Refit the <i>push button guard</i> to the SMB cover.	Shown in the figure <i>Location of brake release board</i> on page 302.
8	If the battery has been disconnected the revolution counter must be updated.	Detailed in the Calibration chapter - section <i>Updating revolution counters</i> on page 401.
9	 <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <i>DANGER - First test run may cause injury or damage!</i> on page 50.	

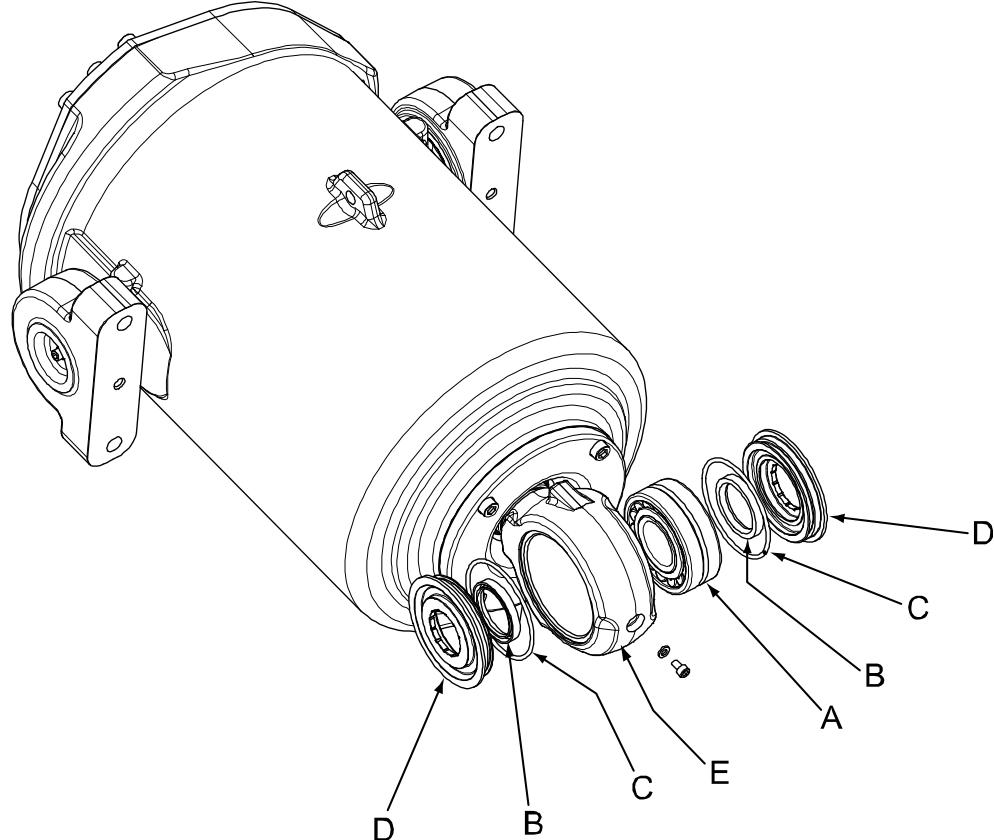
## 4 Repair

### 4.5.3 Replacement of spherical roller bearing, balancing device

#### 4.5.3 Replacement of spherical roller bearing, balancing device

##### Location of bearing

The bearing is located at the front ear of the balancing device, as shown in the figure below.



xx0500002249

A	Spherical roller bearing
B	Sealing ring
C	O-ring
D	Sealing spacer
E	Front ear of balancing device

##### Required equipment

Equipment	Spare part no.	Art. no.	Note
Spherical roller bearing	3HAA2167-17		
Sealing spacer	3HAC12988-1		2 pcs required.
O-ring	3HAB3772-76		2 pcs required.
Sealing ring	3HAC11581-6		2 pcs required.
Grease		3HAB3537-1	For lubrication of the components.

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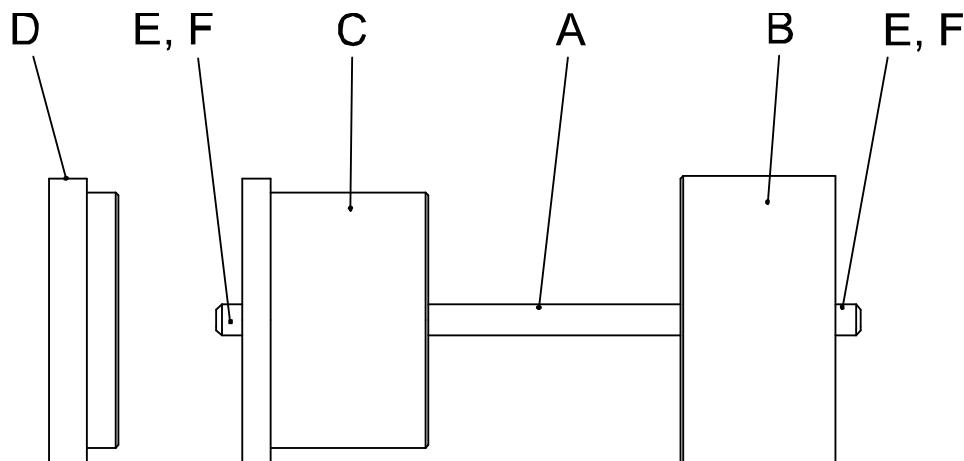
## 4.5.3 Replacement of spherical roller bearing, balancing device

*Continued*

Equipment	Spare part no.	Art. no.	Note
Toolkit		3HAC15943-1	The tools in the set are shown in the section Tool set.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

**Tool set**

The parts of the tool set for replacing the spherical roller bearing are shown in the figure.



xx0500002259

A	Threaded bar
B	Dolly
C	Press tool for removal of bearing
D	Press tool for refitting of bearing
E	Hexagon nut M12 (2pcs)
F	Plain washer 13x24x2,5 (2pcs)

**Removal, spherical roller bearing**

Use this procedure to remove the spherical roller bearing from the balancing device front ear.

	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	

*Continues on next page*

## 4 Repair

### 4.5.3 Replacement of spherical roller bearing, balancing device

*Continued*

Action	Note
2 Remove the balancing device from the robot.	Detailed in section <a href="#">Replacing the balancing device on page 309</a> .
3 Remove the both <i>sealing spacers</i> with a screwdriver or any equal tool.	Shown in the figure <a href="#">Location of bearing on page 306</a> .
4 Insert the threaded bar through the bearing.	
5 Fit the press tool and dolly to the threaded bar. Secure with the nut and washer at each end.	A Threaded bar 3HAC15945-1 B Dolly 3HAC15948-1 C Press tool 3HAC15941-1
6 Press out the bearing from the front ear.	

#### Refitting, spherical roller bearing

Use this procedure to refit the spherical roller bearing to the balancing device front ear.

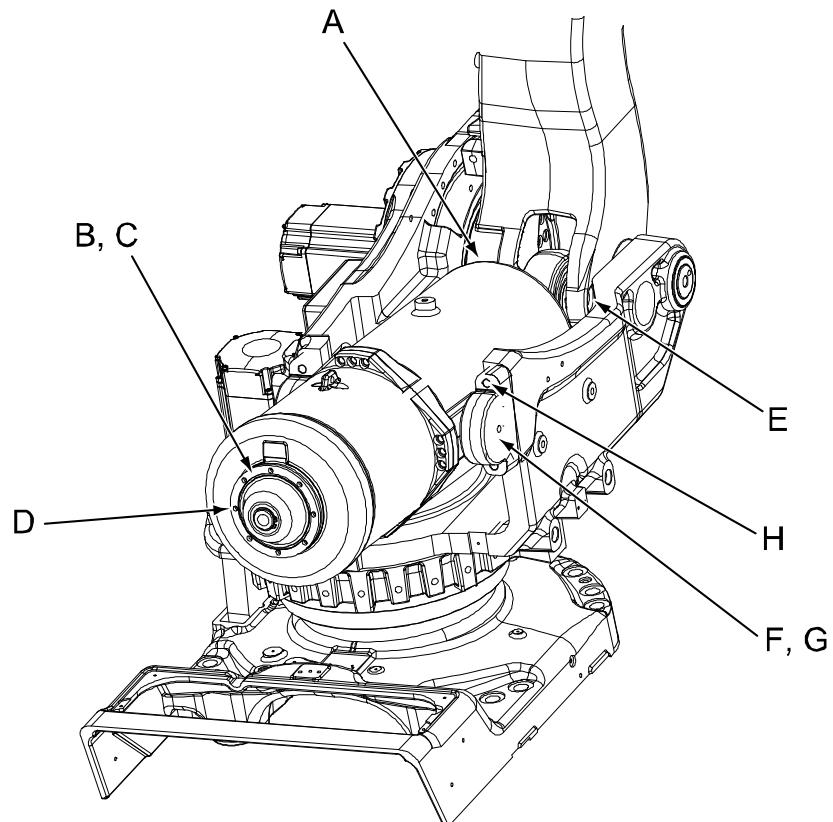
Action	Note
1  <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2 Grease the inside walls of the front ear.	
3 Press in the bearing properly inside the ear.	
4 Apply grease to the new <i>sealing rings</i> and <i>o-rings</i> and fit one of each to the new <i>sealing spacers</i> . Also, grease the sealing spacers.	Spare part no:s are specified in <a href="#">Required equipment on page 306</a> .
5 Refit the balancing device to the robot.	Detailed in section <a href="#">Refitting, balancing device on page 313</a> .
6 Lubricate the spherical roller bearing in the ear.   <b>Note</b>  The balancing device must be mounted on the robot when lubrication is performed!	Detailed in section <a href="#">Lubrication of spherical roller bearing, balancing device on page 203</a>
7 Make sure no incorrect leakage occurs. It could indicate damaged o-rings.	This is detailed in section <a href="#">Check for leakage on page 158</a> .
8  <b>DANGER</b>  Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

## 4.5.4 Replacement of balancing device

### 4.5.4.1 Replacing the balancing device

#### Location of balancing device

The balancing device is located on rear top of the frame as shown in the figure below.



xx0300000533

A	Balancing device
B	Rear cover
C	Support shaft inside
D	Attachment screws, rear cover
E	Balancing device shaft, including securing screw
F	Bearing attachment
G	Parallel pin (inside bearing attachment)
H	Attachment screws, bearing attachments

*Continues on next page*

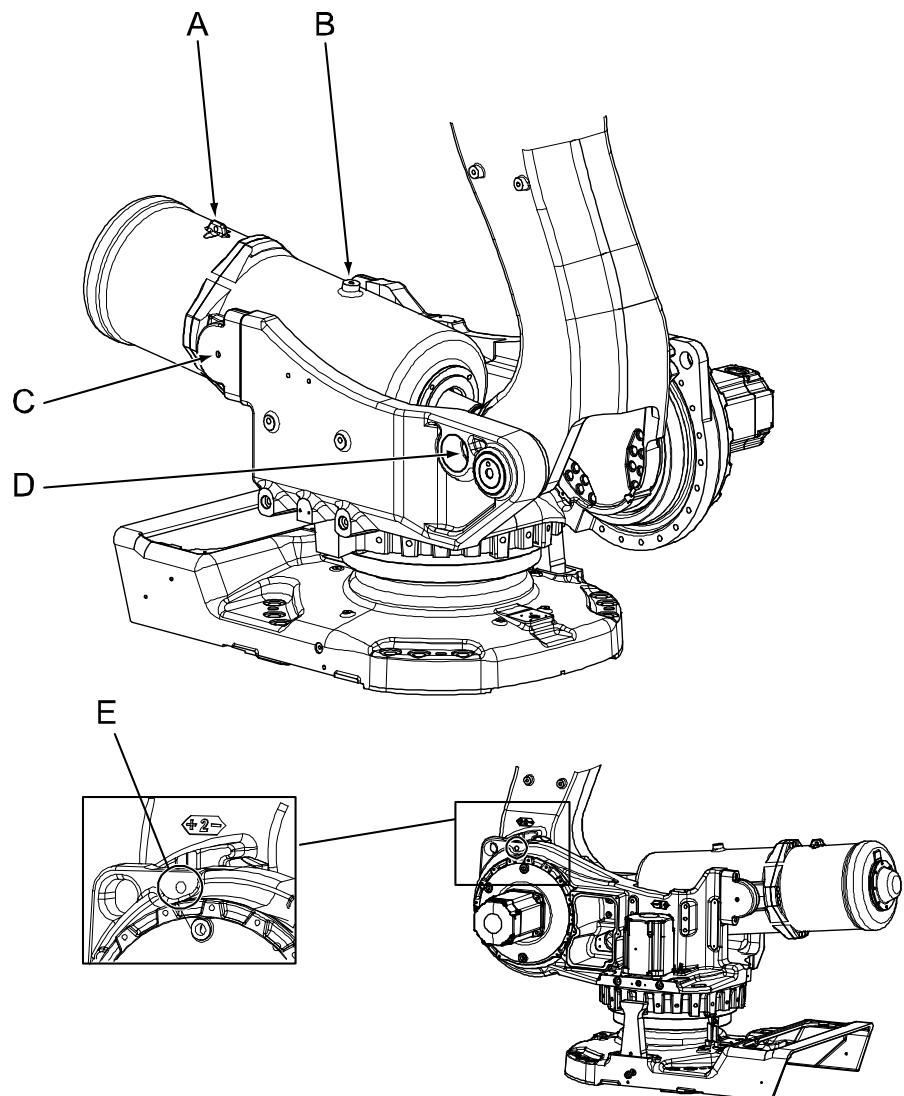
## 4 Repair

### 4.5.4.1 Replacing the balancing device

*Continued*

#### Attachment points, balancing device

The attachment points for the lifting tools etc. are located as shown in the figure below.



xx0300000481

B	Lifting eye for the lifting equipment
C	Securing screw attachment hole, secures the bearing attachment to the balancing device (remove the protection plug)
D	Hole in the frame to access the balancing device shaft with the puller/press tool
E	Locking screw attachment hole, secures the lower arm to the frame

#### Required equipment

Equipment	Spare part no.	Art. no.	Note
Balancing device	See <a href="#">Spare part lists on page 425</a> .		Includes balancing device 3HAC020040-001! Includes o-rings 3HAB3772-44.

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4.5.4.1 Replacing the balancing device  
*Continued*

Equipment	Spare part no.	Art. no.	Note
O-ring		3HAB3772-44	3 pcs, to be replaced if damaged!
Locking screw		3HAA1001-266	M16 x 60 For securing the lower arm.
Securing screw		9ADA183-66	M12 x 35, 2 pcs required For securing the bearing attachments to the balancing device when lifting.
Bearing grease		3HAB3537-1	For lubricating the o-rings and the shaft.
Grease		3HAA1001-294	80 ml, Optimol PDO For lubrication of spherical roller bearing in ear, in case of new balancing device.
Locking liquid		-	Loctite 243 To apply to the securing screw in the shaft.
Grease pump		-	To lubricate spherical roller bearing.
Guide pins M16 x 300		3HAC13120-5	Always use guide pins in pairs!
Lifting eye M12		3HAC14457-3	
Shackle, balancing device		3HAC 020997-1	
Lifting tool (chain)		3HAC15556-1	
Press tool, balancing device		3HAC020902-001	
Puller tool, balancing device shaft		3HAC12475-1	
Press tool, balancing device shaft		3HAC17129-1	
Hydraulic cylinder		3HAC11731-1	To be used with the press and puller tools. 2 pcs required!
Hydraulic pump, 80 MPa		3HAC13086-1	To be used with the hydraulic cylinder.
Hydraulic valve with hose		3HAC022643-001	
Standard toolkit		-	Content is defined in section <i>Standard tools on page 435</i> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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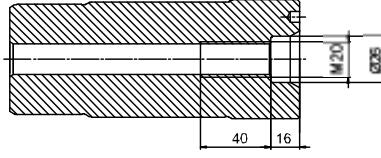
## 4 Repair

### 4.5.4.1 Replacing the balancing device

*Continued*

#### Removal, balancing device

The procedure below details how to remove the balancing device.

	Action	Note
1	Move the lower arm to a position close to the calibration position.	
2	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
3	Secure the lower arm to the frame by inserting the <i>locking screw</i> into the attachment hole in the frame.	Attachment hole for the locking screw is shown in the figure <a href="#">Attachment points, balancing device on page 310</a> . Art. no. is specified in <a href="#">Required equipment on page 310</a> !
4	 <b>CAUTION</b> The balancing device weighs 407 kg! All lifting equipment used must be sized accordingly!	
5	Apply the <i>lifting eye</i> and the <i>shackle</i> to the attachments on the balancing device and raise to unload the weight.	Art. no. is specified in <a href="#">Required equipment on page 310</a> ! Attachments are shown in the figure <a href="#">Attachment points, balancing device on page 310</a> .
6	Unload the balancing device with the <i>press tool</i> in order to make the piston rod and front ear adjustable when pulling the shaft out.	Art. no. is specified in <a href="#">Required equipment on page 310</a> ! Detailed in section <a href="#">Unloading the balancing device using hydraulic press tool on page 316</a> .
7	Remove the securing screw from the <i>balancing device shaft</i> .	Shown in the figure <a href="#">Location of balancing device on page 309</a> !
8	Apply the <i>puller tool, balancing device shaft</i> to the shaft through the hole in the frame. The shaft has a M20 thread diameter, as shown in the figure to the right. Pull the shaft out using the puller tool and the <i>hydraulic pump</i> .  <b>Note</b> Make sure to keep the balancing device unloaded by keeping the tap to the press device closed and using the second hose of the hydraulic valve to the puller tool.	Art. no. is specified in <a href="#">Required equipment on page 310</a> ! The hole in the frame is shown in the figure <a href="#">Attachment points, balancing device on page 310</a> !  xx0300000060  <b>Note</b> The dimension of the shaft puller tool is M20. Do not mix up with the shaft press tool used when mounting the shaft.

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4.5.4.1 Replacing the balancing device  
Continued

Action	Note
9 Restore the balancing device.	Detailed in section <a href="#">Restoring the balancing device using a hydraulic press tool on page 320</a> .
10 Secure the two <i>bearing attachments</i> to the balancing device by replacing the protection plug on the outside of each attachment, with <i>securing screws</i> . The protection plugs must be refitted after refitting the balancing device, do not loose them!	Shown in the figure <a href="#">Attachment points, balancing device on page 310</a> ! Dimensions for the securing screws are specified in <a href="#">Required equipment on page 310</a> .
11 Remove the two <i>bearing attachments</i> from the frame by unscrewing their four <i>attachment screws</i> .	Shown in the figure <a href="#">Location of balancing device on page 309</a> ! Make sure the parallel pins inside are not lost!
12 Fit two <i>guide pins</i> through the upper holes of the bearing attachments, to the frame.	Art. no. is specified in <a href="#">Required equipment on page 310</a> !
13 Lift the balancing device gently backwards to a secure area, allowing the bearing attachments to slide on the guide pins.	 Note Make sure not to burden the guide pins with the weight of the balancing device!

### Refitting, balancing device

The procedure below details how to refit the balancing device.

Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2 Secure the lower arm to the frame by inserting the <i>locking screw</i> into the attachment hole in the frame.	Art. no. is specified in <a href="#">Required equipment on page 310</a> ! Attachment hole is shown in the figure <a href="#">Attachment points, balancing device on page 310</a> .
3 Secure the <i>bearing attachments</i> to the balancing device with <i>securing screws</i> .	Shown in the figure <a href="#">Attachment points, balancing device on page 310</a> ! Dimension of the securing screws is specified in <a href="#">Required equipment on page 310</a> .
4 Refit the two <i>parallel pins</i> in the frame.	Shown in the figure <a href="#">Location of balancing device on page 309</a> !
5 Fit two <i>guide pins</i> to the upper holes in the frame, where the bearing attachments are to be attached.	

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## 4 Repair

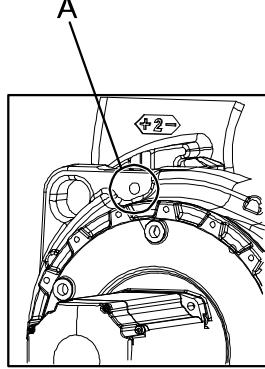
### 4.5.4.1 Replacing the balancing device

*Continued*

	Action	Note
6	Fit the <i>lifting eye</i> and the <i>shackle</i> to the attachment points on the balancing device.	Art. no. is specified in <a href="#">Required equipment on page 310!</a> Attachments are shown in the figure <a href="#">Attachment points, balancing device on page 310.</a>
7	 <b>CAUTION</b> The balancing device weighs 407 kg! All lifting equipment used must be sized accordingly!	
8	Lift the balancing device and bring it forward, gliding the bearing attachments on to the guide pins.	 <b>Note</b> Make sure not to burden the guide pins with the weight of the balancing device!
9	Remove the guide pins.	
10	Secure the rear of the balancing device by fastening the two bearing attachments to the frame with their four <i>attachment screws</i> .	Shown in the figure <a href="#">Location of balancing device on page 309!</a> 4 pcs, M16x70, 12.9 quality UN-BRAKO, tightening torque: 300 Nm. Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.
11	Remove the screws from outside of the bearing attachments and refit the protection plugs.	
12	Raise the balancing device to a position where the balancing device shaft may be inserted through the piston shaft front eye.	
13	Unload the balancing device with the <i>press tool</i> .	Detailed in section <a href="#">Unloading the balancing device using hydraulic press tool on page 316.</a> Art. no. is specified in <a href="#">Required equipment on page 310!</a> For an easier reassembling of the shaft, the piston rod may be pressed out more than necessary and then pressed in when fitting the shaft.
14	Lubricate the shaft with grease.	Art. no. is specified in <a href="#">Required equipment on page 310!</a>
15	Apply the <i>shaft press tool</i> to the lubricated <i>shaft</i> . Fit the shaft to the piston shaft front eye through the hole in the frame, using the shaft press tool and the <i>hydraulic pump</i> .	The hole in the frame is shown in the figure <a href="#">Attachment points, balancing device on page 310!</a> Art. no. is specified in <a href="#">Required equipment on page 310!</a>
	 <b>Note</b> Make sure to keep the balancing device unloaded by keeping the tap to the press device closed and using the second hose of the hydraulic valve to the puller tool.	 <b>Note</b> Make sure the shaft is pressed all the way to the bottom.

*Continues on next page*

4.5.4.1 Replacing the balancing device  
Continued

	Action	Note
16	Refit the securing screw into the shaft using <i>locking liquid</i> .	M16 x 180, tightening torque: 120 Nm. Locking liquid is specified in <a href="#">Required equipment on page 310!</a>
17	Lubricate the bearing in the ear with <i>grease</i> through the lubricating nipple, with a grease pump. Fill until excessive grease pierces between the shaft and the sealing spacer.	Art. no. and amount are specified in <a href="#">Required equipment on page 310!</a> Lubrication is further detailed in section <a href="#">Lubrication of spherical roller bearing, balancing device on page 203.</a>
18	Restore the balancing device.	Detailed in section <a href="#">Restoring the balancing device using a hydraulic press tool on page 320.</a>
19	 <b>DANGER</b> The rear cover of the balancing device is a safety device for the piston rod during operation! Make sure the cover is properly secured before commissioning of the robot!	
20	Remove the locking screw that secures the lower arm to the frame.	 xx0300000484 Attachment hole for the securing screw.
21	 <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50.</a>	

## 4 Repair

### 4.5.4.2 Unloading the balancing device using hydraulic press tool

#### Prerequisite

This section details how to unload the balancing device using the hydraulic press tool.

The lower arm must be secured before unloading the balancing device! How to secure the lower arm is detailed in the current repair activity, for example removal of the balancing device.



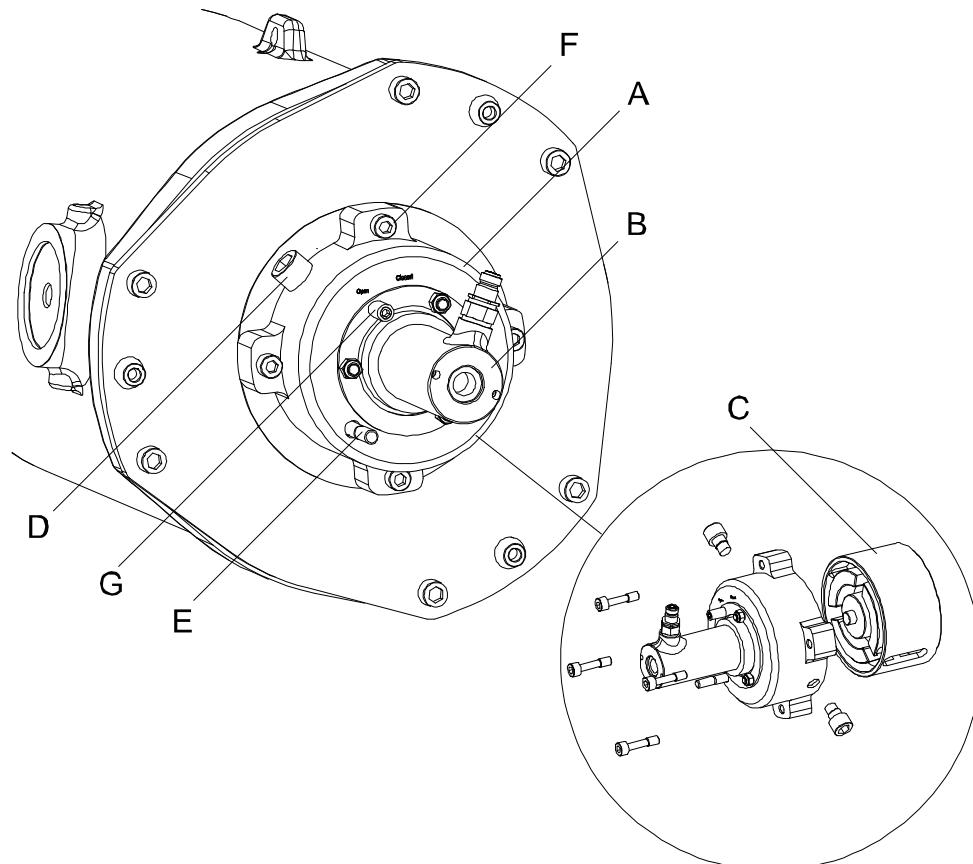
#### DANGER

There is a high tensioned spring inside the balancing device, incorrect handling may cause injuries and damage property.

#### Press tool and hydraulic cylinder

The figure below shows the hydraulic cylinder mounted on the press tool.

The press tool includes two press devices that are used to different models of the balancing device.



xx0200000174

A	Press block
B	Hydraulic cylinder

Continues on next page

## 4.5.4.2 Unloading the balancing device using hydraulic press tool

*Continued*

C	Press device
D	Bolt, press device
E	Moving pin with marking
F	Bolt (4 pcs)
G	Pin, attached to the fix plate

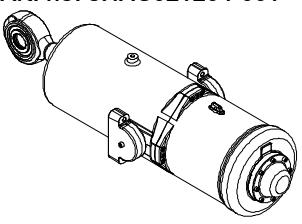
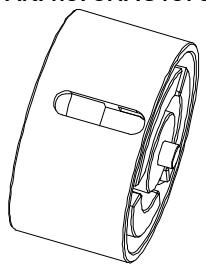
**Required equipment**

Equipment, etc.	Art. no.	Note
Press tool, balancing device	3HAC020902-001	Includes <ul style="list-style-type: none"> <li>• press device 3HAC15767-2</li> <li>• press device 3HAC18100-1</li> </ul> Choose the correct device, depending on model of balancing device.
Hydraulic cylinder	3HAC11731-1	To be used with the press tool. 2 pcs required!
Hydraulic valve with hose	3HAC022643-001	
Hydraulic pump, 80 MPa	3HAC13086-1	To be used with the hydraulic cylinder.
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .

**Using the correct press device**

The different designs of the balancing device require different versions of the press device, included in the complete press tool. The table below specifies which press device to use to which balancing device.

The article number of the balancing device may be found on a label at the rear of the balancing device.

