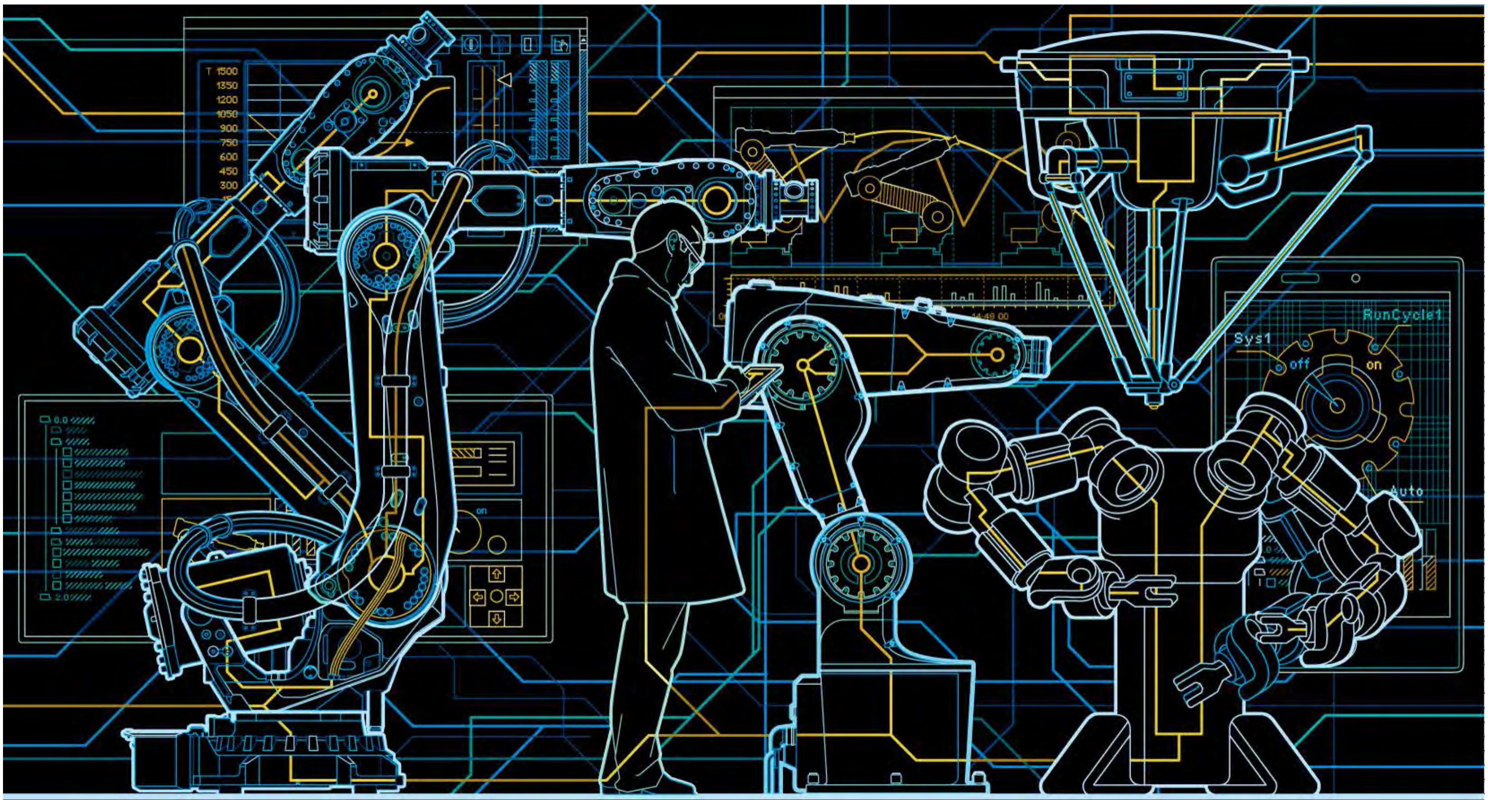

Product manual
IRB 660

Power and productivity
for a better world™

ABB

Trace back information:
Workspace R16-2 version a5
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Product manual

IRB 660 - 180/3.15
IRB 660 - 250/3.15

IRC5

Document ID: 3HAC025755-001

Revision: M

ABB AB
Robotics Products
Se-721 68 Västerås
Sweden

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Overview of this manual

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.

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.

Who should read this manual?

This manual is intended for:

- installation personnel
- maintenance personnel
- repair personnel.

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.

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.
Calibration Information	Procedures that does not require specific calibration equipment. General information about calibration.
Decommissioning	Environmental information about the robot and its components.

Continues on next page

Chapter	Contents
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 of the robot components, shown in 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
Product specification - IRB 660	*3HAC023932-001*
Product manual, spare parts - IRB 660	*3HAC049102-001*
Operating manual - General safety information [i]	*3HAC031045-001*
Circuit diagram - IRB 660	*3HAC025691-001*
Product manual - IRC5 IRC5 with main computer DSQC 639.	*3HAC021313-001*
Product manual - IRC5 IRC5 with main computer DSQC1000.	*3HAC047136-001*
Operating manual - IRC5 with FlexPendant	*3HAC050941-001*
Operating manual - Calibration Pendulum	*3HAC16578-1*
Operating manual - Service Information System	*3HAC050944-001*
Application manual - Additional axes and stand alone controller	*3HAC051016-001*
Technical reference manual - Lubrication in gearboxes	*3HAC042927-001*
Technical reference manual - System parameters	*3HAC050948-001*
Application manual - CalibWare Field 5.0	*3HAC030421-001*

i This manual contains all safety instructions from the product manuals for the manipulators and the controllers.

Revisions

Revision	Description
-	First edition
A	Detailed illustrations added in some procedures. Art. no. on tools added. Chapter "Replacement of tilthouse unit" has been changed, in order to make it easier to follow the procedure.

Continues on next page

Revision	Description
B	Changes made in: • Prerequisites in section Overview • Oil change in section Maintenance This revision also includes the following additions and/or changes: • The section "*Type of oil in gearboxes*" in chapter Maintenance has been updated according to changes made in oil types and intervals for oil change. • Section "*Replacement of Cable harness lower end*" in chapter Repair has been updated. • Section "*Replacement of Parallel rod*" in chapter Repair has been updated. • Section "*Replacement of Balancing device*" in chapter Repair has been updated. • Section "*Replacement of Gearbox axis 6*" in chapter Repair has been updated. • Values for tightening torque on M24 screws in chapter Reference information, added. • New revision on Circuit diagrams.
C	This revision includes the following addtions and/or changes: • Section "*Securing the robot*" in Installation chapter has been removed. Content is not applicable to IRB 660. • Section *What is an emergency stop?* added to chapter Safety • Section *Maintenance schedule* in chapter Maintenance: Intervals for inspection activities and oilchanges have been revised • Section *Maintenance schedule* in chapter Maintenance: Overhaul of robot is new • Section *Maintenance schedule* in chapter Maintenance: The information about Service Information System (SIS) has been updated • Section *Maintenance schedule* in chapter Maintenance: Intervals for replacement of battery pack changed • Section *Expected lifetime* in chapter Maintenance: The lifetime of certain parts has been revised • Section *Cleaning of robot* updated
D	This revision includes the following addtions and/or changes: • Instruction for how to inspect oil level corrected, see *Inspecting, oil level gearbox axis 6 on page 117*. • Circuit diagrams are not included in this document but delivered as separate files. See *