Balancing device	Press device
Art. no: 3HAC021204-001 	Art. no: 3HAC15767-2 

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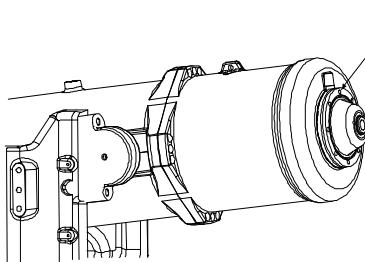
## 4 Repair

### 4.5.4.2 Unloading the balancing device using hydraulic press tool

Continued

#### Unloading the balancing device

The procedure below details how to use the press tool in order to unload the balancing device. How to remove the press tool, is detailed in section [Restoring the balancing device using a hydraulic press tool on page 320](#).

Action	Note
1 Fit the <i>moving pin</i> to the current press device.	Choose the correct press device, according to the table <a href="#">Using the correct press device on page 317</a> . The moving pin is shown in the figure <a href="#">Press tool and hydraulic cylinder on page 316</a> .
2 Fit the correct press device and moving pin to the press tool. Secure with the <i>bolt</i> , <i>press device</i> .  <b>Note</b> Make sure the bolt is secured properly!	Shown in the figure <a href="#">Press tool and hydraulic cylinder on page 316</a> .
3 Remove the <i>rear cover</i> of the balancing device, by unscrewing the <i>attachment screws</i> .  <b>DANGER</b> DO NOT! remove any other screws than the rear cover attachment screws.	 xx0300000606 • E: Rear cover attachment screws, 8 pcs
4 Remove <ul style="list-style-type: none"><li>• the o-ring from the balancing device end.</li><li>• the support shaft, including the damper, from the balancing device.</li><li>• the remaining o-ring from the balancing device end.</li></ul>	
5 Fit the <i>press tool</i> to the rear of the balancing device with enclosed <i>bolts</i> . Tighten them properly!	Art. no. is specified in <a href="#">Required equipment on page 317</a> . See the figure <a href="#">Press tool and hydraulic cylinder on page 316</a> .
6 Fit the <i>hydraulic cylinder</i> to the press tool.	Art. no. is specified in <a href="#">Required equipment on page 317</a> . See the figure <a href="#">Press tool and hydraulic cylinder on page 316</a> .
7 Connect the <i>hydraulic pump</i> to the hydraulic valve and connect one of the hoses to the hydraulic cylinder on the press tool.	

Continues on next page

## 4.5.4.2 Unloading the balancing device using hydraulic press tool

*Continued*

Action	Note
8 Open the tap to the connected hose. Check that the other tap is closed.   <b>Note</b> Only one tap may be open at a time!	
9 Increase the pressure and press until the front eye of the piston rod is aligned with the hole in the frame, through which the shaft may be pulled out or pressed in.	 <b>Note</b> Make sure the piston rod is properly unloaded before removing the shaft from the front eye, otherwise the shaft may be damaged!
10 Close the tap to the hose.	
11 Keep the hydraulic cylinder and pump connected in order to keep the balancing device unloaded in correct position!  The hydraulic pump can be used by connecting the second hose of the hydraulic valve to an other tool.	

## 4 Repair

### 4.5.4.3 Restoring the balancing device using a hydraulic press tool

#### Overview

This section details how to restore the balancing device and how to remove the press tool from the device.



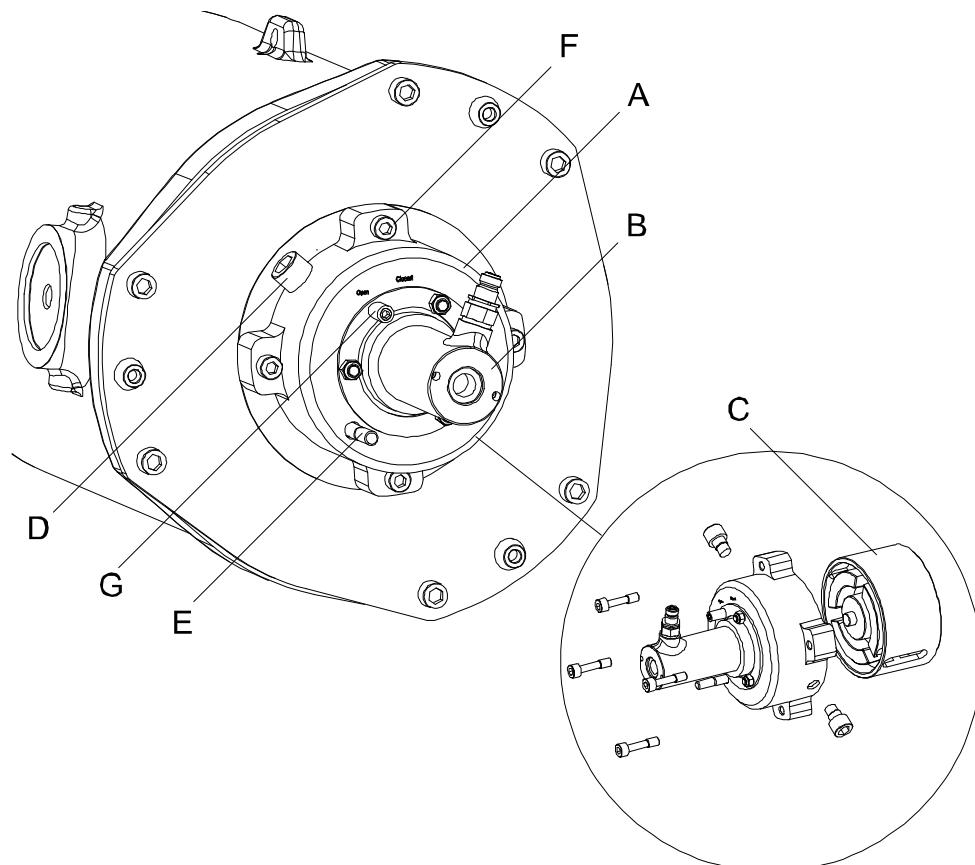
#### DANGER

There is a high tensioned spring inside the balancing device, incorrect handling may cause injuries and damage property.

#### Press tool and hydraulic cylinder

The figure below shows the hydraulic cylinder mounted on the press tool.

The press tool includes two press devices that are used to different models of the balancing device.



xx0200000174

A	Press block
B	Hydraulic cylinder
C	Press device
D	Bolt, press device
E	Moving pin with marking

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## 4.5.4.3 Restoring the balancing device using a hydraulic press tool

Continued

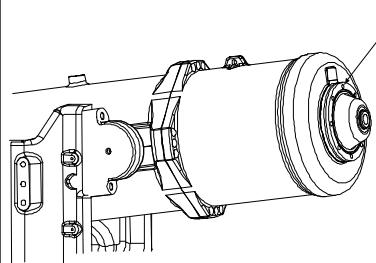
F	Bolt (4 pcs)
G	Pin, attached to the fix plate

**Required equipment**

Equipment, etc.	Art. no.	Note
Hydraulic valve with hose	3HAC022643-001	
Hydraulic cylinder	3HAC11731-1	To be used with press tool.
Hydraulic pump, 80 MPa	3HAC13086-1	To be used with hydraulic cylinder.
Locking liquid	-	Loctite 577 Used to secure the attachment screws of the rear cover at the end of the balancing device.
Standard toolkit	3HAC15571-1	Content is defined in section <a href="#">Standard tools on page 435</a> .
Sikaflex 521FC		

**Restoring the balancing device**

The procedure below details how to restore the balancing device, that is removing the press tool.

	Action	Note
1	Open the tap on the hydraulic valve to unload the hydraulic cylinder and make sure the <i>moving pin</i> indicates that the tool has returned to its starting position.	
2	Remove the hydraulic cylinder.	
3	Remove the press tool by unscrewing the <i>bolts</i> .	Shown in the figure <a href="#">Press tool and hydraulic cylinder on page 320!</a>
4	Lubricate and refit the o-ring at the end of the balancing device.	Make sure the o-ring is seated properly! Replace if damaged.
5	Make sure the damper is properly fitted to the support shaft and refit them both to the balancing device.	
6	Lubricate and refit the o-ring on the support shaft.	Make sure the o-ring is seated properly! Replace if damaged.
7	Refit the rear cover to the balancing device with its attachment screws, using locking liquid. Apply sikaflex 521FX on the cover.	 xx0300000606 <ul style="list-style-type: none"> <li>E: 8 pcs: M10x45, tightening torque: 50 Nm.</li> </ul> Locking liquid is specified in <a href="#">Required equipment on page 321</a> .

Continues on next page

## 4 Repair

### 4.5.4.3 Restoring the balancing device using a hydraulic press tool

*Continued*

Action	Note
8  <b>DANGER</b> The rear cover of the balancing device is a safety device for the piston rod during operation! Make sure the cover is properly secured before commissioning of the robot!	

## 4.6 Motors

### 4.6.1 Replacement of motor, axis 1



#### Note

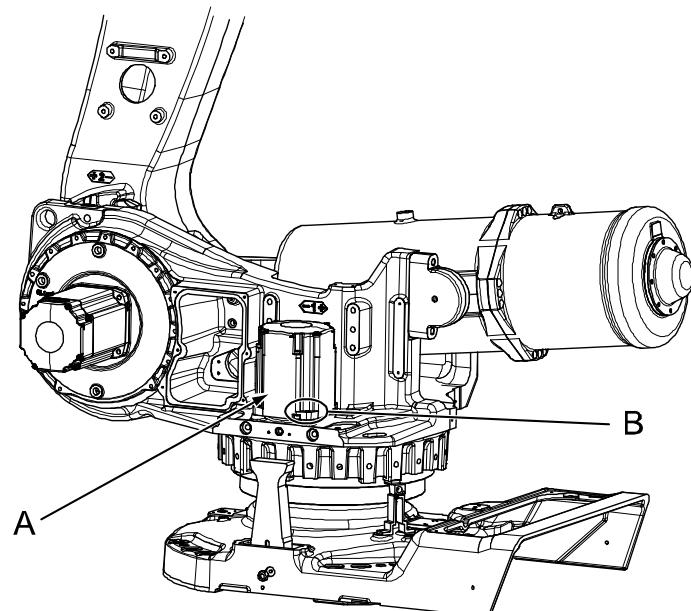
This procedure requires calibration of the robot.

The robot is calibrated by either Calibration Pendulum or Axis Calibration at factory. Always use the same calibration method as used at the factory.

Information about valid calibration method is found on the calibration label or in the calibration menu on the FlexPendant.

#### Location of motor

The motor axis 1 is located on the left hand side of the robot as shown in the figure below.



xx0300000499

A	Motor, axis 1
B	Motor attachment screws and washers

#### Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Motor including pinion	See <a href="#">Spare part lists on page 425</a> .		Includes <ul style="list-style-type: none"> <li>• motor</li> <li>• pinion</li> <li>• o-ring 21522012-430.</li> </ul>
O-ring	21522012-430		Must be replaced when reassembling the motor.

*Continues on next page*

## 4 Repair

### 4.6.1 Replacement of motor, axis 1

*Continued*

Equipment, etc.	Spare part no.	Art. no.	Note
Mobilux EP 2	-	-	Used to lubricate the motor clutch.
Grease		3HAB3537-1	Used to lubricate the o-ring.
Removal tool, motor M12x		3HAC14631-1	Always use the removal tools in pairs!
Lifting tool, motor ax 1, 4, 5		3HAC14459-1	
Power supply		-	24 VDC, max. 1,5 A For releasing the brakes.
Standard toolkit		-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Calibration Pendulum toolkit		3HAC15716-1	Complete kit that also includes operating manual. Required if Calibration Pendulum is the valid calibration method for the robot.
Calibration tool box, Axis Calibration		3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.
Circuit diagram			See chapter <a href="#">Circuit diagram on page 441</a> .

#### Deciding calibration routine

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

	Action	Note
1	Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"><li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li><li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li></ul>	

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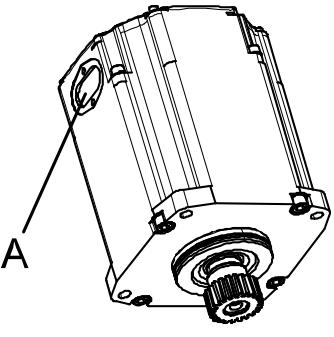
## 4.6.1 Replacement of motor, axis 1

Continued

Action	Note
<p>If the robot is to be calibrated with reference calibration:</p> <p>Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot.</p> <p>If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.</p>	<p>Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values.</p> <p>Creating new values requires possibility to move the robot.</p> <p>Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a>.</p> <p>Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a>.</p>
<p>If the robot is to be calibrated with fine calibration:</p> <p>Remove all external cable packages (DressPack) and tools from the robot.</p>	

**Removal, motor axis 1**

The procedure below details how to remove motor, axis 1.

Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
3 Remove the cover for connector access on top of the motor by unscrewing its four attachment screws.	
4 Remove the cable gland cover at the cable exit by unscrewing its two attachment screws.   <b>Note</b> Make sure the gasket is not damaged!	 xx0200000199 <ul style="list-style-type: none"><li>• A: Cable gland cover</li></ul>
5 Disconnect all connectors beneath the motor cover.	
6 Apply <i>lifting tool, motor axis 1, 4, 5</i> to the motor.	Art. no. is specified in <a href="#">Required equipment on page 323</a> .
7 In order to release the brakes, connect the 24 VDC power supply.	Connect to connector R2.MP1 <ul style="list-style-type: none"><li>• +: pin 2</li><li>• -: pin 5</li></ul>

*Continues on next page*

## 4 Repair

### 4.6.1 Replacement of motor, axis 1

*Continued*

Action	Note
8 Remove the motor by unscrewing its four <i>attachment screws</i> and plain washers.	Shown in the figure <a href="#">Location of motor on page 323</a> .
9  <b>CAUTION</b> The motor weighs 25 kg! All lifting equipment used must be sized accordingly!	
10 Lift the motor to get the pinion away from the gear and disconnect the brake release voltage.	
11 Remove the motor by gently lifting it straight up.	

### Refitting, motor axis 1

The procedure below details how to refit motor, axis 1.

Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2 Make sure the <i>o-ring</i> on the circumference of the motor is seated properly. Lightly lubricate the o-ring with <i>grease</i> .	Art no. is specified in <a href="#">Required equipment on page 323</a> .
3  <b>CAUTION</b> The motor weighs 25 kg! All lifting equipment used must be sized accordingly!	
4 Apply the <i>lifting tool, motor axis 1, 4, 5</i> to the motor.	Art no. is specified in <a href="#">Required equipment on page 323</a> .
5 In order to release the brake, connect the 24 VDC power supply.	Connect to connector R2.MP1 <ul style="list-style-type: none"><li>• +: pin 2</li><li>• -: pin 5</li></ul>
6 Fit the motor, making sure the motor pinion is properly mated to gearbox of axis 1.	Make sure the motor is turned the correct way, that is connection of motor cable forwards.. Make sure the motor pinion does not get damaged!
7 Fit the clutch on the pinion on the motor.	
8 Secure the motor with its four attachment screws and plain washers.	M10 x 40, tightening torque: 50 Nm.
9 Disconnect the brake release voltage.	
10 Reconnect all connectors beneath the motor cover.	
11 Refit the cable gland cover at the cable exit with its two attachment screws.	Make sure the cover is tightly sealed!

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## 4.6.1 Replacement of motor, axis 1

*Continued*

Action	Note
12 Refit the motor cover with its four attachment screws.	Make sure the cover is tightly sealed!
13 Recalibrate the robot!	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> . General calibration information is included in section <a href="#">Calibration on page 393</a> .
14  <b>DANGER</b>  Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

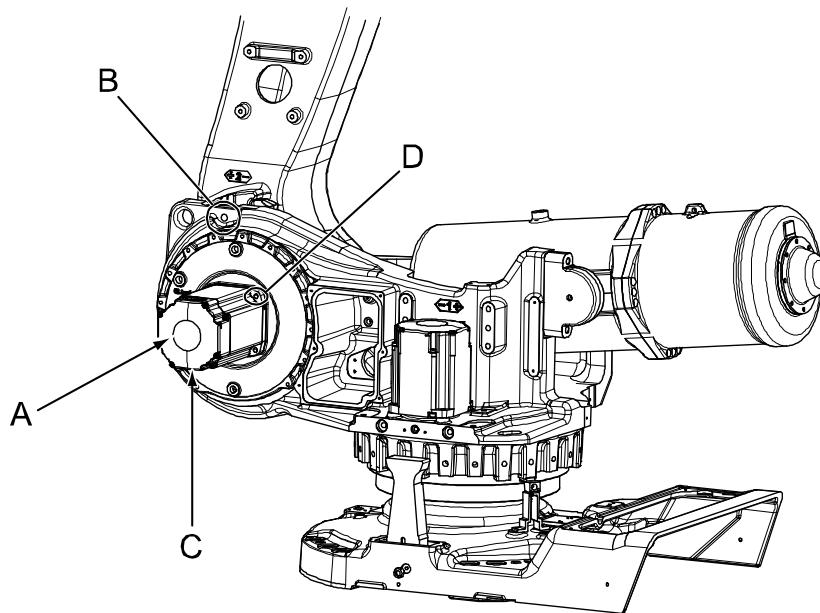
## 4 Repair

### 4.6.2 Replacement of motor axis 2

#### 4.6.2 Replacement of motor axis 2

##### Location of motor

The motor, axis 2, is located on the left-hand side of the robot as shown in the figure below.



xx0300000500

A	Motor axis 2
B	Hole for lock screw
C	Cable gland cover (located on the lower side of the motor)
D	Motor attachment holes (4 pcs)

##### Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Motor including pinion	See <a href="#">Spare part lists on page 425</a> .		Includes <ul style="list-style-type: none"><li>• motor</li><li>• pinion</li><li>• o-ring 2152 2012-430</li></ul>
O-ring	21522012-430		Must be replaced when re-assembling motor!
Grease		3HAB3537-1	For lubricating the o-ring.
Locking screw		3HAA1001-266	M16 x 60 For securing the lower arm.
Removal tool, motor M12x		3HAC14631-1	Always use the removal tools in pairs!
Guide pins M10 x 150		3HAC15521-2	For guiding the motor. Guides are to be used in pairs!

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## 4.6.2 Replacement of motor axis 2

*Continued*

Equipment, etc.	Spare part no.	Art. no.	Note
Lifting tool, motor ax 2, 3, 4		3HAC15534-1	
Extension bar, 300 mm for bits 1/2"		3HAC12342-1	
Power supply		-	24 VDC, 1.5 A For releasing the brakes.
Rotation tool		3HAC17105-1	Used to rotate the motor pinion when mating it to the gear when brakes are released with 24VDC power supply.
Standard toolkit		-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Calibration Pendulum toolkit		3HAC15716-1	Complete kit that also includes operating manual. Required if Calibration Pendulum is the valid calibration method for the robot.
Calibration tool box, Axis Calibration		3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.
Circuit diagram			<a href="#">See chapter Circuit diagram on page 441</a> .

**Deciding calibration routine**

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

	Action	Note
1	Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"> <li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li> <li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li> </ul>	

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## 4 Repair

### 4.6.2 Replacement of motor axis 2

*Continued*

Action	Note
<p><b>If the robot is to be calibrated with reference calibration:</b>            Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot.            If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.</p>	Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a> . Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a> .
<p><b>If the robot is to be calibrated with fine calibration:</b>            Remove all external cable packages (DressPack) and tools from the robot.</p>	

#### Removal, motor

The procedure below details how to remove the motor, axis 2.

Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2 Move the robot to a position close enough to its calibration position, to allow the lock screw to be inserted into the <i>hole for lock screw</i> .	Shown in the figure <a href="#">Location of motor on page 328</a> .
3  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
4 Lock the lower arm by inserting the <i>lock screw</i> into the hole.	Art. no. and dimension is specified in <a href="#">Required equipment on page 328</a> .
5 Drain the oil from gearbox, axis 2.	Detailed in the section <a href="#">Changing oil, axis-2 gearbox on page 183</a> .
6 Remove the cover on top of the motor by unscrewing its four attachment screws.	
7 Remove the <i>cable gland cover</i> at the cable exit by unscrewing its two attachment screws.	Shown in the figure <a href="#">Location of motor on page 328</a> . Make sure the gasket is not damaged!
8 Disconnect all connectors beneath the motor cover.	

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	Action	Note
9	 <b>DANGER</b> Secure the weight of the lower arm properly before releasing the brakes of motor, axis 2! When releasing the holding brakes of the motor, the lower arm will be movable and may fall down!	Use the lock screw to lock the lower arm, as detailed above!
10	In order to release the brake, connect the 24 VDC power supply.	Connect to connector R2.MP2 • +: pin 2 • -: pin 5
11	Remove the motor by unscrewing its four attachment screws and plain washers.	
12	Fit the two <i>guide pins</i> in two of the <i>motor attachment holes</i> .	Art. no. is specified in <a href="#">Required equipment on page 328</a> . Shown in the figure <a href="#">Location of motor on page 328</a> .
13	If required, press the motor out of position by fitting the <i>removal tool, motor</i> to the remaining <i>motor attachment holes</i> .	Art. no. is specified in <a href="#">Required equipment on page 328</a> . Shown in the figure <a href="#">Location of motor on page 328</a> . Always use the removal tools in pairs!
14	Remove the removal tools and fit the <i>lifting tool, motor axis 2, 3, 4</i> to the motor.	Art. no. is specified in <a href="#">Required equipment on page 328</a> .
15	 <b>CAUTION</b> The motor weighs 32 kg! All lifting equipment used must be sized accordingly!	
16	Lift the motor to get the pinion away from the gear.	Make sure the motor pinion does not get damaged!
17	Remove the motor by gently lifting it straight out and place it on a secure surface. Disconnect the brake release voltage.	

**Refitting, motor**

The procedure below details how to refit the motor axis 2.

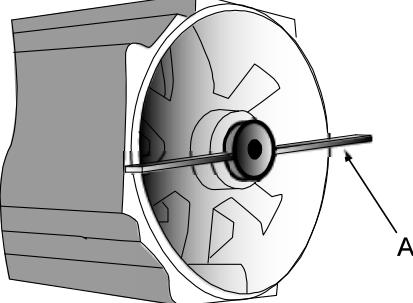
	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	

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## 4 Repair

### 4.6.2 Replacement of motor axis 2

*Continued*

Action	Note
2 Make sure the <i>o-ring</i> on the circumference of the motor is seated properly. Lightly lubricate the o-ring with <i>grease</i> .	Art. no. is specified in <a href="#">Required equipment on page 328</a> .
3 In order to release the brake, remove the cover on top of the motor and connect the 24 VDC power supply.	Connect to connector R2.MP2 <ul style="list-style-type: none"> <li>• +: pin 2</li> <li>• -: pin 5</li> </ul>
4 Fit the <i>lifting tool, motor axis 2, 3, 4</i> to the motor.	Art. no. is specified in <a href="#">Required equipment on page 328</a> .
5 Fit the two <i>guide pins</i> in the two lower <i>motor attachment holes</i> .	Art. no. is specified in <a href="#">Required equipment on page 328</a> . Shown in the figure <a href="#">Location of motor on page 328</a> .
6  <b>CAUTION</b> The motor weighs 32 kg! All lifting equipment used must be sized accordingly!	
7 Lift the motor and guide it onto the guide pins, as close to the correct position as possible without pushing the motor pinion into the gear. Make sure that the motor is turned the right direction, that is the cables facing downwards.	
8 Remove the lifting tool and allow the motor to rest on the guide pins.	
9 Use the <i>rotation tool</i> in order to rotate the motor pinion when mating it to the gear (see the figure to the right). Fit the motor, making sure the motor pinion is properly mated to the gear of gearbox axis 2 and that it does not get damaged.	Art. no. is specified in <a href="#">Required equipment on page 328</a> .  xx020000165 The rotation tool is used beneath the motor cover, directly on the motor shaft as shown in the figure above. <ul style="list-style-type: none"> <li>• A: Rotation tool</li> </ul>
10 Remove the guide pins.	
11 Secure the motor with four attachment screws and plain washers.	M10 x 40, tightening torque: 50 Nm. Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.
12 Disconnect the brake release voltage.	
13 Reconnect all connectors beneath the motor cover.	Connect in accordance with markings on connectors.

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## 4.6.2 Replacement of motor axis 2

*Continued*

	Action	Note
14	Refit the <i>cable gland cover</i> at the cable exit with its two attachment screws.	Shown in the figure <a href="#">Location of motor on page 328</a> .
15	Refit the cover on top of the motor with its four attachment screws.	Make sure the cover is tightly sealed!
16	Remove the lock screw from the <i>hole for lock screw</i> .	Shown in the figure <a href="#">Location of motor on page 328</a> .
17	Perform a leak down test.	Detailed in <a href="#">Performing a leak-down test on page 218</a> .
18	Refill the gearbox with oil.	Detailed in the section <a href="#">Changing oil, axis-2 gearbox on page 183</a> .
19	Recalibrate the robot.	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> . General calibration information is included in section <a href="#">Calibration on page 393</a> .
20	 <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

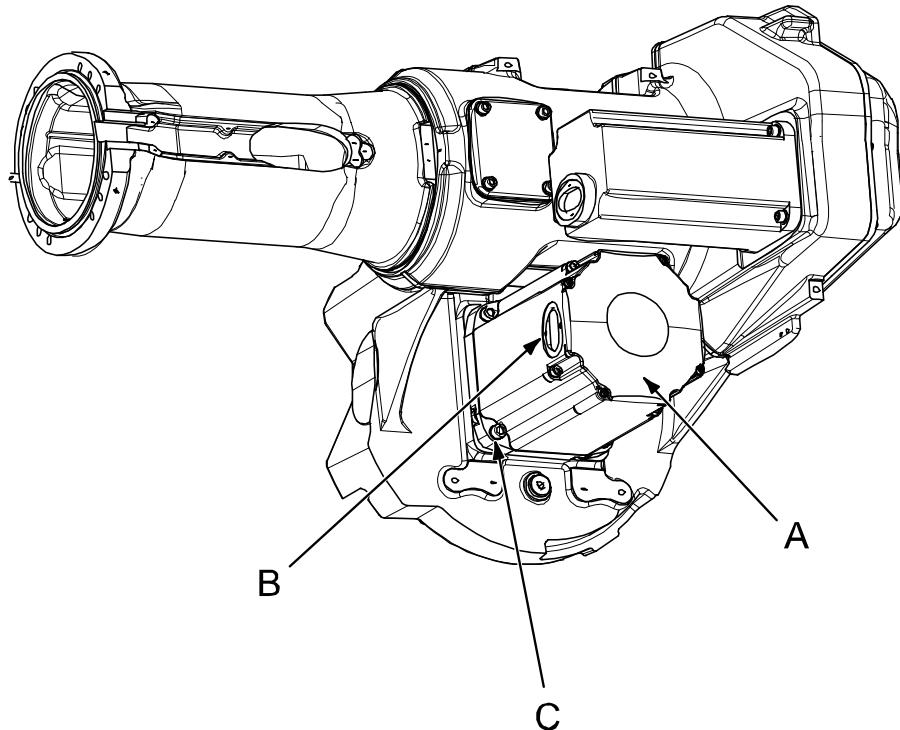
## 4 Repair

### 4.6.3 Replacement of motor, axis 3

#### 4.6.3 Replacement of motor, axis 3

##### Location of motor

The motor axis 3 is located on the left hand side of the robot as shown in the figure below.



xx0200000186

A	Motor axis 3
B	Cable gland cover, motor axis 3
C	Motor attachment holes (4 pcs)

##### Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Motor including pinion	See <a href="#">Spare part lists on page 425</a> .		Includes <ul style="list-style-type: none"><li>• motor</li><li>• pinion</li><li>• o-ring 21522012-430</li></ul>
O-ring	21522012-430		Must be replaced when reassembling motor!
Mechanical stop axis 3		3HAC12708-1	May be used to fix axis 3. Use attachment screws 3HAB 3409-86 (M16 x 60).
Grease		3HAB3537-1	For lubricating the o-ring.
Removal tool, motor M12x		3HAC14631-1	Always use the removal tools in pairs!

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## 4.6.3 Replacement of motor, axis 3

*Continued*

Equipment, etc.	Spare part no.	Art. no.	Note
Lifting tool, motor ax 2, 3, 4		3HAC15534-1	
Bolts M16x60 (for mechanical stop axis 3)		3HAB3409-86	
Washers (for mechanical stop axis 3)		3HAA1001-186	
Guide pins M10 x 100		3HAC15521-1	For guiding the motor.
Guide pins M10 x 150		3HAC15521-2	For guiding the motor.
Rotation tool		3HAC17105-1	Used to rotate the motor pinion when mating it to the gear when brakes are released with 24 VDC power supply.
Power supply	-	-	24 VDC, max. 1.5 A For releasing the brakes.
Standard toolkit	-	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Calibration Pendulum toolkit		3HAC15716-1	Complete kit that also includes operating manual. Required if Calibration Pendulum is the valid calibration method for the robot.
Calibration tool box, Axis Calibration		3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.
Circuit diagram			<a href="#">See chapter Circuit diagram on page 441</a> .

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## 4 Repair

### 4.6.3 Replacement of motor, axis 3

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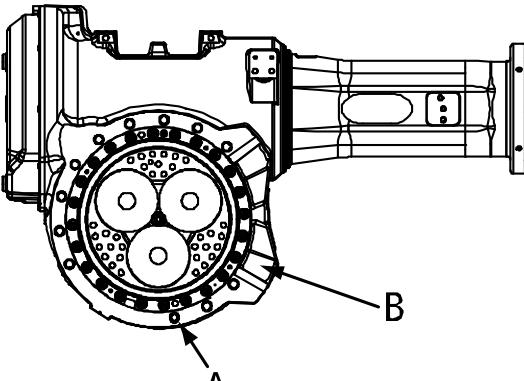
#### Deciding calibration routine

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

Action	Note
1 Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"><li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li><li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li></ul>	
If the robot is to be calibrated with reference calibration: Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot. If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.	Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a> . Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a> .
If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

#### Removal, motor

The procedure below details how to remove motor, axis 3.

Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2 Unload the upper arm of the robot by either: <ul style="list-style-type: none"><li>• Use a fork lift to rest the upper arm onto.</li><li>• Use lifting slings and an overhead crane to rest the upper arm.</li><li>• Use a mechanical stop to rest the upper arm. Fit the mechanical stop in the attachment hole (A) with tightening torque: 115 Nm.</li></ul>	 xx0300000051 Fit the mechanical stop to the third and final attachment hole (A), below the fixed stop (B) in the upper arm. See the figure above!

Continues on next page

Action	Note
3  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
4 Drain the oil from gearbox axis 3.	Detailed in section <a href="#">Changing oil, axis-3 gearbox on page 186</a> .
5 Remove any equipment hindering access to motor axis 3.	
6 Remove the cover on top of the motor by unscrewing its four attachment screws.	
7 Remove the <i>cable gland cover</i> at the cable exit by unscrewing its two securing screws.	Shown in the figure <a href="#">Location of motor on page 334</a> . Make sure the gasket is not damaged!
8 Disconnect all connectors beneath the motor cover.	
9 Unscrew the motors four <i>attachment screws and plain washers</i> .	Shown in the figure <a href="#">Location of motor on page 334</a> .
10 Fit the two <i>guide pins</i> in two of the motor attachment screw holes.	Art. no. is specified in <a href="#">Required equipment on page 334</a> .
11 Press the motor out of position by fitting <i>removal tool, motor</i> to the remaining motor attachment screw holes.	Art. no. is specified in <a href="#">Required equipment on page 334</a> . Always use the removal tools in pairs!
12 Apply the <i>lifting tool, motor axis 2 ,3, 4</i> to the motor.	Art. no. is specified in <a href="#">Required equipment on page 334</a> .
13  <b>CAUTION</b> The motor weighs 27 kg! All lifting equipment used must be sized accordingly!	
14 Lift the motor to get the pinion away from the gear.	
15 Remove the motor by gently lifting it straight out and disconnect the brake release voltage.	Make sure the motor pinion is not damaged!

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## 4 Repair

### 4.6.3 Replacement of motor, axis 3

Continued

#### Refitting, motor

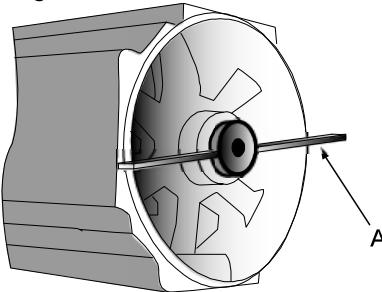
The procedure below details how to refit motor, axis 3.

Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2 Make sure the <i>o-ring</i> on the circumference of the motor is seated properly. Lightly lubricate it with <i>grease</i> .	Art no. is specified in <a href="#">Required equipment on page 334</a> .
3 Fit the <i>lifting tool, motor axis 2, 3, 4</i> to the motor.	Art no. is specified in <a href="#">Required equipment on page 334</a> .
4 Fit the two <i>guide pins</i> in the two lower <i>motor attachment holes</i> .	Art no. is specified in <a href="#">Required equipment on page 334</a> . Shown in the figure <a href="#">Location of motor on page 334</a>
5  <b>CAUTION</b> The motor weighs 27 kg! All lifting equipment used must be sized accordingly!	
6 Lift the motor and guide it onto the guide pins, as close to the correct position as possible without pushing the motor pinion into the gear.	
7 Remove the lifting tool and allow the motor to stay on the guide pins.	
8 In order to release the brake, connect the 24 VDC power supply.	Connect to connector R2.MP3 <ul style="list-style-type: none"><li>• +: pin 2</li><li>• -: pin 5</li></ul>

Continues on next page

## 4.6.3 Replacement of motor, axis 3

Continued

Action	Note
9 Use the <i>rotation tool</i> in order to rotate the motor pinion when mating it to the gear! Fit the motor, making sure the motor pinion is properly mated to the gear of gearbox, axis 3.	Art no. is specified in <a href="#">Required equipment on page 334</a> . Make sure the motor pinion does not get damaged! Make sure the motor is turned the right direction, that is the cables facing forwards.  xx0200000165 The rotation tool is used beneath the motor cover, directly on the motor shaft as shown in figure above. • A: Rotation tool.
10 Remove the guide pins.	
11 Secure the motor with four attachment screws and plain washers.	4 pcs: M10 x 40, tightening torque: 50 Nm.
12 Disconnect the brake release voltage.	
13 Reconnect all connectors beneath the motor cover.	Connect in accordance with markings on connectors.
14 Refit the <i>cable gland cover</i> at the cable exit with its two attachment screws.	Make sure the cover is tightly sealed! Shown in the figure <a href="#">Location of motor on page 334</a> .
15 Refit the cover on top of the motor with its four attachment screws.	Make sure the cover is tightly sealed!
16 Remove the equipment used to unload the upper arm.	
17 Perform a leak-down test.	Detailed in the section <a href="#">Performing a leak-down test on page 218</a> .
18 Refill the gearbox with oil.	Detailed in the section <a href="#">Changing oil, axis-3 gearbox on page 186</a> .
19 Recalibrate the robot!	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> . General calibration information is included in section <a href="#">Calibration on page 393</a> .

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## 4 Repair

### 4.6.3 Replacement of motor, axis 3

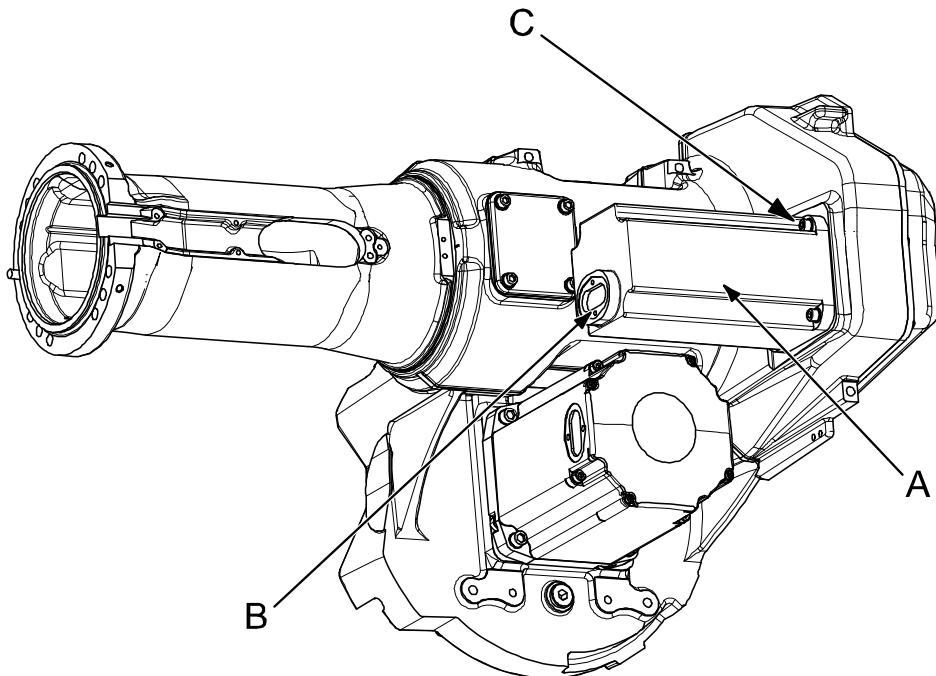
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	Action	Note
20	 <b>DANGER</b>  Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <i>DANGER - First test run may cause injury or damage!</i> on page 50.	

## 4.6.4 Replacement of motor, axis 4

### Location of motor

The motor axis 4 is located on the left-hand side of the upper arm as shown in the figure below.



xx0200000202

A	Motor, axis 4
B	Cable gland cover, motor axis 4
C	Motor attachment holes (4 pcs)

### Required equipment

Equipment, etc.	Art. no.	Note
Motor including pinion	See spare part number in <a href="#">Spare part lists on page 425</a> .	Includes: <ul style="list-style-type: none"><li>• motor</li><li>• pinion</li><li>• o-ring 21522012-430</li></ul>
O-ring	21522012-430	Must be replaced when reassembling motor!
Lifting tool, motor ax 1, 4, 5	3HAC14459-1	
Lifting tool, motor ax 2, 3, 4	3HAC15534-1	
Grease	3HAB3537-1	Used to lubricate the o-ring.
Loctite 574, Flange sealant	12340011-116	Option Foundry Plus
Removal tool, motor M10x	3HAC14972-1	Always use the removal tools in pairs!
Guide pins M8 x 100	3HAC15520-1	For guiding the motor.

*Continues on next page*

## 4 Repair

### 4.6.4 Replacement of motor, axis 4

Continued

Equipment, etc.	Art. no.	Note
Guide pins M8 x 150	3HAC15520-2	For guiding the motor.
Rotation tool	3HAC17105-1	Used to rotate the motor pinion when mating it to the gear when brakes are released with 24 VDC power supply.
Power supply	-	24 VDC, max. 1,5 A For releasing the brakes.
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Calibration Pendulum toolkit	3HAC15716-1	Complete kit that also includes operating manual. Required if Calibration Pendulum is the valid calibration method for the robot.
Calibration tool box, Axis Calibration	3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.
Circuit diagram		See chapter <a href="#">Circuit diagram on page 441</a> .

#### Deciding calibration routine

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

	Action	Note
1	Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"><li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li><li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li></ul>	
	If the robot is to be calibrated with reference calibration:  Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot.  If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.	Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a> . Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a> .

Continues on next page

Action	Note
If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

**Removal, motor axis 4**

The procedure below details how to remove the motor, axis 4.

Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2 Move the robot to a position where the upper arm is pointed straight up. This position enables the motor to be replaced without draining the gear oil, which in turn saves time. Any other position of the upper arm requires a draining of oil from the gearbox for axis 4.	Draining of oil is described in section <a href="#">Draining, oil on page 189</a> .
3  <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
4 Remove the <i>cable gland cover</i> at the cable exit of the motor by unscrewing its two attachment screws.	Shown in the figure <a href="#">Location of motor on page 341</a> . Make sure the gasket is not damaged!
5 Remove the cover on top of the motor by unscrewing its four attachment screws.	
6 Disconnect all connectors beneath the motor cover.	
7 In order to release the brake, connect the 24 VDC power supply.	Connect to connector R2.MP4 <ul style="list-style-type: none"><li>• +: pin 2</li><li>• -: pin 5</li></ul>
8 Unscrew the motors four attachment screws and plain washers.	Shown in the figure <a href="#">Location of motor on page 341</a> .
9 Fit the two <i>guide pins</i> in two of the motor attachment screw holes.	
10 If required, press the motor out of position by fitting <i>removal tool, motor</i> to the motor attachment screw holes.	Art. no. is specified in <a href="#">Required equipment on page 341</a> . Always use the removal tools in pairs!
11 Lift the motor to get the pinion away from the gear and disconnect the brake release voltage.	
12 Remove the motor by gently lifting it straight out.	Make sure the motor pinion is not damaged!

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## 4 Repair

### 4.6.4 Replacement of motor, axis 4

*Continued*

#### Refitting, motor axis 4

The procedure below details how to refit motor, axis 4.

	Action	Note
1	 <b>DANGER</b>	
	<p>Turn off all:</p> <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul>	
	<p>Before entering the robot working area.</p>	
2	<p>Make sure the <i>o-ring</i> on the circumference of the motor is seated properly. Lightly lubricate the <i>o-ring</i> with <i>grease</i>.</p>	Art. no. is specified in <a href="#">Required equipment on page 341</a> .
3	<p>In order to release the brakes, connect the 24 VDC power supply.</p>	Connect to connector R2.MP4:
		<ul style="list-style-type: none"> <li>• +: pin 2</li> <li>• -: pin 5</li> </ul>
4	<p>Fit the two <i>guide pins</i> in two of the <i>motor attachment holes</i>.</p>	Art. no. is specified in <a href="#">Required equipment on page 341</a> .
		Shown in the figure <a href="#">Location of motor on page 341</a> .
5	<p>Fit the motor with guidance of the pins, making sure the motor pinion is properly mated to the gear of gearbox 4.</p>	Make sure the motor pinion does not get damaged!
6	<p>Use the <i>rotation tool</i> in order to rotate the motor pinion when mating it to the gear!</p>	Art. no. is specified in <a href="#">Required equipment on page 341</a> .
	<p>Fit the motor, making sure the motor pinion is properly mated to the gear, axis 4.</p>	Make sure the motor pinion does not get damaged!
		Make sure the motor is turned the right direction, that is the cables facing forwards.
7	<p>Remove the guide pins.</p>	
8	<p>Secure the motor with four attachment screws and plain washers.</p>	4 pcs: M8 x 25, tightening torque: 24 Nm.
9	<p>Disconnect the brake release voltage.</p>	

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	Action	Note
10	Reconnect all connectors beneath the motor cover.	
11	Refit the cover on top of the motor with its four attachment screws.	Make sure the cover is tightly sealed!
12	Refit the <i>cable gland cover</i> at the cable exit with its two attachment screws.	Shown in the figure <a href="#">Location of motor on page 341</a> .
13	Perform a leak-down test if the gearbox has been drained.	Detailed in the section <a href="#">Performing a leak-down test on page 218</a> .
14	Refill the gearbox with oil if drained.	Detailed in the section <a href="#">Filling, oil on page 190</a> .
15	Recalibrate the robot!	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> . General calibration information is included in section <a href="#">Calibration on page 393</a> .
16	 <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

## 4 Repair

### 4.6.5 Replacement of motor, axis 5

#### 4.6.5 Replacement of motor, axis 5

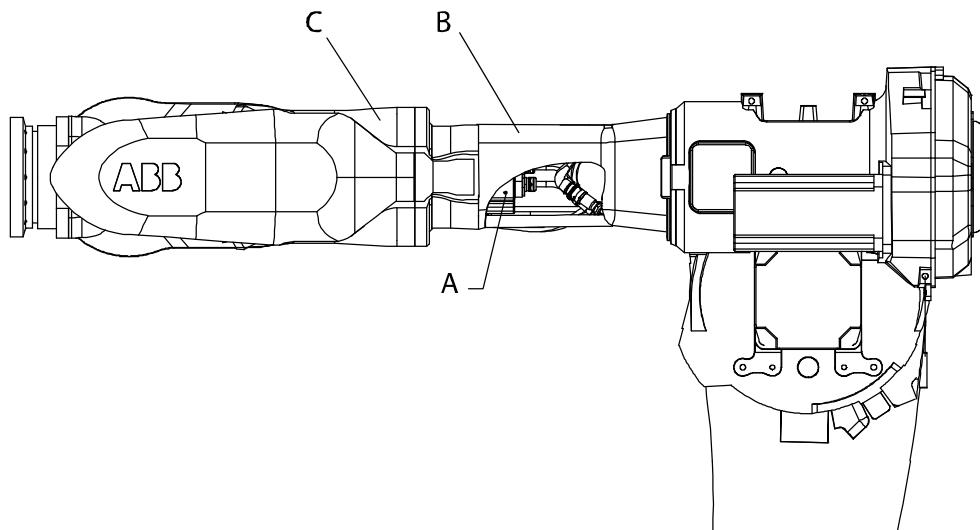
##### Reused pinion

The pinion in the motor, axis 5, is matched with the bevel gear for axis 5. When the motor is replaced the pinion must therefore be removed from the dismounted motor and fitted onto the new motor shaft as detailed in this section.

##### Location of motor

The motor axis 5 is located inside the upper arm tube, but attached to the wrist unit, as shown in the figure below.

A more detailed view of the component and its position may be found in [Spare part lists on page 425](#).



xx0200000204

A	Motor, axis 5
B	Upper arm tube
C	Wrist unit

##### Required equipment

Equipment, etc.	Art. no.	Note
Motor	For spare part number, see <a href="#">Spare part lists on page 425</a> .	Does not include pinion. Use the pinion from the motor to be replaced. Includes o-ring 21522012-430.
Set of shim, motor	3HAC7941-28	Used to obtain the correct distance between motor flange and outer surface of motor pinion.
O-ring	21522012-430	Must be replaced when reassembling motor!
Grease	3HAB3537-1	For lubricating the o-ring.
Loctite 574, Flange sealant	12340011-116	Option Foundry Plus

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Equipment, etc.	Art. no.	Note
Isopropanol	11771012-208	For cleaning motor pinion and motor pinion hole.
Mineral oil	CS 320	For lubrication of pinion shaft and pinion hole.
Removal tool, motor M10x	3HAC14972-1	Always use the removal tools in pairs!
Oil injector / max 500 MPa	3HAC021590-001	For pressing out the pinion, motor 5.
Press fixture (for pinion)	-	For pressing the pinion on to the new motor.
Measuring tool	6896134-GN	
Guide pins M8 x 100	3HAC15520-1	For guiding the motor.
Guide pins M8 x 150	3HAC15520-2	For guiding the motor.
Power supply	-	24 VDC, 1.5 A For releasing the brakes.
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.
Circuit diagram	-	See chapter <a href="#">Circuit diagram on page 441</a> .

### Deciding calibration routine

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

	Action	Note
1	<p>Decide which calibration routine to use for calibrating the robot.</p> <ul style="list-style-type: none"> <li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li> <li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li> </ul>	
	<p>If the robot is to be calibrated with reference calibration:</p> <p>Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot.</p> <p>If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.</p>	<p>Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values.</p> <p>Creating new values requires possibility to move the robot.</p> <p>Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a>.</p> <p>Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a>.</p>

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## 4 Repair

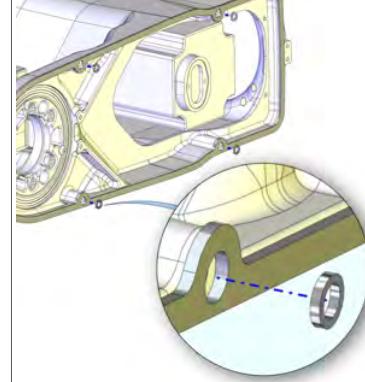
### 4.6.5 Replacement of motor, axis 5

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Action	Note
If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

#### Removal, motor, axis 5

The procedure below details how to remove motor, axis 5.

Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
3 Drain the oil from gearbox axis 5.	Detailed in the section <a href="#">Changing oil, axis-5 gearbox on page 192</a> .
4 Remove the wrist unit.	Detailed in the section <a href="#">Removal, wrist unit on page 263</a> .  xx1400002580
5 Place the wrist unit safely on a workbench, in a fixture or similar.	
6 Remove the cover on top of the motor by unscrewing its four attachment screws.	
7 Remove the cable gland cover at the cable exit by unscrewing its two attachment screws.	
8 Disconnect all connectors beneath the motor cover and remove the separate cable of the axis-5 motor.	

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Action	Note
9 In order to release the brake, connect the 24 VDC power supply.	Connect to either: - connector R4.MP5 (in the motor): • + : pin 2 • - : pin 5 - connector R3.MP5 (on the separate cable, if not removed): • +: pin C • -: pin D
10 Remove the motor by unscrewing its four attachment screws and plain washers.	
11 Fit the two <i>guide pins</i> in two of the motor attachment screw holes.	Art. no. is specified in <a href="#">Required equipment on page 346</a> .
12 If required, press the motor out of position by fitting <i>removal tool, motor, M10</i> to the motor attachment screw holes.	Art. no. is specified in <a href="#">Required equipment on page 346</a> . Always use the removal tools in pairs and diagonally!
13 Lift the motor to get the pinion away from the gear and disconnect the brake release voltage.	Make sure the motor pinion is not damaged!
14 Remove the motor by gently lifting it straight out.	Keep track of the shims between the motor flange and the wrist housing.
15 Measure the distance between the motor flange, included eventual shims, and the outer surface of the pinion, with <i>measuring tool</i> .	Art. no. is specified in <a href="#">Required equipment on page 346</a> . Make a note of the distance.
16 Press out the pinion from the dismounted motor, with the equipment included in the <i>oil injector kit</i> .	Replacing the complete wrist unit is detailed in section <a href="#">Replacement of complete wrist unit on page 261</a> . Art. no. is specified in <a href="#">Required equipment on page 346</a> .
 Note  If the pinion is damaged the complete wrist unit must be replaced!	

### Refitting, motor, axis 5

The procedure below details how to refit motor, axis 5.

Action	Note
1  <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
2 Make sure the <i>o-ring</i> on the circumference of the motor is seated properly. Lightly lubricate the <i>o-ring</i> with <i>grease</i> .	Art. no. is specified in <a href="#">Required equipment on page 346</a> .

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## 4 Repair

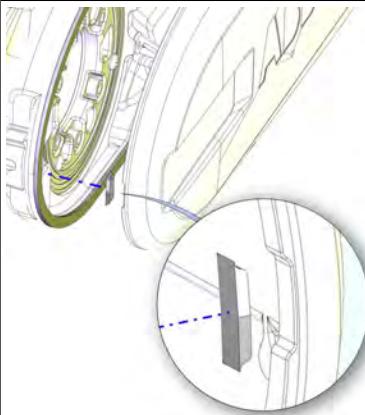
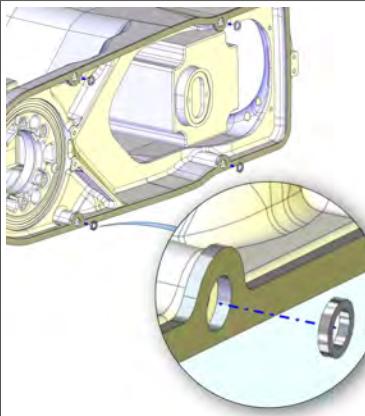
### 4.6.5 Replacement of motor, axis 5

*Continued*

Action	Note
3 Clean the pinion and the pinion hole in the motor, with <i>isopropanol</i> .   <b>Note</b> If the pinion is damaged the complete wrist unit must be replaced!	Art. no. is specified in <a href="#">Required equipment on page 346</a> . Replacing the complete wrist unit is detailed in section <a href="#">Replacement of complete wrist unit on page 261</a> .
4 Apply a thin film of <i>mineral oil</i> to the pinion shaft and the pinion hole in order to make the pinion run smoothly and to achieve an even friction torque when assembling the pinion.	Art. no. is specified in <a href="#">Required equipment on page 346</a> .
5 Place the motor and pinion in a <i>press fixture</i> .	
6 Press the pinion onto the new motor and check the pressing force. For an axis diameter of 15.5 mm, use min. pressing force: 18.5 kN and max. pressing force: 39.5 kN.	If the pressing force is outside the given range or if the pinion "jumps" in bit by bit, it must be dismounted, checked, cleaned and oiled before it is assembled once again!
7 Measure the distance between the motor flange and the outer surface of the pinion with the <i>measuring tool</i> . Modify the distance with <i>shims</i> in order to obtain the same distance as measured when dismounting the old motor (+ 0-0,05 mm).	Art. no. is specified in <a href="#">Required equipment on page 346</a> .
8 In order to release the brake, connect the 24 VDC power supply.	Connect to either: - connector R4.MP5 (in the motor): • +: pin 2 • -: pin 5 - connector R3.MP5 (on the separate cable, if not removed): • +: pin C • -: pin D
9 Fit the two <i>guide pins</i> in two of the motor attachment holes.	Art. no. is specified in <a href="#">Required equipment on page 346</a> .
10 Fit the motor, with guidance from the pins, making sure the motor pinion is properly mated to the gear of axis 5.	Make sure the motor pinion does not get damaged!
11 Secure the motor with four attachment screws and plain washers.	4 pcs: M8 x 25; tightening torque: 24 Nm.
12 Disconnect the brake release voltage.	
13 Refit the separate cable of the axis-5 motor and reconnect all connectors beneath the motor cover.	
14 Refit the cable gland cover at the cable exit with its two attachment screws.	
15 Refit the cover on top of the motor with its four attachment screws.	Make sure the cover is tightly sealed!
16 Perform a leak-down test.	Detailed in the section <a href="#">Performing a leak-down test on page 218</a> .
17 Refit the wrist unit.	Detailed in the section <a href="#">Refitting, wrist unit on page 264</a> .

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#### 4.6.5 Replacement of motor, axis 5 Continued

	Action	Note
18	<p><i>Foundry Plus</i></p> <p>Make sure that the gasket is undamaged. Also the small gasket fitted in the cover recess. Replace if damaged.</p>	 xx1400002579
19	<p><i>Foundry Plus</i></p> <p>Make sure the washers are fitted in the gasket holes. Refit the cover, <i>wrist unit Foundry Plus</i>.</p>	 xx1400002580
20	Refill the gear with oil.	Detailed in the section <a href="#">Changing oil, axis-5 gearbox on page 192</a> .
21	Recalibrate the robot.	<p>Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i>, enclosed with the calibration tools.</p> <p>Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a>.</p> <p>General calibration information is included in section <a href="#">Calibration on page 393</a>.</p>
22	 <p><b>DANGER</b></p> <p>Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a>.</p>	

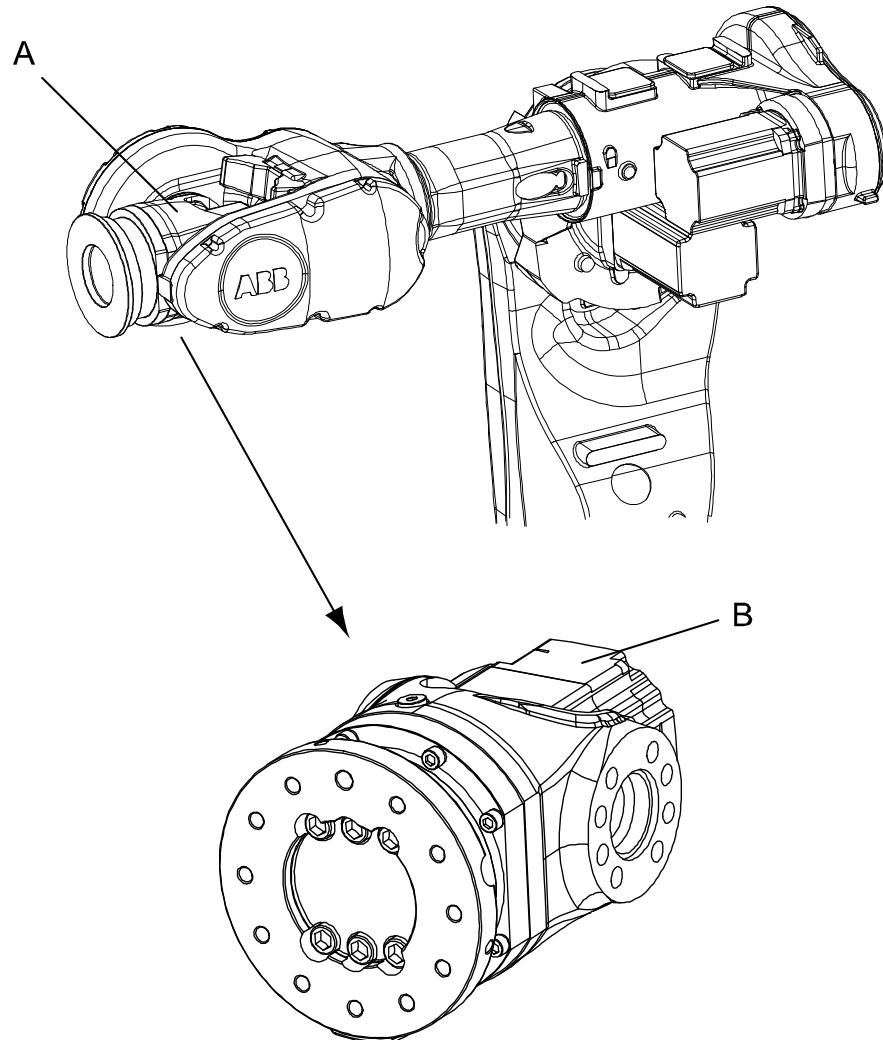
## 4 Repair

### 4.6.6 Replacement of motor, axis 6

#### 4.6.6 Replacement of motor, axis 6

##### Location of motor

The motor axis 6 is located in the center of the wrist unit as shown in the figure below.



xx0200000222

A	Wrist unit
B	Motor, axis 6

##### Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Motor including pinion	See spare part number in <a href="#">Spare part lists on page 425</a> .		Includes: <ul style="list-style-type: none"><li>• motor</li><li>• pinion</li><li>• o-ring 21522012-430</li></ul>
O-ring	21522012-430		Must be replaced when reassembling motor!

Continues on next page

## 4.6.6 Replacement of motor, axis 6

*Continued*

Equipment, etc.	Spare part no.	Art. no.	Note
Gasket	3HAC12877-1		Protection Standard. Must be replaced when replacing motor
Gasket	3HAC033206-001		Protection Foundry Plus Must be replaced when replacing motor
Gasket, cover	3HAC033489-001		Must be replaced when opening cover.
Removal tool, motor M10x		3HAC14972-1	Always use the removal tools in pairs!
Guide pins M8 x 100		3HAC15520-1	For guiding the motor.
Guide pins M8 x 150		3HAC15520-2	For guiding the motor.
Power supply		-	24 VDC, 1.5 A For releasing the brakes.
Grease		3HAB3537-1	For lubricating the o-ring.
Loctite 574, Flange sealant		12340011-116	Option Foundry Plus
Standard toolkit		-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Calibration Pendulum toolkit		3HAC15716-1	Complete kit that also includes operating manual. Required if Calibration Pendulum is the valid calibration method for the robot.
Calibration tool box, Axis Calibration		3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.
Circuit diagram		-	See chapter <a href="#">Circuit diagram on page 441</a> .

*Continues on next page*

## 4 Repair

### 4.6.6 Replacement of motor, axis 6

Continued

#### Deciding calibration routine

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

Action	Note
1 Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"><li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li><li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li></ul>	
If the robot is to be calibrated with reference calibration: Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot. If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.	Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a> . Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a> .
If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

#### Removal, motor

The procedure below details how to remove the motor, axis 6.



#### Note

Robots with protection type Foundry Plus or Foundry Prime require special repair routines to maintain the tightness level, in addition to the procedure below, described in [Replacement of the motor axis 6 \(Foundry Plus\) on page 356](#).

Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2 Move the robot to a position where the motor in axis 6 is pointed straight up. This position enables the motor to be replaced without draining the gear oil, which in turn saves time.	

Continues on next page

Action	Note
3  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
4 Remove the rear motor cover by unscrewing the five attachment screws.	
5 Disconnect all connectors beneath the cover.	
6 In order to release the brake, connect the 24 VDC power supply.	Connect to connector R3.MP6 <ul style="list-style-type: none"><li>• +: pin 2</li><li>• -: pin 5</li></ul>
7 Remove the motor by unscrewing its four attachment screws and plain washers.	
8 If required, press the motor out of position by fitting <i>removal tool, motor</i> to the motor attachment screw holes.	Art. no. is specified in <a href="#">Required equipment on page 352</a> . Always use the removal tools in pairs!
9 Lift the motor carefully to get the pinion away from the gear and disconnect the brake release voltage.	Make sure the motor pinion is not damaged!
10 Remove the motor by gently lifting it straight out.	

**Refitting, motor**

The procedure below details how to refit motor, axis 6.

**Note**

Robots with protection type Foundry Plus or Foundry Prime require special repair routines to maintain the tightness level, in addition to the procedure below, described in [Replacement of the motor axis 6 \(Foundry Plus\) on page 356](#).

Action	Note
1 Make sure the <i>o-ring</i> on the circumference of the motor is seated properly. Lightly lubricate the <i>o-ring</i> with <i>grease</i> .	Art. no. is specified in <a href="#">Required equipment on page 352</a> .
2 In order to release the brake, connect the 24 VDC power supply.	Connect to connector R3.MP6 <ul style="list-style-type: none"><li>• +: pin 2</li><li>• -: pin 5</li></ul>
3 Fit the two <i>guide pins</i> in two of the motor attachment holes.	Art. no. is specified in <a href="#">Required equipment on page 352</a> .
4 Fit the motor, with guidance from the pins, making sure the motor pinion is properly mated to the gear of gearbox, axis 6.	Make sure the pinion on the motor shaft is not damaged!
5 Remove the guide pins.	
6 Secure the motor with its four attachment screws and plain washers.	4 pcs: M8 x 25, tightening torque: 24 Nm.

*Continues on next page*

## 4 Repair

### 4.6.6 Replacement of motor, axis 6

Continued

	Action	Note
7	Disconnect the brake release voltage.	
8	Reconnect all connectors beneath the motor cover.	
9	Refit the cover on top of the motor with its five attachment screws.	Make sure the cover is tightly sealed!
10	Recalibrate the robot.	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> . General calibration information is included in section <a href="#">Calibration on page 393</a> .
11	 <b>DANGER</b>  Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

### Replacement of the motor axis 6 (Foundry Plus)

Robots with protection type Foundry Plus require special repair routines to maintain the tightness level.

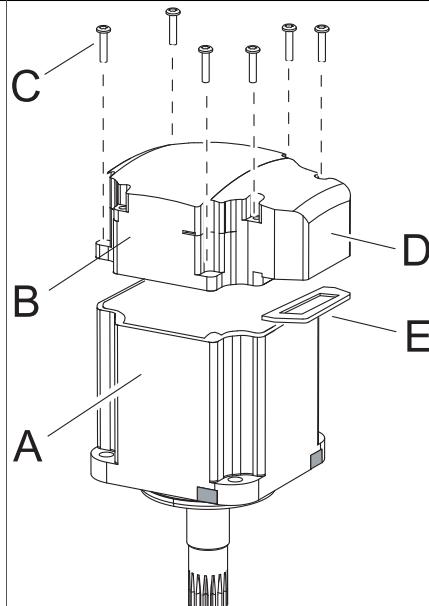
The repair must be done according to the previous repair procedure with the following additions.

	Action	Note
1	Move the robot to a position where the motor in axis 6 is pointed straight up. This position enables the motor to be replaced without draining the gear oil, which in turn saves time.	
2	 <b>DANGER</b>  Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	

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#### 4.6.6 Replacement of motor, axis 6

*Continued*

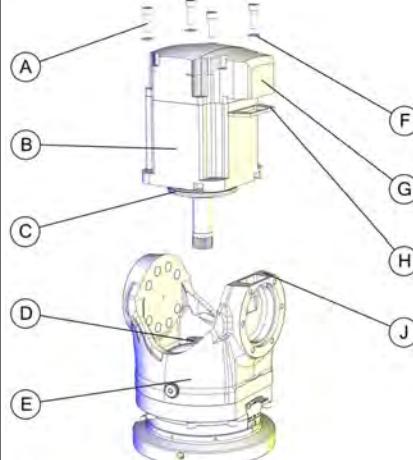
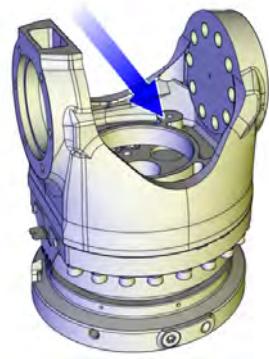
Action	Note
3 Remove the rear motor cover by unscrewing the five attachment screws.	 <p>xx1500002524</p> <ul style="list-style-type: none"> <li>• A: Motor unit</li> <li>• B: Connection box</li> <li>• C: Attachment screw (5 pcs)</li> <li>• D: Rear motor cover</li> <li>• E: Gasket</li> </ul>
4 Continue to remove the motor unit, according to step 6 and forwards in <i>Removal, motor on page 354</i> .	
5  Note Keep the old <i>rear motor cover</i> with the air nipple.	

*Continues on next page*

## 4 Repair

### 4.6.6 Replacement of motor, axis 6

*Continued*

Action	Note
6 Remove the protection strip on the <i>gasket</i> and mount it on the <i>motor</i> .	 <p>xx1500002425</p> <ul style="list-style-type: none"> <li>A: Attachment screw (4pcs) Mercasol 3106</li> <li>B: Motor unit</li> <li>C: O-ring</li> <li>D: Sikaflex in screw recesses</li> <li>E: Tilt house</li> <li>F: Washer</li> <li>G: Rear motor cover</li> <li>H: Sealing</li> <li>J: Loctite 574</li> </ul>
7 Apply Mercasol 3106 on the <i>motor end cover</i> .	
8 Apply Loctite 574 flange sealant on the contact surface.	 <p>xx1400000992</p>
9 Apply grease on the <i>o-ring</i> on the <i>motor</i> .	
10 Continue to refit the new motor according to section, <i>Refitting, motor</i> on page 355.	

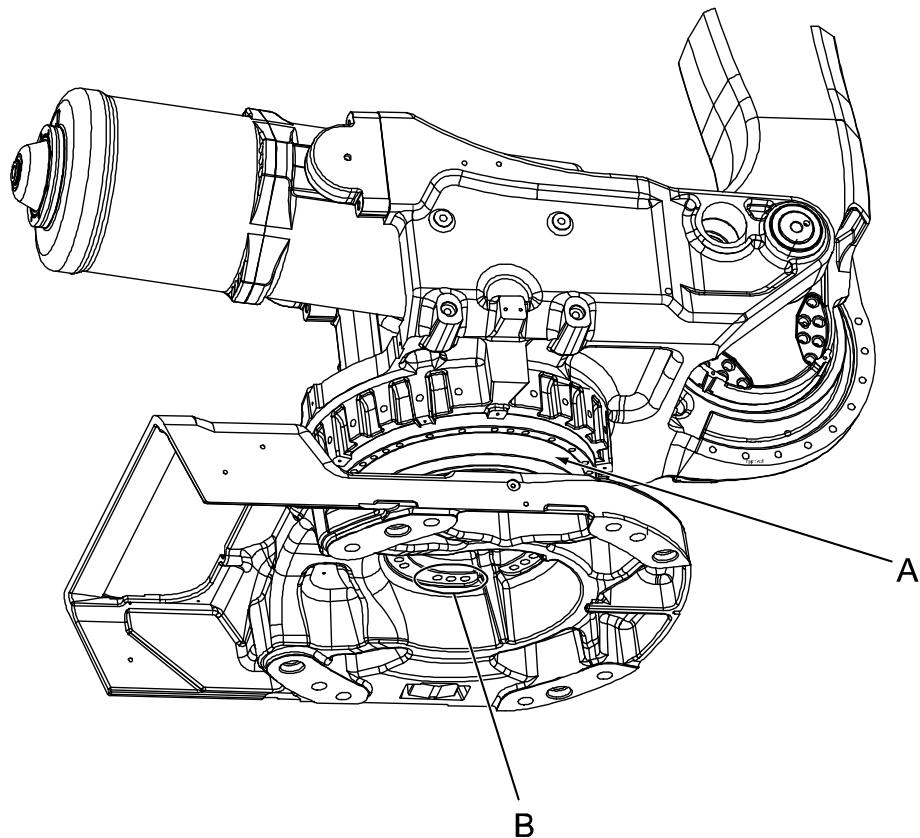
## 4.7.1 Replacing the axis 1 gearbox

## 4.7 Gearboxes

## 4.7.1 Replacing the axis 1 gearbox

## Location of gearbox

The axis 1 gearbox is located between the frame and base as shown in the figure.



xx0300000538

A	Gearbox, axis 1
B	Attachment screws, gearbox axis 1 (18 pcs)

## Required equipment

Equipment, etc.		Art. no.	Note
Gearbox		For spare part no. see: • <i>Spare part lists on page 425.</i>	Includes: • gearbox • all o-rings and sealing rings
O-ring		3HAB3772-54	Replace if damaged!
O-ring		3HAB3772-55	Replace if damaged!
Sealing ring		3HAC11581-4	Replace if damaged!
Grease		3HAB3537-1	For lubricating the o-rings.

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## 4 Repair

### 4.7.1 Replacing the axis 1 gearbox

*Continued*

Equipment, etc.		Art. no.	Note
Support, base and gear 1		3HAC15535-1	
Lifting accessory, base		3HAC15560-1	
Lifting accessory (chain)		3HAC15556-1	
Guide pins			2 pcs, M16x150. Used for guiding the gearbox into place in the base. Always use guide pins in pairs!
Calibration Pendulum toolkit		3HAC15716-1	Complete kit that also includes operating manual. Required if Calibration Pendulum is the valid calibration method for the robot.
Calibration tool box, Axis Calibration		3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.
Standard toolkit		-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

#### Deciding calibration routine

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

	Action	Note
1	Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"><li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li><li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li></ul>	

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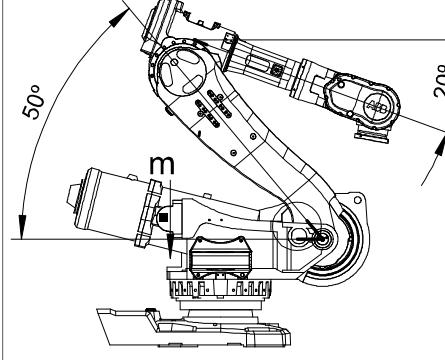
#### 4.7.1 Replacing the axis 1 gearbox

*Continued*

Action	Note
<p><b>If the robot is to be calibrated with reference calibration:</b>            Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot.</p> <p>If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.</p>	<p>Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values.            Creating new values requires possibility to move the robot.            Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a>.            Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a>.</p>
<p><b>If the robot is to be calibrated with fine calibration:</b>            Remove all external cable packages (DressPack) and tools from the robot.</p>	

#### Removal, gearbox axis 1

Use this procedure to remove gearbox, axis 1.

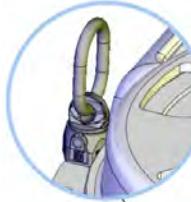
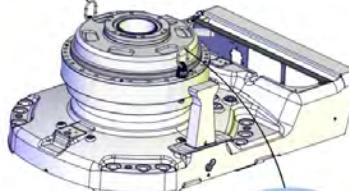
Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2 Move the robot to its most stable position, shown in the figure to the right.	 xx0300000632
3 <p> <b>DANGER</b></p> <p>Turn off all:</p> <ul style="list-style-type: none"> <li>• electric power supply</li> <li>• hydraulic pressure supply</li> <li>• air pressure supply</li> </ul> <p>to the robot, before entering the robot working area.</p>	
4 Drain the axis 1 gearbox.	See <a href="#">Changing oil, axis-1 gearbox on page 180</a> .
5 Remove the complete arm system.	Detailed in section <a href="#">Removal, arm system on page 253</a> .
6 Unfasten the robot base from the foundation by removing the base attachment screws.	

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## 4 Repair

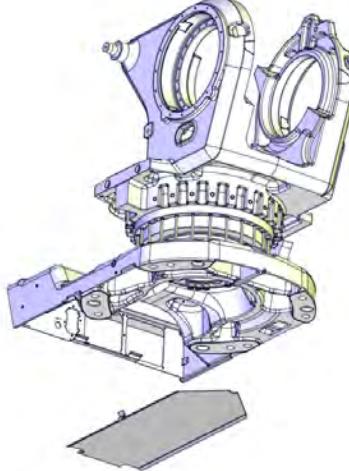
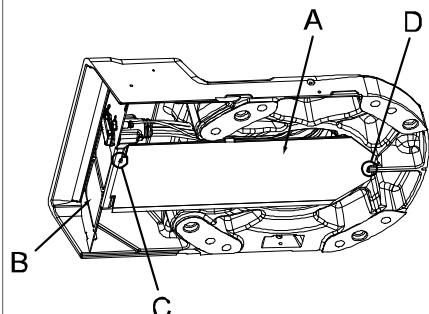
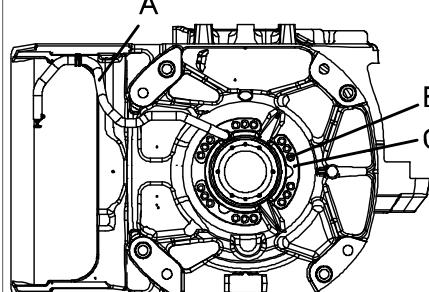
### 4.7.1 Replacing the axis 1 gearbox

*Continued*

Action	Note
7 Attach the <i>lifting accessory, base and gear 1</i> and the <i>lifting tool (chain)</i> to the gearbox and base.	  xx1000001395 Specified in <a href="#">Required equipment on page 359</a> .
8  <b>CAUTION</b> The base and axis 1 gearbox weighs 300 kg + 200 Kg. All lifting accessories used must be sized accordingly!	
9 Lift the robot base including the axis 1 gearbox to allow the <i>base and gear 1 support</i> be fitted on each sides of the base.	Art. no. is specified in <a href="#">Required equipment on page 359</a> .
10 Secure the support to the base and to the foundation. Make sure the base remains in a stable position before performing any work underneath the base!	 xx1000000364 A Support base (4 pcs)

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**4.7.1 Replacing the axis 1 gearbox**  
*Continued*

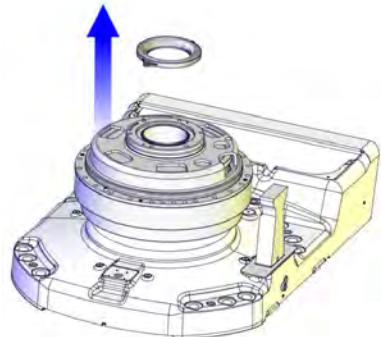
Action	Note
<p><b>11</b> Remove the bottom plate from underneath the base in order to get access to the attachment screws.  It may be necessary to also remove the rear connector plate.</p>	 xx1000001385  xx0300000612 <ul style="list-style-type: none"> <li>A Bottom plate</li> <li>B Rear connector plate</li> <li>C Attachment screw</li> <li>D Groove</li> </ul>
<p><b>12</b> Unscrew the attachment screws and remove the washers.</p>	 xx0200000227 <p><b>A view from below:</b></p> <ul style="list-style-type: none"> <li>• A: Oil drain hose</li> <li>• B: Attachment screws, gearbox axis 1, 18 pcs</li> <li>• C: Washers, 3 pcs</li> </ul>

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## 4 Repair

### 4.7.1 Replacing the axis 1 gearbox

*Continued*

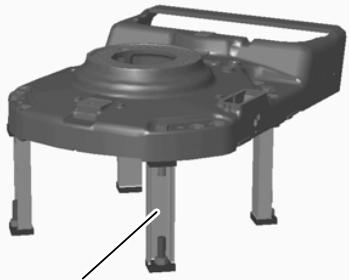
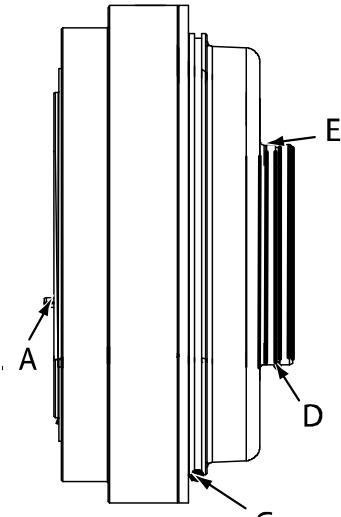
Action	Note
13 Remove the cable guide in the center of gearbox 1 by unscrewing its attachment screws.	 xx1000001387
14 <b>CAUTION</b> The gearbox weighs 200 Kg. All lifting accessories used must be sized accordingly!	
15 Lift the gearbox away with the already mounted lifting tools.	
16 Turn the gearbox, and remove the protection pipe by unscrewing two attachment screws.  <b>Note</b> Move the protective pipe over to the new gearbox.	 xx1400000786

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4.7.1 Replacing the axis 1 gearbox  
Continued

**Refitting, gearbox axis 1**

Use this procedure to refit gearbox, axis 1.

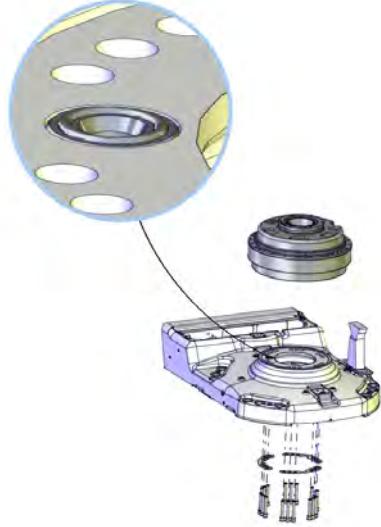
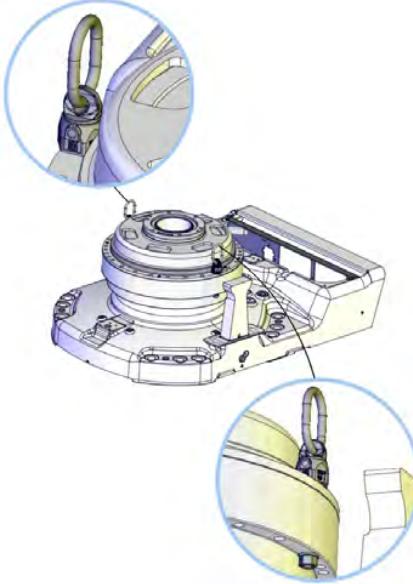
	Action	Note
1	Fit the <i>support, base and gear 1</i> to the base.  Mounting of the support, base and gear 1 is detailed in section <a href="#">Removal, gearbox axis 1 on page 361</a> .	 xx1000000364 A Support base (4 pcs)
2	Make sure the two <i>o-rings</i> on the circumference of the gearbox are seated properly in their respective groove. Lubricate them with <i>grease</i> .	Art no. is specified in <a href="#">Required equipment on page 359</a> .  xx0200000055 <ul style="list-style-type: none"> <li>• A: Guide pin</li> <li>• C: O-ring 3HAB 3772-54</li> <li>• D: O-ring 3HAB 3772-55</li> <li>• E: Sealing ring 3HAC 11581-4</li> </ul>

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## 4 Repair

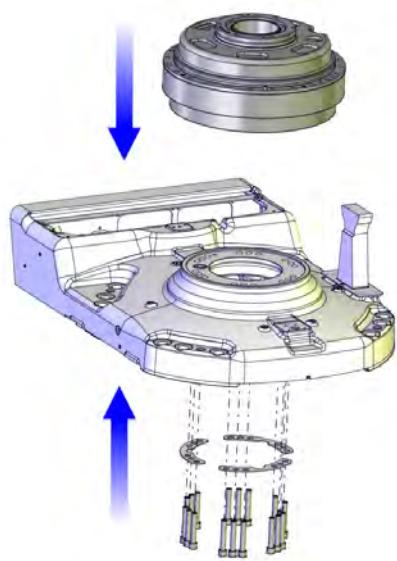
### 4.7.1 Replacing the axis 1 gearbox

*Continued*

Action	Note
3 Make sure the small o-ring around the oil hole is fitted properly!	 xx1000001392
4 Attach the <i>lifting accessory, base and gear 1</i> and the <i>lifting tool (chain)</i> to the gearbox.	Specified in <a href="#">Required equipment on page 359</a> .  xx1000001395
5 Fit two <i>guide pins</i> in two of the attachment holes in the gearbox, parallel to each other.	Specified in <a href="#">Required equipment on page 359</a> .
6  <b>CAUTION</b> The gearbox weighs 200 Kg. All lifting accessories used must be sized accordingly!	

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**4.7.1 Replacing the axis 1 gearbox**  
*Continued*

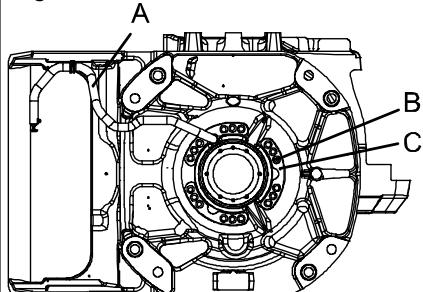
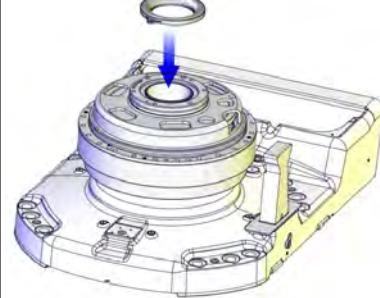
	Action	Note
7	<p>Lift the gearbox.            Make sure the guide pin in the bottom face of the gearbox is properly aligned with the base.</p>	 xx1000001389
8	<p>Lift gearbox axis 1 onto the guide pins and lower it carefully to its mounting position.</p>	Always use guide pins in pairs!

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## 4 Repair

### 4.7.1 Replacing the axis 1 gearbox

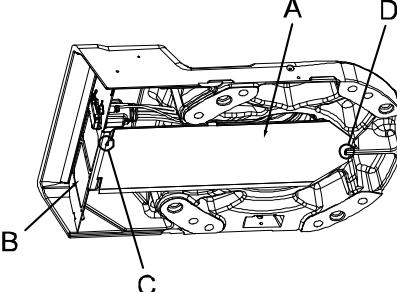
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	Action	Note
9	<p>Secure the gearbox with its <i>attachment screws</i> and washers.</p>	<p>18 pcs, M16 x 90, 12.9 quality UN-BRAKO. Tightening torque: 300 Nm Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.</p>  <p>xx0200000227</p> <p><b>A view from below:</b></p> <ul style="list-style-type: none"> <li>• A: Oil drain hose</li> <li>• B: Attachment screws, gearbox axis 1, 18 pcs</li> <li>• C: Washers, 3 pcs</li> </ul>
10	<p>Refit the cable guide in the center of gearbox 1 with its attachment screws.</p>	 <p>xx1000001393</p>

*Continues on next page*

#### 4.7.1 Replacing the axis 1 gearbox

*Continued*

Action	Note
<p>11 Refit the bottom plate underneath the robot base by pushing it into the groove and fitting the attachment screw. If removed, also refit the rear connector plate.</p> <p> <b>Note</b> Direct the bends on the bottom plate downwards!</p>	<p>1 screw: M6 x 8.</p>  <p>xx0300000612</p> <ul style="list-style-type: none"> <li>• A: Bottom plate</li> <li>• B: Rear connector plate</li> <li>• C: Attachment screw</li> <li>• D: Groove</li> </ul>
<p>12  <b>CAUTION</b> The base and axis 1 gearbox weighs 300 kg + 200 Kg. All lifting accessories used must be sized accordingly!</p>	
13 Lift the robot base and gearbox 1 and remove the base and gear support.	
14 Secure the base to the mounting site.	See <a href="#">Orienting and securing the robot on page 86</a> .
15 Refit the complete arm system.   <b>CAUTION</b> This is a complex task to be performed with utmost care in order to avoid injury or damage!	Detailed in section <a href="#">Refitting, arm system on page 255</a> .
16 Perform a leak-down test.	See section <a href="#">Performing a leak-down test on page 218</a> .
17 Refill the gearbox with oil.	See <a href="#">Changing oil, axis-1 gearbox on page 180</a> .
18 Recalibrate the robot.	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <i>Calibrating with Axis Calibration method on page 406</i> . General calibration information is included in section <a href="#">Calibration on page 393</a> .

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## 4 Repair

### 4.7.1 Replacing the axis 1 gearbox

*Continued*

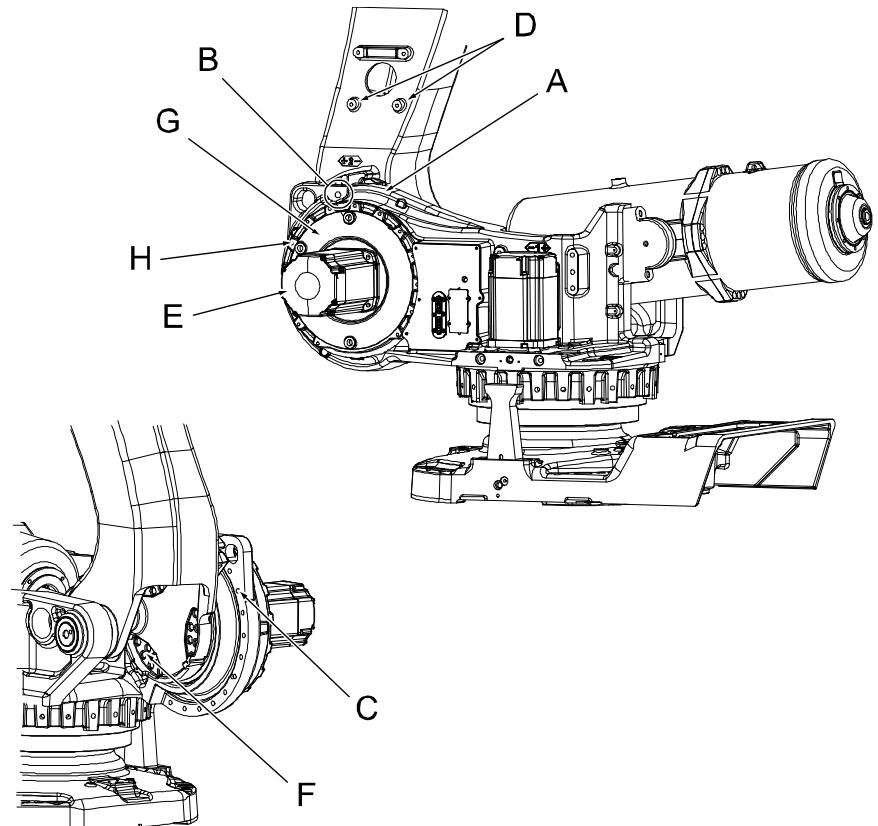
	Action	Note
19	 <b>DANGER</b>  Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <i>DANGER - First test run may cause injury or damage! on page 50.</i>	

## 4.7.2 Replacement of gearbox axis 2

### Location of gearbox

The gearbox for axis 2 is located in the lower arm rotational center, underneath the cover.

A more detailed view of the component and its position may be found in [Spare part lists on page 425](#).



xx0300000546

A	Gearbox, axis 2 (inside the frame)
B	Attachment hole for the locking screw, lower arm
C	Attachment holes inside of frame for the fixture, lower arm
D	Attachment holes for the fixture, lower arm
E	Motor, axis 2
F	Rear attachment screws, gearbox
G	Cover, axis 2
H	Attachment screws, cover

*Continues on next page*

## 4 Repair

### 4.7.2 Replacement of gearbox axis 2

*Continued*

#### Required equipment

Equipment	Art. no.	Note
Gearbox axis 2	For spare part number, see <a href="#">Spare part lists on page 425</a> .	Includes <ul style="list-style-type: none"><li>• gearbox</li><li>• o-ring.</li></ul> Does not include "Sealing, axis 2/3"!
O-ring	3HAB3772-77	O-ring in gearbox, 1 pc.
O-ring	3HAB3772-73	O-ring in the cover, axis 2, 1 pc. Should be replaced if damaged!
Sealing, axis 2	3HAC020123-001	A new sealing must be used on each assembly!
Grease	3HAB3537-1	For lubricating o-rings.
Fixture lower arm	3HAC020729-001	
Lifting tool, gearbox axis 2	3HAC020386-001	
Guide pins M12 x 150	3HAC13056-2	For guiding the gearbox.
Guide pins M12 x 200	3HAC13056-3	For guiding the gearbox.
Press tool, balancing device	3HAC020902-001	
Hydraulic cylinder	3HAC11731-1	To be used with the press tool and the hydraulic pump, when unloading the balancing device.
Hydraulic pump, 80 MPa	3HAC13086-1	To be used with the press tool and the hydraulic cylinder, when unloading the balancing device.
Guide pins, sealing ax 2/3, 80mm	3HAC14628-1	For guiding the sealing!
Guide pins, sealing ax 2/3, 100mm	3HAC14628-2	For guiding the sealing!
Gearbox crank, axis 2	3HAC020999-001	Used to turn the gear in correct position.
Standard toolkit	-	The contents are defined in section <a href="#">Standard tools on page 435</a> in part 2 of the Product manual.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

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**Deciding calibration routine**

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

Action	Note
1 Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"> <li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li> <li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li> </ul>	
If the robot is to be calibrated with reference calibration: Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot. If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.	Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a> . Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a> .
If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

**Removal, gearbox axis 2**

The procedure below details how to remove the gearbox, axis 2.

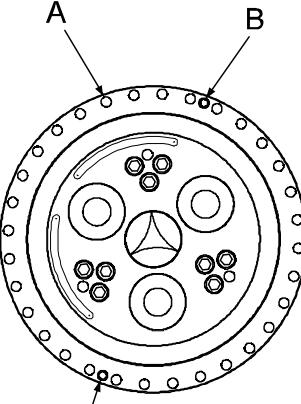
Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
3 Secure the lower arm with the special fixture equipment according to section <a href="#">Securing the lower arm on page 295</a> .	
4 Unload the balancing device shaft by using the press tool, balancing device, according to section <a href="#">Unloading the balancing device using hydraulic press tool on page 316!</a>	Art. no. is specified in <a href="#">Required equipment on page 372!</a>

*Continues on next page*

## 4 Repair

### 4.7.2 Replacement of gearbox axis 2

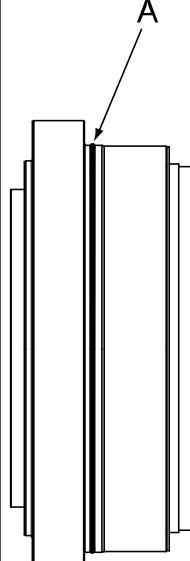
*Continued*

Action	Note
5 Drain the gearbox, axis 2.	Notice! Time-consuming activity! Detailed in section <a href="#">Changing oil, axis-2 gearbox on page 183</a> .
6 Remove the motor, axis 2.	Detailed in section <a href="#">Removal, motor on page 330</a> .
7 Remove the <i>rear attachment screws</i> , gearbox from inside of the lower arm.	Shown in the figure <a href="#">Location of gearbox on page 371</a> !
8 Remove the <i>cover, axis 2</i> by unscrewing its 14 attachment screws.	Shown in the figure <a href="#">Location of gearbox on page 371</a> !
9 Remove the front attachment screws, gearbox, shown in the figure to the right.	 xx0300000550 <ul style="list-style-type: none"> <li>• A: Front attachment screws, gearbox (32 pcs)</li> <li>• B: M12 holes for pressing the gearbox out</li> </ul>
10 Fit two <i>guide pins</i> in 180° relation to each other in the empty holes of the front gearbox attachment screws.	Art. no. is specified in <a href="#">Required equipment on page 372</a> !
11 If required, apply two M12 screws to the holes, shown in the figure above, to press it free.	
12 Fit the <i>lifting tool, gearbox axis 2</i> to the gearbox.	Art. no. is specified in <a href="#">Required equipment on page 372</a> !
13  <b>CAUTION</b> The gearbox weighs 100 kg! All lifting equipment used must be sized accordingly!	
14 Remove the gearbox axis 2 using an overhead crane or similar, with guidance from the mounted guide pins.	
15 Remove the sealing from the lower arm.	

*Continues on next page*

**Refitting, gearbox axis 2**

The procedure below details how to refit the gearbox axis 2.

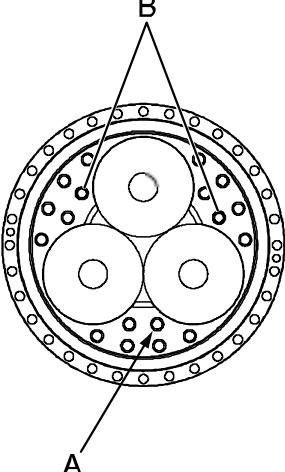
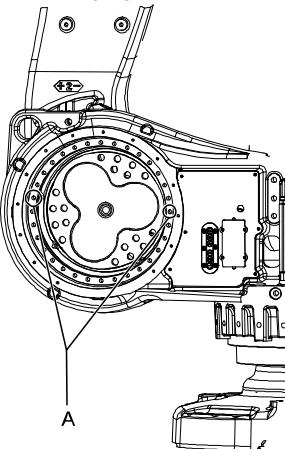
	Action	Note
1	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
2	Make sure the o-ring is fitted to the gearbox as shown in the figure to the right. Lightly lubricate it with <i>grease</i> .	Art. no. is specified in <a href="#">Required equipment on page 372!</a>  xx0300000551 • A: O-ring, gearbox axis 2
3	Fit the <i>lifting tool, gearbox axis 2</i> to the gearbox.	Art. no. is specified in <a href="#">Required equipment on page 372!</a>
4	Fit the new <i>sealing, axis 2/3</i> to the gearbox.	Art. no. is specified in <a href="#">Required equipment on page 372!</a>

*Continues on next page*

## 4 Repair

### 4.7.2 Replacement of gearbox axis 2

*Continued*

	Action	Note
5	<p>Fit the <i>guide pins, sealing axis 2/3</i> to the rear of the gearbox, axis 2 to hold the sealing in place.</p> <p>Use the attachment holes shown in the figure to the right!</p> <p> <b>Note</b></p> <p>Do not remove the guide pins for the sealing until the rear attachment screws are secured.</p>	 <p>xx0300000552</p> <ul style="list-style-type: none"> <li>A: Rear attachment screws, gearbox (18 pcs)</li> <li>B: Holes for the guide pins, sealing axis 2/3 on the gearbox</li> </ul>
6	<p>Fit two <i>guide pins, M12</i> in 180° relation to each other in the frame, in the screw holes for the gearboxes front attachment screws.</p>	<p>Art. no. is specified in <a href="#">Required equipment on page 372</a>!</p>  <p>xx0300000554</p> <ul style="list-style-type: none"> <li>A: Attachments in the frame for the two guiding pins</li> </ul>
7	<p> <b>CAUTION</b></p> <p>The gearbox weighs 100 kg! All lifting equipment used must be sized accordingly!</p>	
8	<p>Lift the gearbox to its mounting position and slide it onto the guiding pins attached in the frame, through the front attachment screw holes.</p>	

*Continues on next page*

## 4.7.2 Replacement of gearbox axis 2

Continued

	Action	Note
9	Align the gearbox attachment screw holes to the hole patterns in the lower arm, with help from the guide pins, sealing axis 2/3. If necessary, use a <i>gearbox crank</i> to turn the gear! Use the gearbox crank with caution! The gearbox may be damaged if the crank is inserted too far into the gear!	Art. no. is specified in <a href="#">Required equipment on page 372</a> !
10	Fit the gearbox with guidance from the guide pins and slide it into position. If necessary, use the front gearbox attachment screws to press the gearbox into place.	
11	Remove the lifting tool from the gearbox.	
12	Insert and secure 30 of the 32 <i>front attachment screws, gearbox</i> . Remove the guide pins, M12 and refit the two remaining screws.	32 pcs: M12 x 60, tightening torque: 115 Nm.
13	Lubricate the <i>o-ring</i> at the sealing surface of the cover, axis 2. Replace it if damaged.	Art. no. is specified in <a href="#">Required equipment on page 372</a> .
14	Refit the <i>cover, axis 2</i> to the frame with the <i>attachment screws, cover</i> .	Shown in the figure <a href="#">Location of gearbox on page 371</a> .
15	Insert and secure 16 of the 18 <i>rear attachment screws, gearbox</i> on the inside of the lower arm.	Shown in the figure <a href="#">Location of gearbox on page 371</a> ! 18 pcs: M16 x 50, tightening torque: 300 Nm. Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.
16	Remove the guide pins, sealing axis 2/3, and tighten the two remaining screws as detailed above.	
17	Refit the motor.	Detailed in section <a href="#">Refitting, motor on page 331</a> .
18	Perform a leak-down test.	Detailed in section <a href="#">Performing a leak-down test on page 218</a> .
19	Refill the gearbox with oil.	Detailed in section <a href="#">Changing oil, axis-2 gearbox on page 183</a> .
20	Restore the balancing device.	This is detailed in section <a href="#">Restoring the balancing device using a hydraulic press tool on page 320</a> .
21	Remove the fixture, lower arm.	
22	Remove the locking screw, lower arm, and re-attach it to the fixture tool.	
23	Refit any mechanical stops if such were removed during disassembly.	
24	Refit any equipment to the turning disk if such was removed during disassembly.	

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## 4 Repair

### 4.7.2 Replacement of gearbox axis 2

*Continued*

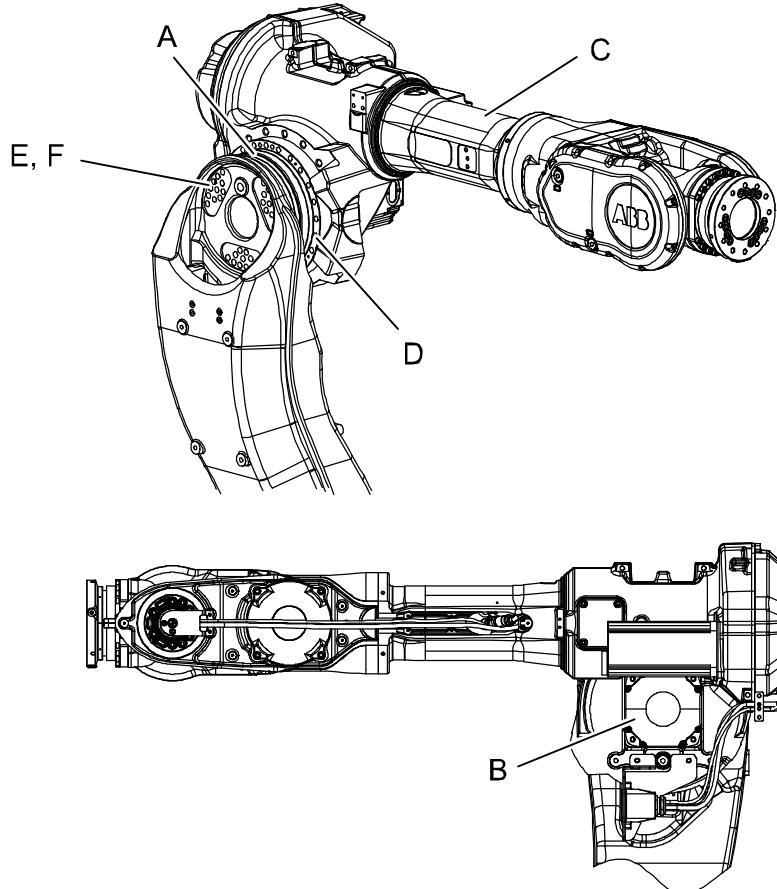
	Action	Note
25	Recalibrate the robot.	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> . General calibration information is included in section <a href="#">Calibration on page 393</a> .
26	 <b>DANGER</b>  Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

### 4.7.3 Replacement of gearbox, axis 3

#### Location of gearbox

The axis 3 gearbox is located in the upper arm rotational center as shown in the figure below.

A more detailed view of the component and its position may be found in chapter *Exploded views in Product manual, spare parts - IRB 7600*.



xx0200000194

A	Gearbox, axis 3
B	Motor, axis 3
C	Upper arm
D	Attachment screws, M12x60 quality Gleitmo (24 pcs)

#### Required equipment

Equipment, etc.		Art. no.	Note
Gearbox		For spare part number, see <a href="#">Spare part lists on page 425</a> .	Includes <ul style="list-style-type: none"> <li>• gearbox</li> <li>• o-ring.</li> </ul> Does not include the sealing, axis 2/3!

*Continues on next page*

## 4 Repair

### 4.7.3 Replacement of gearbox, axis 3

*Continued*

Equipment, etc.		Art. no.	Note
O-ring		3HAB3772-68	1 pc on the gearbox. Replace if damaged.
Grease		3HAB3537-1	For lubricating the o-rings.
Sealing, axis 3		3HAC17212-1	A new sealing must be used on each assembly!
Mechanical stop axis 3		3HAC12708-1	Used to secure the upper arm. Use attachment screws 3HAB3409-86 (M16 x 60).
Washers (for mechanical stop axis 3)		3HAA1001-186	
Bolt, M16x60 (for mechanical stop axis 3)		3HAB3409-86	
Lifting accessory RV2		3HAC13698-1	For lifting the gearbox.
Lifting eye M12		3HAC14457-3	
Guide pins M12 x 200		3HAC13056-3	For guiding the gearbox. Use guides in pairs!
Guide pins M12 x 250		3HAC13056-4	For guiding the gearbox. Use guides in pairs!
Guide pins, sealing ax 2/3, 80mm		3HAC14628-1	For guiding the axis-3 sealing. Use guides in pairs!
Guide pins, sealing ax 2/3, 100mm		3HAC14628-2	For guiding the axis-3 sealing. Use guides in pairs!
Standard toolkit	-		Content is defined in section <a href="#">Standard tools on page 435</a> .
Calibration Pendulum toolkit		3HAC15716-1	Complete kit that also includes operating manual. Required if Calibration Pendulum is the valid calibration method for the robot.
Calibration tool box, Axis Calibration		3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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**Deciding calibration routine**

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

	Action	Note
1	<p>Decide which calibration routine to use for calibrating the robot.</p> <ul style="list-style-type: none"> <li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li> <li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li> </ul>	
	<p><b>If the robot is to be calibrated with reference calibration:</b> Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot. If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.</p>	Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a> . Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a> .
	<p><b>If the robot is to be calibrated with fine calibration:</b> Remove all external cable packages (DressPack) and tools from the robot.</p>	

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**Removal, gearbox axis 3**

The procedure below details how to remove gearbox, axis 3.

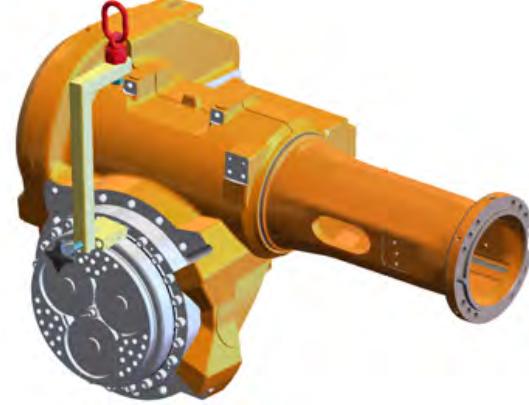
	Action	Note
1	Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2	 <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
3	Secure the upper arm in a horizontal position using round slings.	Art. no. is specified in <a href="#">Required equipment on page 379</a> .

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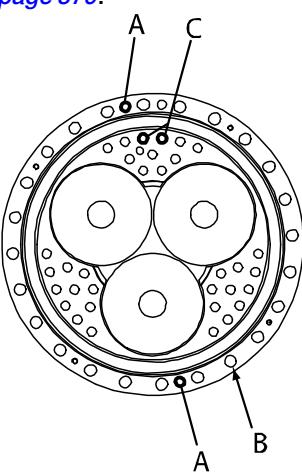
## 4 Repair

### 4.7.3 Replacement of gearbox, axis 3

Continued

	Action	Note
4	Remove the <i>motor, axis 3.</i>	Detailed in section <a href="#">Removal, motor on page 336.</a>   Note When removing the motor axis 3, the brake on axis 3 is released. Make sure the upper arm is secured and disabled to move!
5	Remove the <i>upper arm.</i>	Detailed in section <a href="#">Removal, upper arm on page 271.</a>
6	Remove the <i>sealing, axis 2/3</i> between the gearbox and lower arm.	On reassembly a new sealing must be used! Art. no. is specified in <a href="#">Required equipment on page 379.</a>
7	Place the upper arm safely on a workbench, in a fixture or similar.	
8	Remove the <i>attachment screws, gearbox.</i>	Shown in the figure <a href="#">Location of gearbox on page 379.</a>
9	Fit the two <i>guide pins</i> in 180° relation to each other in the gearbox attachment screw holes.	Art. no. is specified in <a href="#">Required equipment on page 379.</a>
10	Fit the Lifting accessory RV2 according to figure.	

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Action	Note
11 If required, use screws in the holes (A) shown in the figure to the right to press the gearbox free.	<p>Art. no. is specified in <a href="#">Required equipment on page 379</a>.</p>  <p>xx0200000201</p> <ul style="list-style-type: none"> <li>• A: M12 holes for pressing the gearbox out</li> <li>• B: Attachment screw holes, gearbox - upper arm</li> <li>• C: Attachment screw holes, gearbox - lower arm</li> </ul>
12  <b>CAUTION</b> The gearbox weighs 60 kg! All lifting accessories used must be sized accordingly!	
13 Remove the gearbox, with guidance from the guide pins, using an overhead crane or similar.	

### Refitting, gearbox axis 3

The procedure below details how to refit gearbox, axis 3.

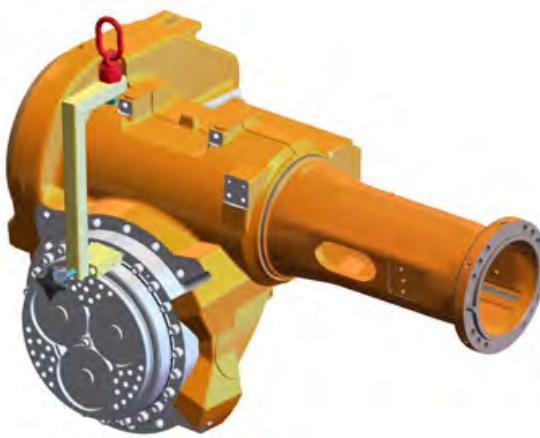
Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	
2 Turn the upper arm in such a position that the gear mating surface faces upwards.	

*Continues on next page*

## 4 Repair

### 4.7.3 Replacement of gearbox, axis 3

*Continued*

Action	Note
3 Fit two <i>guide pins</i> in 180° relation to each other in the holes in the upper arm, used for the gearbox attachment screws.	Art. no. is specified in <i>Required equipment on page 379</i> .
4  <b>CAUTION</b> The gearbox weighs 60 kg! All lifting accessories used must be sized accordingly!	
5 Fit the lifting accessory RV2 according to figure.	 xx0900000113
6 Make sure the <i>o-rings</i> are fitted to the gearbox. Apply <i>grease</i> to the <i>o-rings</i> to make sure they stick in their grooves during assembly. Replace if damaged!	Art. no. is specified in <i>Required equipment on page 379</i> .  xx0200000173 <ul style="list-style-type: none"> <li>• A: O-ring, gearbox axis 3</li> </ul>
7 Lift the gearbox to its mounting position.	

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	Action	Note
8	Turn the gearbox to align the attachment screw holes with those in the upper arm.	
9	Fit the gearbox onto the guide pins and slide it into position.	Make sure the o-rings are seated properly and the gearbox correctly oriented!
10	Remove the lifting tool.	
11	Secure the gearbox with 22 of the 24 gearbox attachment screws. Remove the guide pins and tighten the remaining two screws.	24 pcs: M12 x 60. Tightening torque: 115 Nm. Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.
12	Refit the upper arm with a new sealing, axis 2/3 .	Art. no. is specified in <a href="#">Required equipment on page 379</a> . Detailed in section <a href="#">Refitting, upper arm on page 273</a> .
13	Refit the motor.	Detailed in section <a href="#">Refitting, motor on page 338</a> .
14	Recalibrate the robot!	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> . General calibration information is included in section <a href="#">Calibration on page 393</a> .
15	 <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

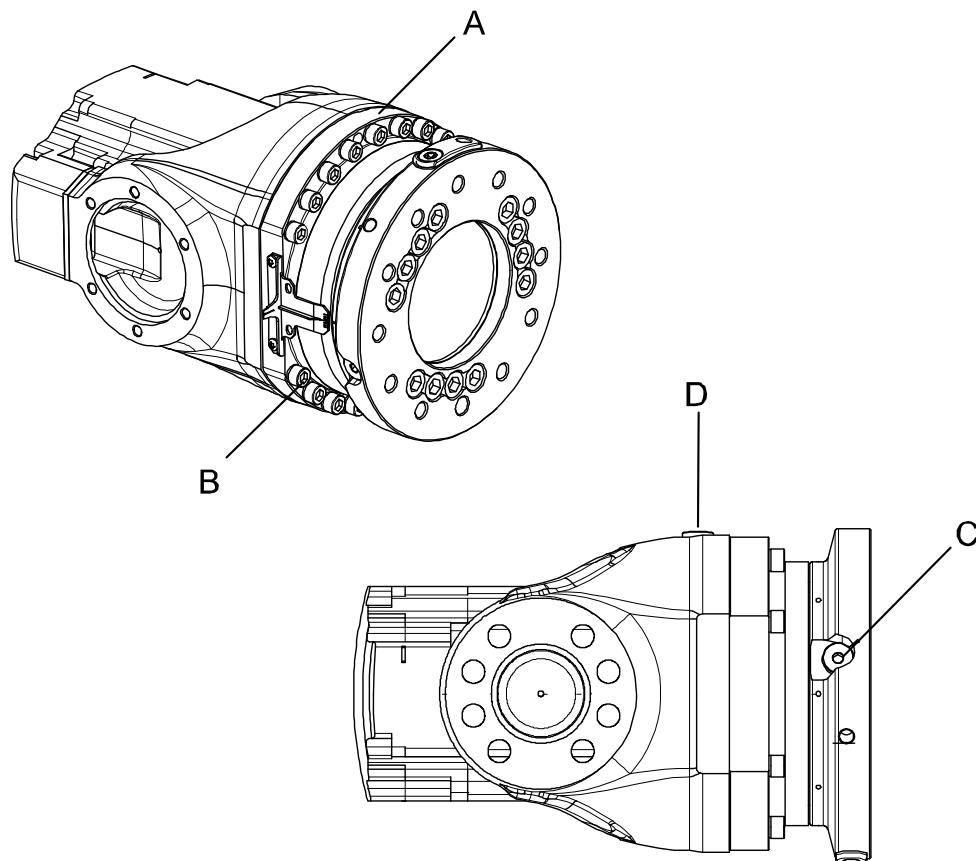
## 4 Repair

### 4.7.4 Replacement of gearbox, axis 6

#### 4.7.4 Replacement of gearbox, axis 6

##### Location of gearbox

The axis 6 gearbox is located in the center of the wrist unit as shown in the figure below.



xx0200000219

A	Gearbox, axis 6
B	Attachment screws and washers, gearbox (18 pcs)
C	Oil plug, draining
D	Oil plug, filling
-	O-ring (not shown in figure)

##### Required equipment

Equipment, etc.		Art. no.	Note
Gearbox		For spare part number, see <a href="#">Spare part lists on page 425</a> .	Includes o-ring.
Washers		3HAA1001-172	Not included in gearbox! Replace only when damaged!

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## 4.7.4 Replacement of gearbox, axis 6

*Continued*

Equipment, etc.		Art. no.	Note
O-ring		3HAB3772-58	Must be replaced when reassembling gearbox!
O-ring		3HAB3772-57	For type 2 of the gearbox. 164.7x3.53 Must be replaced when reassembling gearbox.
O-ring		3HAB3772-64	For type 2 of the gearbox. 150.0x2.0 Must be replaced when reassembling gearbox.
O-ring		3HAB3772-61	For type 2 of the gearbox. 12 pcs, 13.1x1.6 Must be replaced when reassembling gearbox.
Grease		3HAB3537-1	For lubricating the o-ring.
Flange sealant		12340011-116	Loctite 574
Standard toolkit		-	Content is defined in section <i>Standard tools on page 435</i> .
Calibration Pendulum toolkit		3HAC15716-1	Complete kit that also includes operating manual. Required if Calibration Pendulum is the valid calibration method for the robot.
Calibration tool box, Axis Calibration		3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

**Deciding calibration routine**

Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

	Action	Note
1	Decide which calibration routine to use for calibrating the robot. <ul style="list-style-type: none"> <li>• Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot.</li> <li>• Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.</li> </ul>	

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## 4 Repair

### 4.7.4 Replacement of gearbox, axis 6

Continued

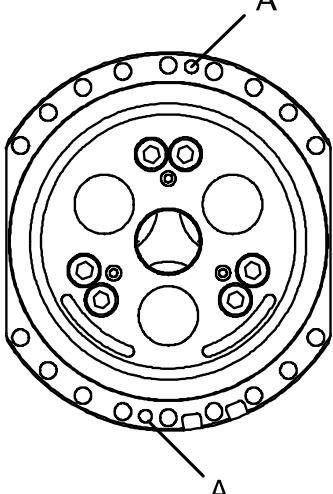
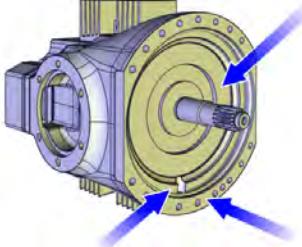
Action	Note
<p><b>If the robot is to be calibrated with reference calibration:</b> Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot. If no previous reference values exist, and no new reference values can be created, then reference calibration is not possible.</p>	<p>Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values. Creating new values requires possibility to move the robot. Read more about reference calibration for Axis Calibration in <a href="#">Reference calibration routine on page 407</a>. Read more about reference calibration for Pendulum Calibration in <a href="#">Operating manual - Calibration Pendulum</a>.</p>
<p><b>If the robot is to be calibrated with fine calibration:</b> Remove all external cable packages (DressPack) and tools from the robot.</p>	

#### Removal, gearbox

The procedure below details how to remove gearbox, axis 6.

Action	Note
1 Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"><li>• electric power supply to the robot</li><li>• hydraulic pressure supply to the robot</li><li>• air pressure supply to the robot</li></ul> Before entering the robot working area.	
3 Drain the oil from gearbox, axis 6.	Detailed in the section <a href="#">Changing oil, axis-6 gearbox on page 195</a> .
4 Remove the <i>turning disk</i> .	Detailed in the section <a href="#">Removing, turning disk on page 258</a> .
5 Remove the gearbox by unscrewing its 18 attachment screws.	Shown in the figure <a href="#">Location of gearbox on page 386</a> .

Continues on next page

Action	Note
6 If required, apply M8 screws to the holes shown in the figure beside to press the gearbox out.	 xx0200000220 <ul style="list-style-type: none"> <li>• A: M8 holes for pressing out the gearbox</li> </ul>
Foundry Plus: Remove old Loctite 574 flange sealant residues and other contamination from the contact surfaces.	 xx1400001123
7 Remove the gearbox axis 6 by lifting it out carefully.	Be careful not to damage the motor pinion!

### Refitting, gearbox

The procedure below details how to refit gearbox, axis 6.

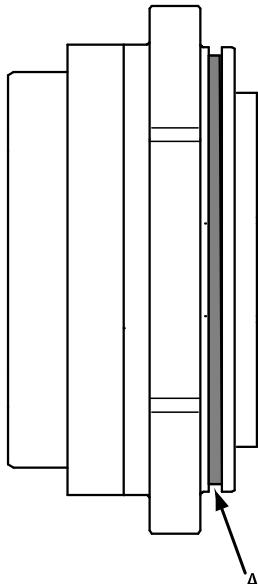
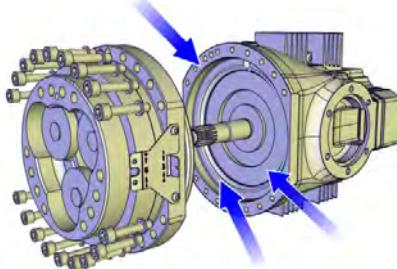
Action	Note
1  <b>DANGER</b> Turn off all: <ul style="list-style-type: none"> <li>• electric power supply to the robot</li> <li>• hydraulic pressure supply to the robot</li> <li>• air pressure supply to the robot</li> </ul> Before entering the robot working area.	

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## 4 Repair

### 4.7.4 Replacement of gearbox, axis 6

*Continued*

Action	Note
2 Make sure the <i>o-ring</i> is fitted to the rear of the gearbox. Lubricate the <i>o-ring</i> with <i>grease</i> .	Art. no. is specified in <a href="#">Required equipment on page 386</a> .   xx0200000221 • A: O-ring, gearbox axis 6
3 Release the holding brake of motor axis 6.	Detailed in the section <a href="#">Manually releasing the brakes on page 78</a> .
4 <b>Foundry Plus:</b> Apply Loctite 574 flange sealant on the contact surface.	 xx1400001122
5 Insert the <i>gearbox, axis 6</i> into the wrist unit.	Art. no. is specified in <a href="#">Required equipment on page 386</a> . Shown in the figure <a href="#">Location of gearbox on page 386</a> . Make sure the gears of the gearbox mate with the gears of the motor!
6 Secure the gearbox with the <i>attachment screws and washers</i> .	Shown in the figure <a href="#">Location of gearbox on page 386</a> . 8 pcs or 18 pcs (depending on wrist version): M8 x 40, 12.9 quality Gleitmo, Tightening torque: 30 Nm. Reused screws may be used, providing they are lubricated as detailed in section <a href="#">Screw joints on page 431</a> before fitting.
7 Refit the <i>turning disk</i> .	Detailed in the section <a href="#">Refitting, turning disk on page 259</a> .

*Continues on next page*

## 4.7.4 Replacement of gearbox, axis 6

Continued

	Action	Note
8	Perform a <i>leak-down test</i> .	Detailed in the section <a href="#">Performing a leak-down test on page 218</a> .
9	Refill the gearbox with oil.	Detailed in the section <a href="#">Changing oil, axis-6 gearbox on page 195</a> .
10	Recalibrate the robot.	Pendulum Calibration is described in <i>Operating manual - Calibration Pendulum</i> , enclosed with the calibration tools. Axis Calibration is described in <a href="#">Calibrating with Axis Calibration method on page 406</a> . General calibration information is included in section <a href="#">Calibration on page 393</a> .
11	 <b>DANGER</b> Make sure all safety requirements are met when performing the first test run. These are further detailed in the section <a href="#">DANGER - First test run may cause injury or damage! on page 50</a> .	

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# 5 Calibration

## 5.1 Introduction to calibration

### 5.1.1 Introduction and calibration terminology

#### Calibration information

This chapter includes general information about the recommended calibration methods and also the detailed procedures for updating the revolution counters, checking the calibration position etc.

Detailed instructions of how to perform Axis Calibration are given on the FlexPendant during the calibration procedure. To prepare calibration with Axis Calibration method, see [Calibrating with Axis Calibration method on page 406](#).

Detailed instructions of how to perform Pendulum Calibration are given in the documentation enclosed with the calibration tools.

#### Calibration terminology

Term	Definition
Calibration method	A collective term for several methods that might be available for calibrating the ABB robot. Each method contains calibration routines.
Synchronization position	Known position of the complete robot where the angle of each axis can be checked against visual synchronization marks.
Calibration position	Known position of the complete robot that is used for calibration of the robot.
Standard calibration	A generic term for all calibration methods that aim to move the robot to calibration position.
Fine calibration	A calibration routine that generates a new zero position of the robot.
Reference calibration	A calibration routine that generates a new zero position of the robot. This routine is more flexible compared to fine calibration and is used when tools and process equipment are installed. Requires that a reference is created before being used for recalibrating the robot.
Update revolution counter	A calibration routine to make a rough calibration of each manipulator axis.
Synchronization mark	Visual marks on the robot axes. When marks are aligned, the robot is in synchronization position.

## 5 Calibration

### 5.1.2 Calibration methods

#### 5.1.2 Calibration methods

##### Overview

This section specifies the different types of calibration and the calibration methods that are supplied by ABB.

##### Types of calibration

Type of calibration	Description	Calibration method
Standard calibration	<p>The calibrated robot is positioned at calibration position.</p> <p>Standard calibration data is found on the SMB (serial measurement board) or EIB in the robot.</p> <p>For robots with RobotWare 5.04 or older, the calibration data is delivered in a file, calib.cfg, supplied with the robot at delivery. The file identifies the correct resolver/motor position corresponding to the robot home position.</p>	Axis Calibration or Calibration Pendulum <sup>i</sup> Levelmeter calibration (alternative method)
Absolute accuracy calibration (optional)	<p>Based on standard calibration, and besides positioning the robot at synchronization position, the Absolute accuracy calibration also compensates for:</p> <ul style="list-style-type: none"><li>Mechanical tolerances in the robot structure</li><li>Deflection due to load</li></ul> <p>Absolute accuracy calibration focuses on positioning accuracy in the Cartesian coordinate system for the robot.</p> <p>Absolute accuracy calibration data is found on the SMB (serial measurement board) in the robot.</p> <p>For robots with RobotWare 5.05 or older, the absolute accuracy calibration data is delivered in a file, absacc.cfg, supplied with the robot at delivery. The file replaces the calib.cfg file and identifies motor positions as well as absolute accuracy compensation parameters.</p> <p>A robot calibrated with absolute accuracy has a sticker next to the identification plate of the robot.</p> <p>To regain 100% absolute accuracy performance, the robot must be recalibrated for absolute accuracy!</p>  <p><b>ABSOLUTE ACCURACY</b></p> <p>xx0400001197</p>	CalibWare

- <sup>i</sup> The robot is calibrated by either Calibration Pendulum or Axis Calibration at factory. Always use the same calibration method as used at the factory.  
Information about valid calibration method is found on the calibration label or in the calibration menu on the FlexPendant.  
If no data is found related to standard calibration, Calibration Pendulum is used as default.

*Continues on next page*

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#### Brief description of calibration methods

##### Calibration Pendulum method

Calibration Pendulum is a standard calibration method for calibration of all ABB robots (except IRB 6400R, IRB 640, IRB 1400H, and IRB 4400S).

Two different routines are available for the Calibration Pendulum method:

- Calibration Pendulum II
- Reference calibration

The calibration equipment for Calibration Pendulum is delivered as a complete toolkit, including the *Operating manual - Calibration Pendulum*, which describes the method and the different routines further.

##### Axis Calibration method

Axis Calibration is a standard calibration method for calibration of IRB 6650S and is the most accurate method for the standard calibration. It is the recommended method in order to achieve proper performance.

The following routines are available for the Axis Calibration method:

- Fine calibration
- Update revolution counters
- Reference calibration

The calibration equipment for Axis Calibration is delivered as a toolkit.

An introduction to the calibration method is given in this manual, see [Calibrating with Axis Calibration method on page 406](#).

The actual instructions of how to perform the calibration procedure and what to do at each step is given on the FlexPendant. You will be guided through the calibration procedure, step by step.

##### Levelmeter calibration - alternative method

Levelmeter calibration is referred to as the alternative method for calibration of ABB robots because of the less accurate values obtained during calibration. The method uses the same principles as Calibration Pendulum, but does not have as good of mechanical tolerances to the toolkit parts as the standard method with Calibration Pendulum.

This method may, after calibration, require modifications in the robot program and is therefore not recommended.

The calibration equipment (Levelmeter 2000) for levelmeter calibration is ordered as separate parts for each robot, and includes the *Operating manual - Levelmeter Calibration*, which describes the method and the different routines further.

##### CalibWare - Absolute Accuracy calibration

To achieve a good positioning in the Cartesian coordinate system, Absolute Accuracy calibration is used as a TCP calibration. The CalibWare tool guides through the calibration process and calculates new compensation parameters. This is further detailed in the *Application manual - CalibWare Field 5.0*.

If a service operation is done to a robot with the option Absolute Accuracy, a new absolute accuracy calibration is required in order to establish full performance.

*Continues on next page*

## 5 Calibration

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### 5.1.2 Calibration methods

*Continued*

For most cases after motor and transmission replacements that do not include taking apart the robot structure, standard calibration is sufficient. Standard calibration also supports wrist exchange.

---

### References

Article numbers for the calibration tools are listed in the section [Special tools on page 436](#).

The calibration equipment for Calibration Pendulum is delivered as a complete toolkit, including the *Operating manual - Calibration Pendulum*, which describes the method and the different routines further.

### 5.1.3 When to calibrate

#### When to calibrate

The system must be calibrated if any of the following situations occur.

##### The resolver values are changed

If resolver values are changed, the robot must be recalibrated using the calibration methods supplied by ABB. Calibrate the robot carefully with standard calibration, according to information in this manual.

If the robot has *absolute accuracy* calibration, it is also recommended, but not always necessary to calibrate for new absolute accuracy.

The resolver values will change when parts affecting the calibration position are replaced on the robot, for example motors or parts of the transmission.

##### The revolution counter memory is lost

If the revolution counter memory is lost, the counters must be updated. See

[Updating revolution counters on page 401](#). This will occur when:

- The battery is discharged
- A resolver error occurs
- The signal between a resolver and measurement board is interrupted
- A robot axis is moved with the control system disconnected

The revolution counters must also be updated after the robot and controller are connected at the first installation.

##### The robot is rebuilt

If the robot is rebuilt, for example, after a crash or when the reach ability of a robot is changed, it needs to be recalibrated for new resolver values.

If the robot has *absolute accuracy* calibration, it needs to be calibrated for new absolute accuracy.

## 5 Calibration

### 5.2.1 Synchronization marks and synchronization position for axes

## 5.2 Synchronization marks and axis movement directions

### 5.2.1 Synchronization marks and synchronization position for axes

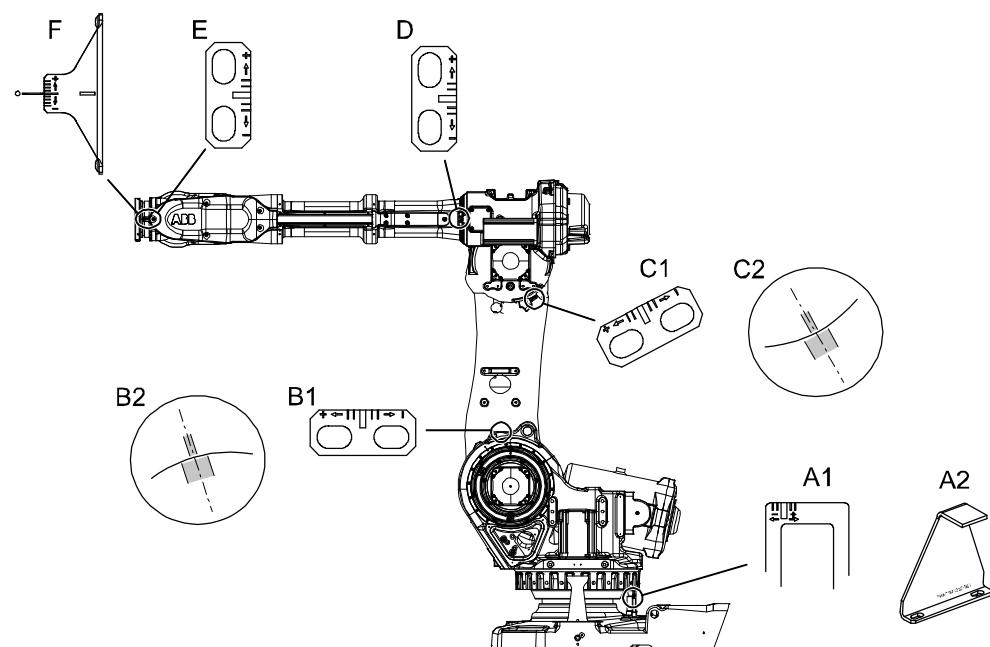
#### Introduction

This section shows the position of the synchronization marks and the synchronization position for each axis.

#### Synchronization marks, IRB 6650S

The illustration below shows the location of the synchronization marks on specific plates and directly in the casting at axes 2 and 3.

The figure shows IRB 6600, but the scales and their positions are the same.



xx0200000176

A1	Synchronization mark, axis 1 (early design)
A2	Synchronization mark, axis 1 (later design)
B1	Synchronization mark, axis 2 (early design)
B2	Synchronization mark, axis 2 (later design)
C1	Synchronization mark, axis 3 (early design)
C2	Synchronization mark, axis 3 (later design)
D	Synchronization mark, axis 4
E	Synchronization mark, axis 5
F	Synchronization mark, axis 6

*Continues on next page*

### 5.2.1 Synchronization marks and synchronization position for axes

*Continued*

#### Synchronization marks at axes 2 and 3

The synchronization marks at axes 2, 3 and 6, shown in the figure above, consist of two single marks that should be positioned opposite to one another when the robot is standing in its synchronization position. One of the marks is more narrow than the other and should be positioned within the limits of the wider mark.

## 5 Calibration

### 5.2.2 Calibration movement directions for all axes

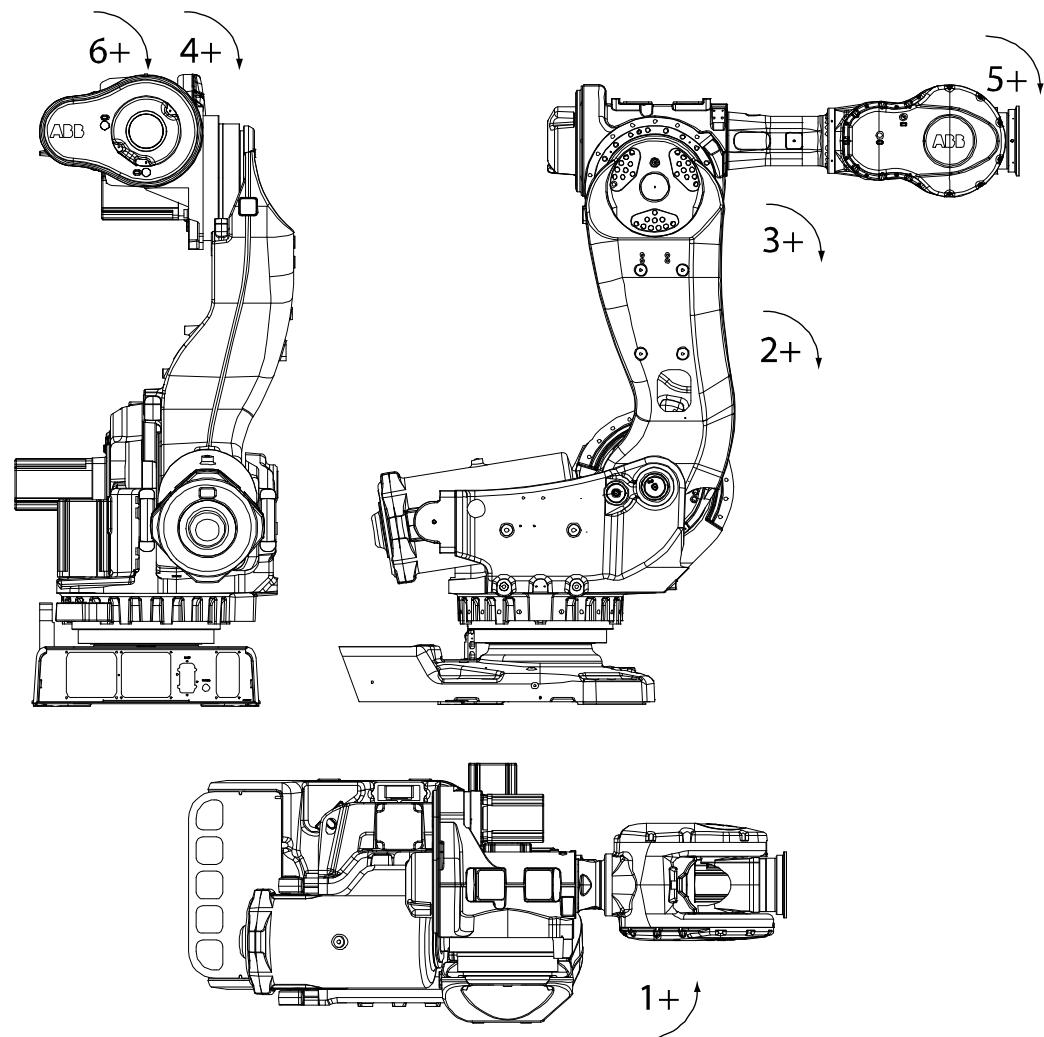
#### Overview

When calibrating, the axis must consistently be run towards the calibration position in the same direction in order to avoid position errors caused by backlash in gears and so on. Positive directions are shown in the graphic below.

Calibration service routines will handle the calibration movements automatically and these might be different from the positive directions shown below.

#### Manual movement directions, 6 axes

Note! The graphic shows an IRB 7600. The positive direction is the same for all 6-axis robots, except the positive direction of axis 3 for IRB 6400R, which is in the opposite direction!



xx0200000089

## 5.3 Updating revolution counters

### Introduction

This section describes how to do a rough calibration of each manipulator axis by updating the revolution counter for each axis, using the FlexPendant.

### Step 1 - Manually running the manipulator to the synchronization position

Use this procedure to manually run the manipulator to the synchronization position.

	Action	Note
1	Select axis-by-axis motion mode.	
2	Jog the manipulator to align the synchronization marks.	See <a href="#">Synchronization marks and synchronization position for axes on page 398</a> .
3	When all axes are positioned, update the revolution counter.	<a href="#">Step 2 - Updating the revolution counter with the TPU on page 402</a> (BaseWare 4.0). <a href="#">Step 2 - Updating the revolution counter with the FlexPendant on page 403</a> .

### Correct calibration position of axis 4 and 6

When jogging the manipulator to synchronization position, it is extremely important to make sure that axes 4 and 6 of the following mentioned manipulators are positioned correctly. The axes can be calibrated at the wrong turn, resulting in an incorrect manipulator calibration.

Make sure the axes are positioned according to the correct calibration values, not only according to the synchronization marks. The correct values are found on a label, located either on the lower arm, underneath the flange plate on the base or on the frame.

At delivery the manipulator is in the correct position, do NOT rotate axis 4 or 6 at power up before the revolution counters are updated.

If one of the following mentioned axes are rotated one or more turns from its calibration position before updating the revolution counter, the correct calibration position will be lost due to non-integer gear ratio. This affects the following manipulators:

Manipulator variant	Axis 4	Axis 6
IRB 6650S	Yes	Yes

If the synchronization marks seem to be wrong (even if the motor calibration data is correct), try to rotate the axis one turn, update the revolution counter and check the synchronization marks again (try both directions, if needed).

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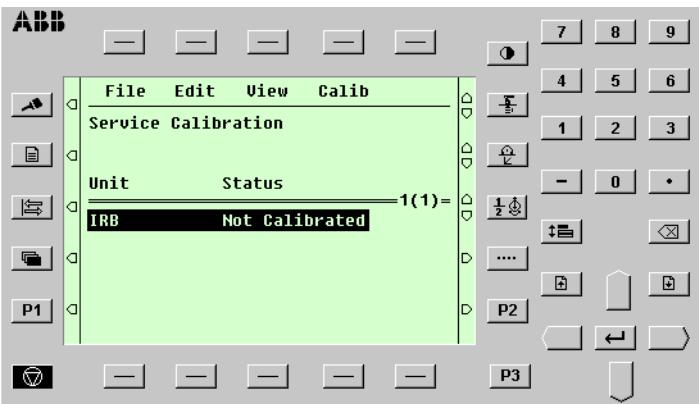
## 5 Calibration

### 5.3 Updating revolution counters

*Continued*

#### Step 2 - Updating the revolution counter with the TPU

Use this procedure to update the revolution counter with the TPU (BaseWare 4.0).

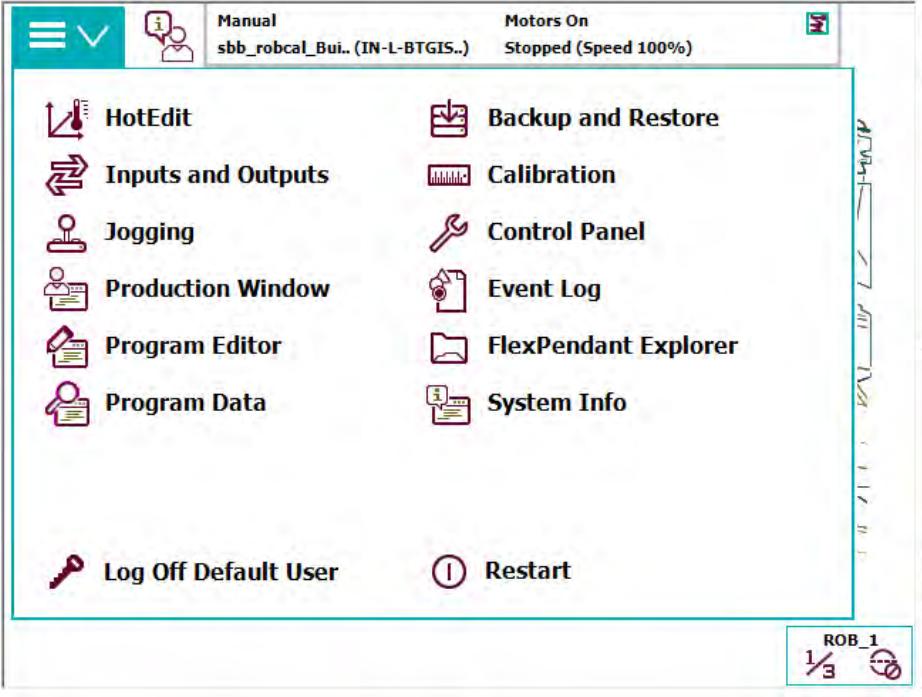
Action	Note
1 Press the button <b>Miscellaneous</b> then <b>ENTER</b> to select the service window.  xx0100000194	
2 Select <b>Calibration</b> from the <b>View</b> menu. The <b>Calibration</b> window appears. If there is more than one unit connected to the manipulator, they will be listed in the window.  xx0100000201	
3 Select the desired unit and choose <b>Rev Counter Update</b> from the <b>Calib</b> menu. The <b>Revolution Counter Update</b> window appears.  xx0100000202	
4 Select the desired axis and press <b>Incl</b> to include it (it will be marked with an x) or press <b>All</b> to select all axes.	
5 Press <b>OK</b> when all axes that are to be updated are marked with an x. <b>CANCEL</b> returns to the <b>Calibration</b> window.	
6 Press <b>OK</b> again to confirm and start the update. <b>CANCEL</b> returns to the <b>Revolution Counter Update</b> window.	

*Continues on next page*

Action	Note
7 At this point, it is <i>recommended</i> that the revolution counter values are saved to a diskette.	Not required.
8  <b>CAUTION</b> If a revolution counter is incorrectly updated, it will cause incorrect manipulator positioning, which in turn may cause damage or injury! Check the synchronization position very carefully after each update. How to perform the check is detailed in section <i>Checking the synchronization position</i> on page 419.	

### Step 2 - Updating the revolution counter with the FlexPendant

Use this procedure to update the revolution counter with the FlexPendant (IRC5).

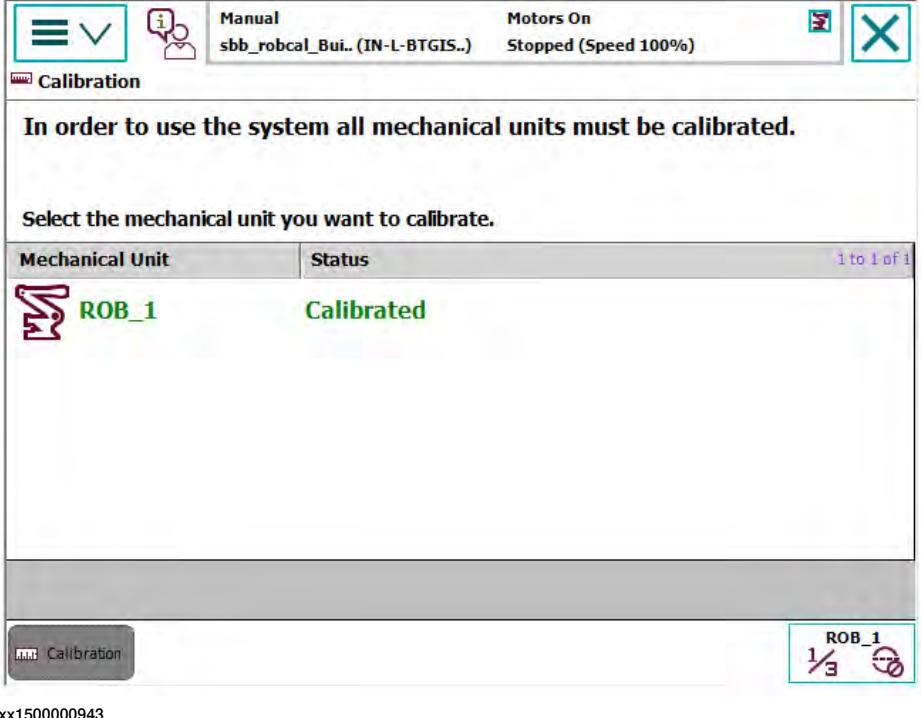
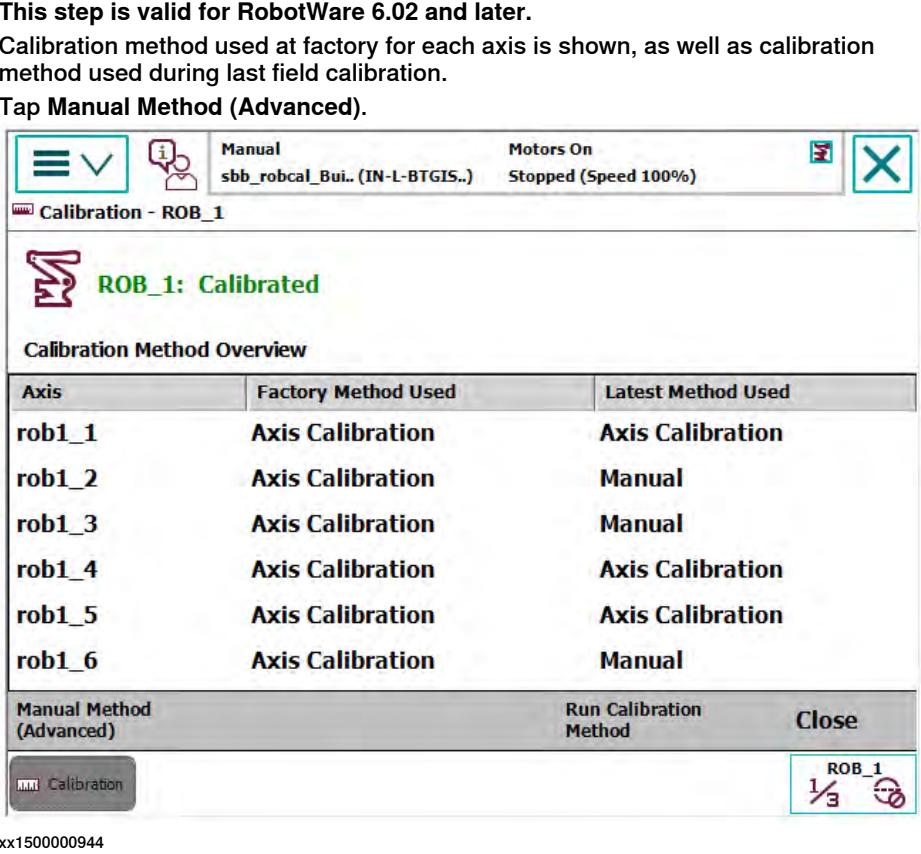
Action
1 On the ABB menu, tap Calibration.


*Continues on next page*

## 5 Calibration

### 5.3 Updating revolution counters

*Continued*

	Action																					
2	<p>All mechanical units connected to the system are shown with their calibration status. Tap the mechanical unit in question.</p>  <p>In order to use the system all mechanical units must be calibrated.</p> <p>Select the mechanical unit you want to calibrate.</p> <table border="1"><thead><tr><th>Mechanical Unit</th><th>Status</th></tr></thead><tbody><tr><td>ROB_1</td><td>Calibrated</td></tr></tbody></table> <p>xx1500000943</p>	Mechanical Unit	Status	ROB_1	Calibrated																	
Mechanical Unit	Status																					
ROB_1	Calibrated																					
3	<p>This step is valid for RobotWare 6.02 and later.</p> <p>Calibration method used at factory for each axis is shown, as well as calibration method used during last field calibration.</p> <p>Tap Manual Method (Advanced).</p>  <p>Calibration Method Overview</p> <table border="1"><thead><tr><th>Axis</th><th>Factory Method Used</th><th>Latest Method Used</th></tr></thead><tbody><tr><td>rob1_1</td><td>Axis Calibration</td><td>Axis Calibration</td></tr><tr><td>rob1_2</td><td>Axis Calibration</td><td>Manual</td></tr><tr><td>rob1_3</td><td>Axis Calibration</td><td>Manual</td></tr><tr><td>rob1_4</td><td>Axis Calibration</td><td>Axis Calibration</td></tr><tr><td>rob1_5</td><td>Axis Calibration</td><td>Axis Calibration</td></tr><tr><td>rob1_6</td><td>Axis Calibration</td><td>Manual</td></tr></tbody></table> <p>Manual Method (Advanced) Run Calibration Method Close</p> <p>xx1500000944</p>	Axis	Factory Method Used	Latest Method Used	rob1_1	Axis Calibration	Axis Calibration	rob1_2	Axis Calibration	Manual	rob1_3	Axis Calibration	Manual	rob1_4	Axis Calibration	Axis Calibration	rob1_5	Axis Calibration	Axis Calibration	rob1_6	Axis Calibration	Manual
Axis	Factory Method Used	Latest Method Used																				
rob1_1	Axis Calibration	Axis Calibration																				
rob1_2	Axis Calibration	Manual																				
rob1_3	Axis Calibration	Manual																				
rob1_4	Axis Calibration	Axis Calibration																				
rob1_5	Axis Calibration	Axis Calibration																				
rob1_6	Axis Calibration	Manual																				

*Continues on next page*

Action
4 A screen is displayed, tap Rev. Counters. 
5 Tap Update Revolution Counters.... A dialog box is displayed, warning that updating the revolution counters may change programmed robot positions: <ul style="list-style-type: none"><li>• Tap Yes to update the revolution counters.</li><li>• Tap No to cancel updating the revolution counters.</li></ul> Tapping Yes displays the axis selection window.
6 Select the axis to have its revolution counter updated by: <ul style="list-style-type: none"><li>• Ticking in the box to the left</li><li>• Tapping Select all to update all axes.</li></ul> Then tap Update.
7 A dialog box is displayed, warning that the updating operation cannot be undone: <ul style="list-style-type: none"><li>• Tap Update to proceed with updating the revolution counters.</li><li>• Tap Cancel to cancel updating the revolution counters.</li></ul> Tapping Update updates the selected revolution counters and removes the tick from the list of axes.
8  CAUTION If a revolution counter is incorrectly updated, it will cause incorrect manipulator positioning, which in turn may cause damage or injury! Check the synchronization position very carefully after each update. See <a href="#">Checking the synchronization position on page 419</a> .

## 5 Calibration

### 5.4.1 Description of Axis Calibration

## 5.4 Calibrating with Axis Calibration method

### 5.4.1 Description of Axis Calibration

#### Instructions for Axis Calibration procedure given on the FlexPendant

The actual instructions of how to perform the calibration procedure and what to do at each step is given on the FlexPendant. You will be guided through the calibration procedure, step by step.

This manual contains a brief description of the method, additional information to the information given on the FlexPendant, article number for the tools and images of where to fit the calibration tools on the robot.

#### Overview of the Axis Calibration procedure

The Axis Calibration procedure applies to all axes, and is performed on one axis at the time. The robot axes are both manually and automatically moved into position, as instructed on the FlexPendant.

A fixed calibration pin/bushing is installed on each robot axis at delivery.

The Axis Calibration procedure described roughly:

- A removable calibration tool is inserted by the operator into a calibration bushing on the axis chosen for calibration, according to instructions on the FlexPendant.



#### WARNING

Calibrating the robot with Axis Calibration requires special calibration tools from ABB. Using other pins in the calibration bushings may cause severe damage to the robot and/or personnel.



#### WARNING

The calibration tool must be fully inserted into the calibration bushing, until the steel spring ring snaps into place.

- During the calibration procedure, RobotWare moves the robot axis chosen for calibration so that the calibration tools get into contact. RobotWare records values of the axis position and repeats the coming-in-contact procedure several times to get an exact value of the axis position.



#### WARNING

Risk of pinching! The contact force for large robots can be up to 150 kg. Keep a safe distance to the robot.

- The axis position is stored in RobotWare with an active choice from the operator.

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#### Routines in the calibration procedure

The following routines are available in the Axis Calibration procedure, given at the beginning of the procedure on the FlexPendant.

##### Fine calibration routine

Choose this routine to calibrate the robot when there are no tools, process cabling or equipment fitted to the robot.

##### Reference calibration routine

Choose this routine to create reference values and to calibrate the robot when the robot is dressed with tools, process cabling or other equipment.

If calibrating the robot with reference calibration there must be reference values created before repair is made to the robot, if values are not already available.

Creating new values requires possibility to move the robot. The reference values contain positions of all axes, torque of axes and technical data about the tool installed. The reference value is unique for the current setup of the robot and will be named according to tool name, date etc.

Follow the instructions given in the reference calibration routine on the FlexPendant to create reference values.

When reference calibration is performed, the robot is restored to the status given by the reference values.

##### Update revolution counters

Choose this routine to make a rough calibration of each manipulator axis by updating the revolution counter for each axis, using the FlexPendant.

##### Validation

In the mentioned routines, it is also possible to validate the calibration data.

---

#### Position of robot axes

The axis chosen for calibration is automatically run by the calibration program to its calibration position during the calibration procedure.

In order for the axis to be able to be moved to calibration position, or in order for getting proper access to the calibration bushing, other axes might need to be jogged to positions different from 0 degrees. Information about which axes are allowed to be jogged will be given on the FlexPendant. These axes are marked with **Unrestricted** in the FlexPendant window.

## 5 Calibration

### 5.4.2 Calibration tools for Axis Calibration

#### 5.4.2 Calibration tools for Axis Calibration

##### Calibration tool set

The calibration tools used for Axis Calibration are designed to meet requirements for calibration performance, durability and safety in case of accidental damage.



##### WARNING

Calibrating the robot with Axis Calibration requires special calibration tools from ABB. Using other pins in the calibration bushings may cause severe damage to the robot and/or personnel.

Equipment, etc.	Article number	Note
Calibration tool box, Axis Calibration	3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.

##### Examining the calibration tool

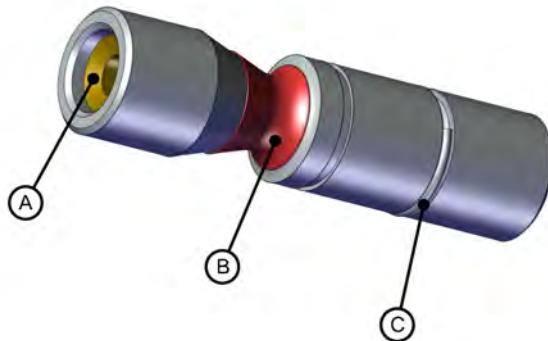
###### Check prior to usage

Before using the calibration tool, make sure that the tube insert, the plastic protection and the steel spring ring are present.



##### WARNING

If any part is missing or damaged, the tool must be replaced immediately.



xx1500001914

A	Tube insert
B	Plastic protection
C	Steel spring ring

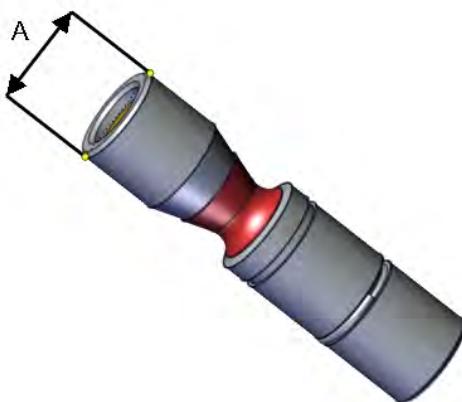
###### Periodic check of the calibration tool

If including the calibration tool in a local periodic check system, the following measures should be checked.

- Outer diameter within Ø12g4 mm, Ø8g4 mm or Ø6g5 mm (depending on calibration tool size).

*Continues on next page*

- Straightness within 0.005 mm.



xx1500000951

A	Outer diameter
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### Identifying the calibrating tools

It is possible to make the calibration tool identifiable with, for example, an RFID chip. The procedure of how to install an RFID chip is described below.



#### Note

The tool identifier is NOT delivered from ABB, it is a customized solution.

	Action	Note
1	<p>It is possible to use any RFID solution, with the correct dimensions. ABB has verified function on some suppliers fulfilling the requirements of NFC compatible devices (13.56 Mhz) according to ISO 14443 or ISO 15693.</p> <p> Note</p> <p>The maximum dimensions on the RFID chip must not exceed Ø7.9 mm x 8.0 mm, Ø5.9 mm x 8.0 mm or Ø3.9 mm x 8.0 mm (depending on calibration tool size).</p>	
2	<p>There is a cavity on one end of the calibration tool in which the RFID chip can be installed.</p> <p>Install the RFID chip according to supplier instructions.</p> <p>Install the chip in flush with the tool end.</p>	

## 5 Calibration

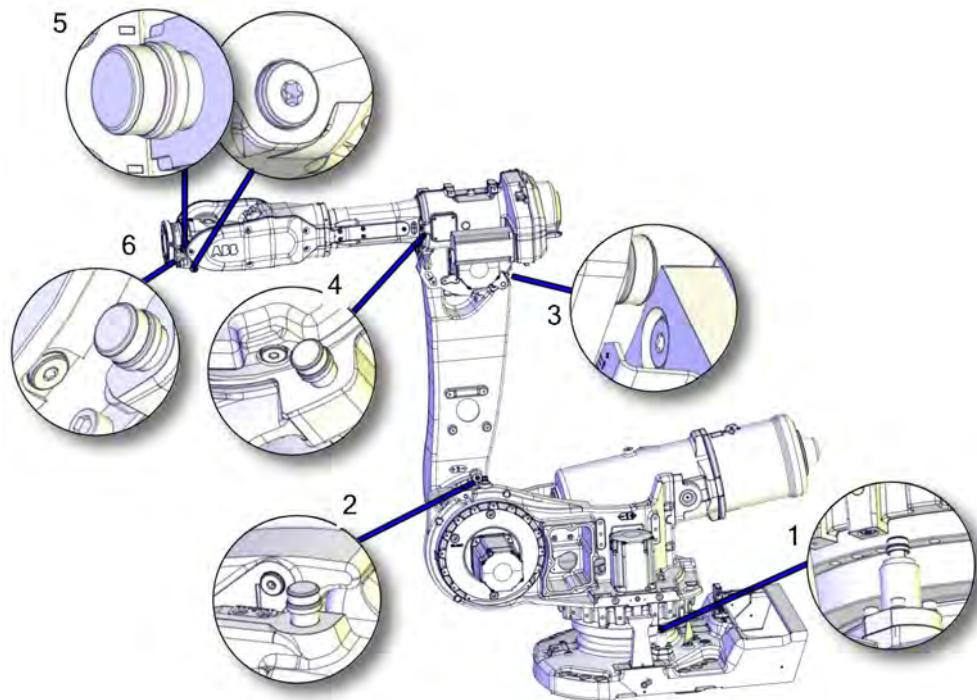
### 5.4.3 Installation locations for the calibration tools

#### 5.4.3 Installation locations for the calibration tools

##### Location of fixed calibration items

The figure shows how the robot is equipped with items for installation of calibration tools for Axis Calibration (fixed calibration pins and/or bushings). The figure does not show installed calibration tools.

A fixed calibration pin and a bushing for the movable calibration tool are located on each axis as follows.



xx1500000912

The fixed calibration pin for axis 1 is installed on a removable tower. The tower will need to be removed if electronic position switches are fitted to the robot. Keep the tower in a safe location for future recalibration needs and mark it with robot serial number to ensure that the correct one is refitted.

##### Spare parts

When calibration is not being performed, a protective cover and an o-ring should always be installed on the fixed calibration pin as well as a protective plug, included a sealing, in the bushing. Replace damaged parts with new, if needed.

Spare part	Article number	Note
Protection cover and plug set	3HAC056806-001	Contains replacement calibration pin covers and protective plugs for the bushing.

## 5.4.4 Axis Calibration - Running the calibration procedure

### Required tools

The calibration tools used for Axis Calibration are designed to meet requirements for calibration performance, durability and safety in case of accidental damage.



#### WARNING

Calibrating the robot with Axis Calibration requires special calibration tools from ABB. Using other pins in the calibration holes may cause severe damage to the robot and/or personnel.

Equipment, etc.	Article number	Note
Calibration tool box, Axis Calibration	3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.

### Required consumables

Consumable	Article number	Note
Clean cloth	-	

### Spare parts

Spare part	Article number	Note
Protection cover and plug set	3HAC056806-001	Contains replacement calibration pin covers and protective plugs for the bushing.

### Overview of the calibration procedure on the FlexPendant

The actual instructions of how to perform the calibration procedure and what to do at each step is given on the FlexPendant. You will be guided through the calibration procedure, step by step.

Use the following list to learn about the calibration procedure before running the RobotWare program on the FlexPendant. It gives you a brief overview of the calibration procedure sequence.

After the calibration method has been called for on the FlexPendant, the following sequence will be run.

- 1 Choose calibration routine. The routines are described in [Routines in the calibration procedure on page 407](#).
- 2 Choose which axis/axes to calibrate.
- 3 The robot moves to synchronization position.
- 4 Validate the synchronization marks.
- 5 The robot moves to preparation position.
- 6 Remove the protective cover from the fixed pin and the protection plug from the bushing, if any, and install the calibration tool.

*Continues on next page*

## 5 Calibration

### 5.4.4 Axis Calibration - Running the calibration procedure

*Continued*

- 7 The robot performs a measurement sequence by rotating the axis back and forth.
- 8 Remove the calibration tool and reinstall the protective cover on the fixed pin and the protection plug in the bushing, if any.
- 9 The robot moves to verify that the calibration tool is removed.
- 10 Choose whether to save the calibration data or not.

Calibration of the robot is not finished until the calibration data is saved, as last step of the calibration procedure.

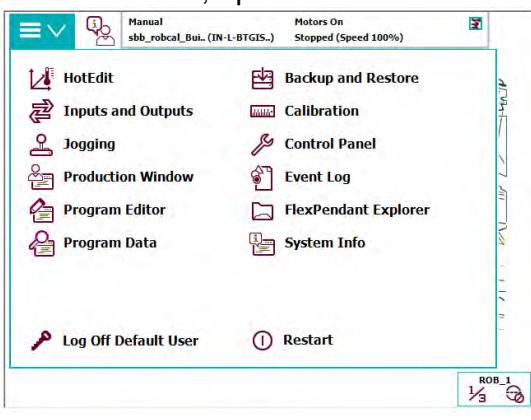
#### Preparation prior to calibration

The calibration procedure is described in the FlexPendant while conducting it.

Action	Note
1  <b>DANGER</b> While conducting the calibration, the robot needs to be connected to power. Make sure that the robots working area is empty, as the robot can make unpredictable movements.	
2 Wipe the calibration tool clean.   <b>Note</b> The calibration method is exact. Dust, dirt or color flakes will affect the calibration value.	Use a clean cloth.

#### Starting the calibration procedure

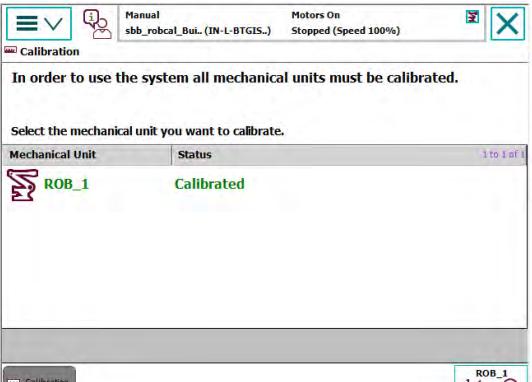
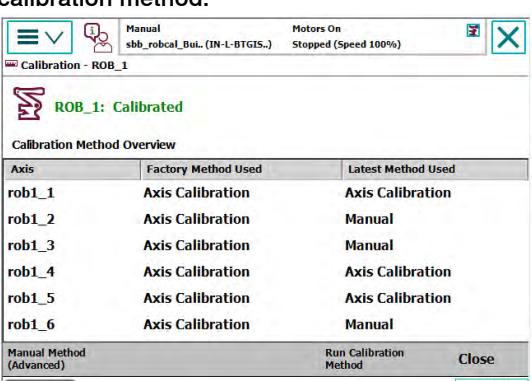
Use this procedure to call for the Axis Calibration method on the FlexPendant.

Action	Note
1 On the ABB menu, tap Calibration. 	

*Continues on next page*

## 5.4.4 Axis Calibration - Running the calibration procedure

Continued

	Action	Note
2	<p>All mechanical units connected to the system are shown with their calibration status. Tap the mechanical unit in question.</p>  <p>xx1500000943</p>	
3	<p>Calibration method used at factory for each axis is shown, as well as calibration method used for the robot during last field calibration. Tap Run Calibration Method. The software will automatically call for the procedure for the valid calibration method.</p>  <p>xx1500000944</p>	<p>The FlexPendant will give all information needed to proceed with Axis Calibration.</p>
4	<p>Follow the instructions given on the FlexPendant.</p>	<p>A brief overview of the sequence that will be run on the FlexPendant is given in <a href="#">Overview of the calibration procedure on the FlexPendant on page 411</a>.</p>

## Restarting an interrupted calibration procedure

If the Axis Calibration procedure is interrupted before the calibration is finished, the RobotWare program needs to be started again. Use this procedure to take required action.

Situation	Action
The three-position enabling device on the FlexPendant has been released during robot movement.	Press and hold the three-position enabling device and press Play.

Continues on next page

## 5 Calibration

### 5.4.4 Axis Calibration - Running the calibration procedure

*Continued*

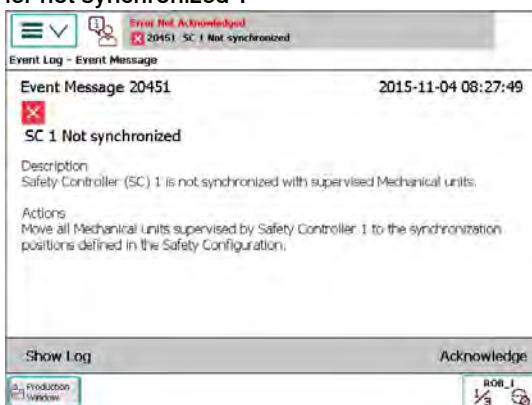
Situation	Action
The RobotWare program is terminated with PP to Main.	<p>Remove the calibration tool, if it is installed, and restart the calibration procedure from the beginning. See <a href="#">Starting the calibration procedure on page 412</a>.</p> <p>If the calibration tool is in contact the robot axis needs to be jogged in order to release the calibration tool. Jogging the axis in wrong direction will cause the calibration tool to break. Directions of axis movement is shown in <a href="#">Calibration movement directions for all axes on page 400</a></p>

#### Axis Calibration with SafeMove option

To be able to run Axis Calibration SafeMove needs to be unsynchronized. The Axis Calibration routine recognizes if the robot is equipped with SafeMove and will force SafeMove to unsynchronize automatically.

However, SafeMove may generate other warning messages anytime during the Axis Calibration routine.

#### Safety controller not synchronized - SafeMove message

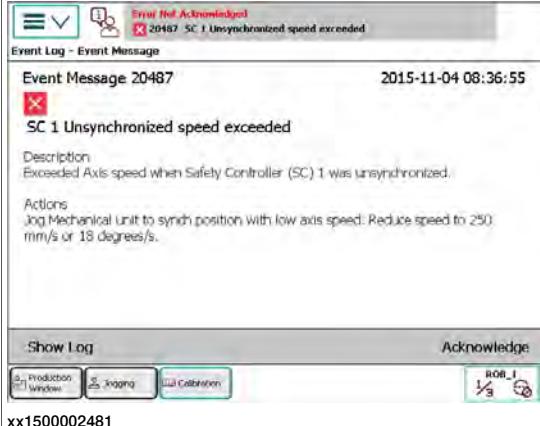
	Action	Note
1	<p>SafeMove generates the message "Safety controller not synchronized".</p>  <p>The screenshot shows an event log entry for event message 20451. The message is titled 'SC 1 Not synchronized' and includes a description: 'Safety Controller (SC) 1 is not synchronized with supervised Mechanical units.' It also lists actions: 'Move all Mechanical Units supervised by Safety Controller 1 to the synchronization positions defined in the Safety Configuration.' Below the message are buttons for 'Show Log' and 'Acknowledge'.</p>	
2	Confirm unsynchronized state by pressing Acknowledge to continue Axis Calibration procedure.	
3	Restart Axis Calibration procedure by pressing Play.	

*Continues on next page*

## 5.4.4 Axis Calibration - Running the calibration procedure

*Continued*

## Unsynchronized speed exceeded - SafeMove message while saving robot data

Action	Note
<p>1 SafeMove generates the message "Unsynchronized speed exceeded" while saving robot data.</p>  <p>The screenshot shows the 'Event Log - Event Message' window. It displays a message from '20467' at '2015-11-04 08:36:55' with the subject 'SC 1 Unsynchronized speed exceeded'. The message details: 'Description: Exceeded Axis speed when Safety Controller (SC) 1 was unsynchronized.' and 'Actions: Jog Mechanical Unit to synch position with low axis speed. Reduce speed to 250 mm/s or 18 degrees/s.' Below the message are buttons for 'Show Log' and 'Acknowledge'. The 'Acknowledge' button is highlighted in green. The status bar at the bottom shows 'xx1500002481'.</p>	
2 Press Acknowledge to continue Axis Calibration procedure.	
3 Restart Axis Calibration procedure by pressing Play.	

## Unsynchronized time limit expired - SafeMove message anytime during Axis Calibration routine

Action	Note
<p>1 SafeMove generates the message "Unsynchronized time limit expired" (anytime).</p>  <p>The screenshot shows the 'Event Log - Event Message' window. It displays a message from '20468' at '2015-11-03 16:45:03' with the subject 'SC 1 Unsynchronized time limit expired'. The message details: 'Description: Available time to move the Robot when unsynchronized has expired for Safety Controller (SC) 1.' and 'Actions: 1. Do a Confirm stop by pressing the Motors ON push button or activate System Input. 2. Synchronize SC 1.' Below the message are buttons for 'Next', 'Previous', and 'OK'. The 'OK' button is highlighted in green. The status bar at the bottom shows 'xx1500002482'.</p>	
2 Press OK to continue Axis Calibration procedure.	
3 Restart Axis Calibration procedure by pressing Play.	

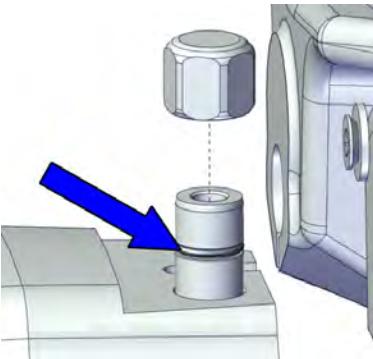
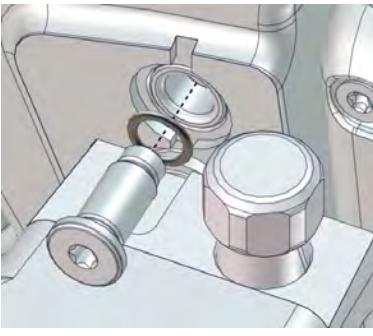
*Continues on next page*

## 5 Calibration

### 5.4.4 Axis Calibration - Running the calibration procedure

*Continued*

#### After calibration

	Action	Note
1	Check the o-ring on the fixed calibration pin. Replace if damaged or missing.	 xx1600002102 Protection cover and plug set: 3HAC056806-001.
2	Reinstall the protective cover on the fixed calibration pin on each axis, directly after the axis has been calibrated.  Replace the cover with new spare part, if missing or damaged.	 xx1500000952 Protection cover and plug set: 3HAC056806-001.
3	Reinstall the protective plug and sealing in the bushing on each axis, directly after the axis has been calibrated. Ensure that the sealing is not damaged.  Replace the plug and the sealing with new spare part, if missing or damaged.	

#### 5.5 Calibrating with Calibration Pendulum method

---

##### Where to find information for Calibration Pendulum

Detailed instructions of how to perform Pendulum Calibration are given in the documentation enclosed with the calibration tools.

## 5 Calibration

---

### 5.6 Verifying the calibration

#### Introduction

Always verify the results after calibrating *any* robot axis to verify that all calibration positions are correct.

#### Verifying the calibration

Use this procedure to verify the calibration result.

Action	Note
1 Run the calibration home position program twice. Do not change the position of the robot axes after running the program!	See <a href="#">Checking the synchronization position on page 419</a> .
2 Adjust the <i>synchronization marks</i> when the calibration is done, if necessary.	This is detailed in section <a href="#">Synchronization marks and synchronization position for axes on page 398</a> .
3 Write down the values on a new label and stick it on top of the calibration label.  The label is located on the lower arm.	
4 Remove any calibration equipment from the robot.	

## 5.7 Checking the synchronization position

### Introduction

Check the synchronization position of the robot before beginning any programming of the robot system. This may be done:

- Using a **MoveAbsJ** instruction with argument zero on all axes.
- Using the **Jogging** window on the FlexPendant.

### Using a MoveAbsJ instruction on the TPU, S4Cplus

Use this procedure to create a program that runs all the robot axes to their synchronization position.

	Action	Note
1	Create the following program: <pre>MoveAbsJ [[0,0,0,0,0,0], [9E9, 9E9,9E9,9E9,9E9,9E9]] \NoEOffs, v1000, z50, Tool0</pre>	
2	Run the program in manual mode.	
3	Check that the synchronization marks for the axes align correctly. If they do not, update the revolution counters.	See <a href="#">Synchronization marks and synchronization position for axes on page 398</a> and <a href="#">Updating revolution counters on page 401</a> .

### Using a MoveAbsJ instruction

Use this procedure to create a program that runs all the robot axes to their synchronization position.

	Action	Note
1	On ABB menu tap <b>Program editor</b> .	
2	Create a new program.	
3	Use <b>MoveAbsJ</b> in the <b>Motion&amp;Proc</b> menu.	
4	Create the following program: <pre>MoveAbsJ [[0,0,0,0,0,0], [9E9,9E9,9E9,9E9,9E9,9E9]] \NoEOffs, v1000, fine, tool0</pre>	
5	Run the program in manual mode.	
6	Check that the synchronization marks for the axes align correctly. If they do not, update the revolution counters.	See <a href="#">Synchronization marks and synchronization position for axes on page 398</a> and <a href="#">Updating revolution counters on page 401</a> .

*Continues on next page*

## 5 Calibration

### 5.7 Checking the synchronization position

*Continued*

#### Using the jogging window on the TPU, S4Cplus

Use this procedure to jog the robot to synchronization position of all axes.

Action	Illustration/Note
1 Open the Jogging window.	 xx0100000195
2 Select running axes-by-axes.	 xx0100000196
3 Manually run the robot axes to a position where the axis position value read on the TPU, is equal to zero.	
4 Check that the synchronization marks for the axes align correctly. If they do not, update the revolution counters.	See <a href="#">Synchronization marks and synchronization position for axes on page 398</a> and <a href="#">Updating revolution counters on page 401</a> .

#### Using the jogging window

Use this procedure to jog the robot to the synchronization position of all axes.

Action	Note
1 On the ABB menu, tap Jogging.	
2 Tap Motion mode to select group of axes to jog.	
3 Tap to select the axis to jog, axis 1, 2, or 3.	
4 Manually run the robots axes to a position where the axis position value read on the FlexPendant, is equal to zero.	
5 Check that the synchronization marks for the axes align correctly. If they do not, update the revolution counters.	See <a href="#">Synchronization marks and synchronization position for axes on page 398</a> and <a href="#">Updating revolution counters on page 401</a> .

# 6 Decommissioning

## 6.1 Environmental information

### Hazardous material

The table specifies some of the materials in the product and their respective use throughout the product.

Dispose components properly to prevent health or environmental hazards.

Material	Example application
Batteries, NiCad or Lithium	Serial measurement board
Copper	Cables, motors
Cast iron/nodular iron	Base, lower arm, upper arm
Steel	Gears, screws, base frame, and so on.
Neodymium	Brakes, motors
Plastic/rubber	Cables, connectors, drive belts, and so on.
Oil, grease	Gearboxes
Aluminium	Covers, synchronization brackets

### Oil and grease

Where possible, arrange for oil and grease to be recycled. Dispose of via an authorized person/contractor in accordance with local regulations. Do not dispose of oil and grease near lakes, ponds, ditches, down drains, or onto soil. Incineration must be carried out under controlled conditions in accordance with local regulations.

Also note that:

- Spills can form a film on water surfaces causing damage to organisms. Oxygen transfer could also be impaired.
- Spillage can penetrate the soil causing ground water contamination.

## **6 Decommissioning**

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### **6.2 Scrapping of robot**

#### **6.2 Scrapping of robot**

---

##### **Important when scrapping the robot**



##### **DANGER**

When a robot is disassembled while being scrapped, it is very important to remember the following before disassembling starts, in order to prevent injuries:

- Always remove all batteries from the robot. If a battery is exposed to heat, for example from a blow torch, it will explode.
- Always remove all oil/grease in gearboxes. If exposed to heat, for example from a blow torch, the oil/grease will catch fire.
- When motors are removed from the robot, the robot will collapse if it is not properly supported before the motor is removed.

## 6.3 Decommissioning of balancing device

### General

There is much energy stored in the balancing device. Therefore a special procedure is required to dismantle it. The coil springs inside the balancing device exert a potentially lethal force unless dismantled properly.

The device must be dismantled by a decommissioning company.

### Required equipment

Equipment	Art. no.	Note
Standard toolkit	-	Content is defined in section <a href="#">Standard tools on page 435</a> .
Cutting torch		For opening housing and cutting coils
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.



#### DANGER

*Do not under any circumstances, deal with the balancing device in any other way than that detailed in the product documentation! For example, attempting to open the balancing device is potentially lethal!*

### Action on field, decommissioning

The procedure below details the actions to perform on field, when the balancing device is to be decommissioned.

	Action	Note
1	Remove the balancing device from the robot.	Detailed in section <a href="#">Removal, balancing device on page 312</a> .
2	Send the device to a decommissioning company.	Make sure the decommissioning company is well informed about the stored energy built up by high tensioned compression springs and that the device contains some grease. The following procedure contains useful information about decommissioning.

*Continues on next page*

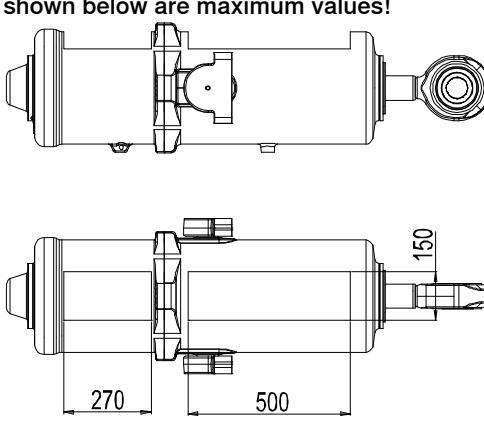
## 6 Decommissioning

### 6.3 Decommissioning of balancing device

*Continued*

#### Decommissioning at decommissioning company, balancing device

The instruction below details how to decommission the balancing device. Contact ABB Robotics for further consultation.

Action	Note
1  <b>DANGER</b> There is stored energy built up by high tensioned compression springs inside the balancing device! The device also contains some grease!	
2 Place the device on a workbench or similar. Make sure it is clamped in position with a vice or similar.	
3 Open a hole in the side of the housing as shown in the figure.	Use a cutting torch. The measurements shown below are maximum values! 
4 Cut the coils of the three springs inside the housing as specified below: <ul style="list-style-type: none"><li>• Outer spring: cut at least five coils!</li><li>• Middle spring: cut at least four coils!</li><li>• Inner spring: cut at least four coils!</li></ul>	Use a cutting torch.
5 Double-check the number of coils cut and make sure all the tension in the springs is removed.	

# 7 Spare part lists

## 7.1 Spare part lists and illustrations

---

### Location

Spare parts and exploded views are not included in the manual but delivered as a separate document on the documentation DVD.

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# 8 Reference information

## 8.1 Introduction

---

### General

This chapter includes general information, complementing the more specific information in the different procedures in the manual.

## 8 Reference information

### 8.2 Applicable standards

#### 8.2 Applicable standards



##### Note

The listed standards are valid at the time of the release of this document. Phased out or replaced standards are removed from the list when needed.

##### Standards, EN ISO

The product is designed in accordance with the requirements of:

Standard	Description
EN ISO 12100	Safety of machinery - General principles for design - Risk assessment and risk reduction
EN ISO 13849-1	Safety of machinery, safety related parts of control systems - Part 1: General principles for design
EN ISO 13850	Safety of machinery - Emergency stop - Principles for design
EN ISO 10218-1	Robots for industrial environments - Safety requirements -Part 1 Robot
EN ISO 9787	Robots and robotic devices -- Coordinate systems and motion nomenclatures
EN ISO 9283	Manipulating industrial robots, performance criteria, and related test methods
EN ISO 14644-1 <sup>i</sup>	Classification of air cleanliness
EN ISO 13732-1	Ergonomics of the thermal environment - Part 1
EN IEC 61000-6-4 (option 129-1)	EMC, Generic emission
EN IEC 61000-6-2	EMC, Generic immunity
EN IEC 60974-1 <sup>ii</sup>	Arc welding equipment - Part 1: Welding power sources
EN IEC 60974-10 <sup>ii</sup>	Arc welding equipment - Part 10: EMC requirements
EN IEC 60204-1	Safety of machinery - Electrical equipment of machines - Part 1 General requirements
IEC 60529	Degrees of protection provided by enclosures (IP code)

<sup>i</sup> Only robots with protection Clean Room.

<sup>ii</sup> Only valid for arc welding robots. Replaces EN IEC 61000-6-4 for arc welding robots.

##### European standards

Standard	Description
EN 614-1	Safety of machinery - Ergonomic design principles - Part 1: Terminology and general principles
EN 574	Safety of machinery - Two-hand control devices - Functional aspects - Principles for design

*Continues on next page*

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#### Other standards

Standard	Description
ANSI/RIA R15.06	Safety requirements for industrial robots and robot systems
ANSI/UL 1740	Safety standard for robots and robotic equipment
CAN/CSA Z 434-14	Industrial robots and robot Systems - General safety requirements

## **8 Reference information**

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### **8.3 Unit conversion**

#### **8.3 Unit conversion**

---

##### **Converter table**

Use the following table to convert units used in this manual.

<b>Quantity</b>	<b>Units</b>		
Length	1 m	3.28 ft.	39.37 in
Weight	1 kg	2.21 lb.	
Weight	1 g	0.035 ounces	
Pressure	1 bar	100 kPa	14.5 psi
Force	1 N	0.225 lbf	
Moment	1 Nm	0.738 lbf-ft	
Volume	1 L	0.264 US gal	

## 8.4 Screw joints

### General

This section describes how to tighten the various types of screw joints on the IRB 6650S.

The instructions and torque values are valid for screw joints comprised of metallic materials and do *not* apply to soft or brittle materials.

### UNBRAKO screws

UNBRAKO is a special type of screw recommended by ABB for certain screw joints. It features special surface treatment (Gleitmo as described below) and is extremely resistant to fatigue.

Whenever used, this is specified in the instructions, and in such cases, *no other type of replacement screw* is allowed. Using other types of screws will void any warranty and may potentially cause serious damage or injury.

### Gleitmo treated screws

Gleitmo is a special surface treatment to reduce the friction when tightening the screw joint. Screws treated with Gleitmo may be reused 3-4 times before the coating disappears. After this the screw must be discarded and replaced with a new one.

When handling screws treated with Gleitmo, protective gloves of **nitrile rubber** type should be used.

### Screws lubricated in other ways

Screws lubricated with Molycote 1000 should *only* be used when specified in the repair, maintenance or installation procedure descriptions.

In such cases, proceed as follows:

- 1 Apply lubricant to the screw thread.
- 2 Apply lubricant between the plain washer and screw head.
- 3 Screw dimensions of M8 or larger must be tightened with a torque wrench. Screw dimensions of M6 or smaller may be tightened without a torque wrench if this is done by trained and qualified personnel.

Lubricant	Article number
Molycote 1000 (molybdenum disulphide grease)	11712016-618

### Tightening torque

Before tightening any screw, note the following:

- Determine whether a **standard** tightening torque or **special** torque is to be applied. The **standard** torques are specified in the following tables. Any **special** torques are specified in the repair, maintenance or installation procedure descriptions. **Any special torque specified overrides the standard torque!**
- Use the *correct* tightening torque for each type of screw joint.
- Only use *correctly calibrated* torque keys.

*Continues on next page*

## 8 Reference information

### 8.4 Screw joints

*Continued*

- Always *tighten the joint by hand*, and never use pneumatic tools.
- Use the *correct tightening technique*, that is *do not jerk*. Tighten the screw in a slow, flowing motion.
- Maximum allowed total deviation from the specified value is 10%!

#### Oil-lubricated screws with slotted or cross-recess head screws

The following table specifies the recommended standard tightening torque for *oil-lubricated screws with slotted or cross-recess head screws*. Any special torque specified in the repair, maintenance or installation procedure overrides the standard torque!

#### Oil-lubricated screws with allen head screws

The following table specifies the recommended standard tightening torque for *oil-lubricated screws with allen head screws*. Any special torque specified in the repair, maintenance or installation procedure overrides the standard torque!

Dimension	Tightening torque (Nm) Class 8.8, oil-lubricated	Tightening torque (Nm) Class 10.9, oil-lubricated	Tightening torque (Nm) Class 12.9, oil-lubricated
M5	6	-	-
M6	10	-	-
M8	24	34	40
M10	47	67	80
M12	82	115	140
M16	200	290	340
M20	400	560	670
M24	680	960	1150

#### Lubricated screws (Molykote, Gleitmo or equivalent) with allen head screws

The following table specifies the recommended standard tightening torque for *screws lubricated with Molykote 1000, Gleitmo 603 or equivalent with allen head screws*. Any special torque specified in the repair, maintenance or installation procedure overrides the standard torque!

Dimension	Tightening torque (Nm) Class 10.9, lubricated <sup>i</sup>	Tightening torque (Nm) Class 12.9, lubricated <sup>i</sup>
M8	28	35
M10	55	70
M12	96	120
M16	235	280
M20	460	550
M24	790	950

<sup>i</sup> Lubricated with Molykote 1000, Gleitmo 603 or equivalent

*Continues on next page*

#### Water and air connectors

The following table specifies the recommended standard tightening torque for *water and air connectors* when *one or both* connectors are made of *brass*. Any special torque specified in the repair, maintenance or installation procedure overrides the standard torque!

Dimension	Tightening torque Nm - Nominal	Tightening torque Nm - Min.	Tightening torque Nm - Max.
1/8	12	8	15
1/4	15	10	20
3/8	20	15	25
1/2	40	30	50
3/4	70	55	90

## **8 Reference information**

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### **8.5 Weight specifications**

#### **8.5 Weight specifications**

---

##### **Definition**

In installation, repair, and maintenance procedures, weights of the components handled are sometimes specified. All components exceeding 22 kg (50 lbs) are highlighted in this way.

To avoid injury, ABB recommends the use of a lifting accessory when handling components with a weight exceeding 22 kg. A wide range of lifting accessories and devices are available for each manipulator model.

---

##### **Example**

Following is an example of a weight specification in a procedure:

	<b>Action</b>	<b>Note</b>
	 <b>CAUTION</b> The robot weighs 2275 kg. All lifting accessories used must be sized accordingly!	

## 8.6 Standard tools

### General

All service (repairs, maintenance, and installation) procedures contains lists of tools required to perform the specified activity.

All special tools required are listed directly in the procedures while all the tools that are considered standard are gathered in the standard toolkit and defined in the following table.

This way, the tools required are the sum of the standard toolkit and any tools listed in the instruction.

### Contents, standard toolkit

Qty	Tool	Rem.
1	Ring-open-end spanner 8-19 mm	
1	Socket head cap 5-17 mm	
1	Torx socket no: 20-60	
1	Box spanner set	
1	Torque wrench 10-100 Nm	
1	Torque wrench 75-400 Nm	
1	Ratchet head for torque wrench 1/2	
2	Hexagon-headed screw M10x100	
1	Hex bit socket head cap no. 14 socket 40 mm L=100 mm	
1	Hex bit socket head cap no. 14 socket 40 mm L=20 mm	To be shortened to 12 mm
1	Hex bit socket head cap no. 6 socket 40 mm L=145 mm	
1	Hex bit socket head cap no. 6 socket 40mm bit L=220 mm	

## 8 Reference information

### 8.7 Special tools

#### 8.7 Special tools

##### General

All service instructions contain lists of tools required to perform the specified activity. The required tools are a sum of standard tools, defined in the section [Standard tools on page 435](#), and of special tools, listed directly in the instructions and also gathered in this section.

##### Basic tools

The following table specifies the tools in the basic toolkit (3HAC15571-3) that are used for the current robot model. This toolkit is necessary primary when removing and refitting the motors.

The tools are also listed directly in the instructions.

Description	Qty	Art. no.
Guide pins M8 x 100	2	3HAC15520-1
Guide pins M8 x 150	2	3HAC15520-2
Guide pins M10 x 100	2	3HAC15521-1
Guide pins M10 x 150	2	3HAC15521-2
Lifting tool, wrist unit	1	3HAC13605-1
Lifting tool, motor ax 1, 4, 5	1	3HAC14459-1
Lifting tool, motor ax 2, 3, 4	1	3HAC15534-1
Removal tool, motor M10x	2	3HAC14972-1 Fits motors, axes 4, 5 and 6.
Removal tool, motor M12x	2	3HAC14631-1 Fits motors axes 1, 2 and 3.
Rotation tool	1	3HAC17105-1
Mechanical stop axis 3	2	3HAC12708-1
Bolts M16 x 60 (for mechanical stop axis 3)	2	3HAB3409-86
Washers (for mechanical stop axis 3)	2	3HAA1001-186
Standard toolkit (content described in section <a href="#">Standard tools on page 435</a> )	1	3HAC15571-1

##### Special tools

The following table specifies the special tools required during several of the service procedures. The tools may be ordered separately and are also specified directly in concerned instructions in the product manual.

Description	Qty	Art. no.
Fixture lower arm	1	3HAC020729-001
Gearbox crank, axis 2	1	3HAC020999-001
Guide pins M12 x 130	2	3HAC022637-001
Guide pins M12 x 150	2	3HAC13056-2
Guide pins M12 x 200	2	3HAC13056-3

*Continues on next page*

Description	Qty	Art. no.
Guide pins M12 x 250	1	3HAC13056-4
Guide pins M16 x 300	2	3HAC13120-5
Guide pins, sealing ax 2/3, 100mm	1	3HAC14628-2
Guide pins, sealing ax 2/3, 80mm	1	3HAC14628-1
Holder for bits (Stahlwille 736/40 S 5/16")	1	3HAC029090-001
Hydraulic cylinder	2	3HAC11731-1
Hydraulic pump, 80 MPa	1	3HAC13086-1
Hydraulic pump, 150 MPa (Glycerin)	1	3HAC021563-012
Hydraulic valve with hose	1	3HAC022643-001
Lifting accessory, base	1	3HAC15560-1
Lifting accessory, robot	1	3HAC15607-1
Lifting accessory, upper arm	1	3HAC15994-1
Lifting eye VLBG M12	1	3HAC16131-1
Lifting eye M12	2	3HAC14457-3
Lifting eye M16	2	3HAC14457-4
Lifting tool (chain)	1	3HAC15556-1
Lifting tool, gearbox axis 2	1	3HAC020386-001
Lifting tool (chain), Balancing device	1	3HAC020540-001
Measuring tool	1	6896134-GN
Oil injector / max 500 MPa	1	3HAC021590-001
Press tool, axis 2 bearing	1	3HAC13527-1
Puller device, axis 2 shaft	1	3HAC021563-001
Press device, axis 2 shaft	1	3HAC021600-001
Press tool, balancing device	1	3HAC020902-001
Press tool, balancing device shaft	1	3HAC17129-1
Puller tool, balancing device shaft	1	3HAC12475-1
Shackle, balancing device	1	3HAC020997-001
Support, base	1	3HAC15535-1
Tool set balancing device	1	3HAC021984-001

**Tools that may be rented**

The following table specifies the tools that may be rented from ABB in order to perform certain service procedures as described in the Product manual.

The special tools are also listed directly in the instructions.

Description	Art. no.	Note
Lifting tool, lower arm	3HAC14691-1	Includes <ul style="list-style-type: none"> <li>• Guidances, 3HAC14446-1</li> </ul>

*Continues on next page*

## 8 Reference information

### 8.7 Special tools

*Continued*

#### Calibration equipment, Levelmeter (alternative method)

The following table specifies the calibration equipment required when calibrating the robot with the alternative method, Levelmeter Calibration.

Description	Art. no.	Note
Angle bracket	68080011-LP	
Calibration bracket	3HAC13908-9	
Calibration tool ax1	3HAC13908-4	
Levelmeter 2000 kit	6369901-347	Includes one sensor.
Measuring pin	3HAC13908-5	
Sensor fixture	68080011-GM	
Sensor plate	3HAC0392-1	
Sync. adapter	3HAC13908-1	

#### Calibration equipment, Calibration Pendulum

The following table specifies the calibration equipment needed when calibrating the robot with the Calibration Pendulum method.

The robot is calibrated by either Calibration Pendulum or Axis Calibration at factory. Always use the same calibration method as used at the factory.

Information about valid calibration method is found on the calibration label or in the calibration menu on the FlexPendant.

If no data is found related to standard calibration, Calibration Pendulum is used as default.

Description	Art. no.	Note
Calibration Pendulum toolkit	3HAC15716-1	Complete kit that also includes operating manual.

#### Calibration equipment, Axis Calibration

The following table specifies the calibration equipment needed when calibrating the robot with the Axis Calibration method.

The robot is calibrated by either Calibration Pendulum or Axis Calibration at factory. Always use the same calibration method as used at the factory.

Information about valid calibration method is found on the calibration label or in the calibration menu on the FlexPendant.

If no data is found related to standard calibration, Calibration Pendulum is used as default.

Description	Art. no.	Note
Calibration tool box, Axis Calibration	3HAC055412-001	Delivered as a set of calibration tools. Required if Axis Calibration is the valid calibration method for the robot.

*Continues on next page*

#### Oil exchange equipment

The following table specifies the recommended equipment for oil exchange.

Description	Art. no.	Note
Oil exchange equipment	3HAC021745-001	<p>Includes:</p> <ul style="list-style-type: none"><li>• Vacuum pump with regulator, hose and coupling</li><li>• Couplings and adapters</li><li>• Pump (manual) with hose and coupling</li><li>• Graduated measuring glass</li><li>• Oil gun</li><li>• User instructions.</li></ul>

## **8 Reference information**

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### **8.8 Lifting accessories and lifting instructions**

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#### **General**

Many repair and maintenance activities require different pieces of lifting accessories, which are specified in each procedure.

The use of each piece of lifting accessories is *not* detailed in the activity procedure, but in the instruction delivered with each piece of lifting accessories.

This implies that the instructions delivered with the lifting accessories should be stored for later reference.

# 9 Circuit diagram

## 9.1 Circuit diagrams

### Overview

The circuit diagrams are not included in this manual, but delivered as separate documents on the documentation DVD. See the article numbers in the tables below.

### Controllers

Product	Article numbers for circuit diagrams
<i>Circuit diagram - IRC5</i>	<i>3HAC024480-011</i>
<i>Circuit diagram - IRC5 Compact</i>	<i>3HAC049406-003</i>
<i>Circuit diagram - IRC5 Panel Mounted Controller</i>	<i>3HAC026871-020</i>
<i>Circuit diagram - Euromap</i>	<i>3HAC024120-004</i>
<i>Circuit diagram - Spot welding cabinet</i>	<i>3HAC057185-001</i>

### Robots

Product	Article numbers for circuit diagrams
<i>Circuit diagram - IRB 120</i>	<i>3HAC031408-003</i>
<i>Circuit diagram - IRB 140 type C</i>	<i>3HAC6816-3</i>
<i>Circuit diagram - IRB 260</i>	<i>3HAC025611-001</i>
<i>Circuit diagram - IRB 360</i>	<i>3HAC028647-009</i>
<i>Circuit diagram - IRB 460</i>	<i>3HAC036446-005</i>
<i>Circuit diagram - IRB 660</i>	<i>3HAC025691-001</i>
<i>Circuit diagram - IRB 760</i>	<i>3HAC025691-001</i>
<i>Circuit diagram - IRB 1200</i>	<i>3HAC046307-003</i>
<i>Circuit diagram - IRB 1410</i>	<i>3HAC2800-3</i>
<i>Circuit diagram - IRB 1600/1660</i>	<i>3HAC021351-003</i>
<i>Circuit diagram - IRB 1520</i>	<i>3HAC039498-007</i>
<i>Circuit diagram - IRB 2400</i>	<i>3HAC6670-3</i>
<i>Circuit diagram - IRB 2600</i>	<i>3HAC029570-007</i>
<i>Circuit diagram - IRB 4400/4450S</i>	<i>3HAC9821-1</i>
<i>Circuit diagram - IRB 4600</i>	<i>3HAC029038-003</i>
<i>Circuit diagram - IRB 6400RF</i>	<i>3HAC8935-1</i>
<i>Circuit diagram - IRB 6600 type A</i>	<i>3HAC13347-1 3HAC025744-001</i>
<i>Circuit diagram - IRB 6600 type B</i>	<i>3HAC13347-1 3HAC025744-001</i>
<i>Circuit diagram - IRB 6620</i>	<i>3HAC025090-001</i>

*Continues on next page*

## 9 Circuit diagram

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### 9.1 Circuit diagrams

*Continued*

Product	Article numbers for circuit diagrams
<i>Circuit diagram - IRB 6620 / IRB 6620LX</i>	<i>3HAC025090-001</i>
<i>Circuit diagram - IRB 6640</i>	<i>3HAC025744-001</i>
<i>Circuit diagram - IRB 6650S</i>	<i>3HAC13347-1</i> <i>3HAC025744-001</i>
<i>Circuit diagram - IRB 6660</i>	<i>3HAC025744-001</i> <i>3HAC029940-001</i>
<i>Circuit diagram - IRB 6700</i>	<i>3HAC043446-005</i>
<i>Circuit diagram - IRB 7600</i>	<i>3HAC13347-1</i> <i>3HAC025744-001</i>
<i>Circuit diagram - IRB 14000</i>	<i>3HAC050778-003</i>
<i>Circuit diagram - IRB 910SC</i>	<i>3HAC056159-002</i>

---

### Use the correct circuit diagram (IRB 6600, IRB 6650 and IRB 6650S)

The cable harness of the robot is available in two different designs. Either the cabling is divided between the upper and lower arm, or not. Accordingly there are also two different versions of the circuit diagram. Decide which circuit diagram is valid for the robot by checking the article number for the cable harness.

## 9.2 Circuit diagram 3HAC 025744-001

### 9.2.1 Validity of circuit diagram 3HAC025744-1

---

#### Is this circuit diagram valid for your robot?

The validity of the circuit diagram depends on which cable harness is fitted to the robot.

Check the article number of the cable harness fitted to the robot and see page 3 of the circuit diagram in order to determine if the diagram is valid for the harness or not.

Where to find the article number	Action
Label on the cable harness	The label is located at the connectors in the base. Remove the rear cover plate to see the label.
WebConfig	

## 9 Circuit diagram

---

### 9.3.1 Validity of circuit diagram 3HAC13347-1

## 9.3 Circuit diagram 3HAC 13347-1

### 9.3.1 Validity of circuit diagram 3HAC13347-1

#### Is this circuit diagram valid for your robot?

The validity of the circuit diagram depends on which cable harness is fitted to the robot.

Check the article number of the cable harness fitted to the robot.

Where to find the article number	Action
Label on the cable harness	The label is located at the connectors in the base. Remove the rear cover plate to see the label.
WebConfig	-

This circuit diagram is valid for the following cable harness assemblies:

Robot	Cable harness	Revision
IRB 6600	3HAC 14940-1	all
IRB 6650, IRB 6650S	3HAC 16331-1	all
IRB 7600	3HAC 14940-1	revision 0-2

For remaining cable harness assemblies, see section [Validity of circuit diagram 3HAC025744-1 on page 443](#).

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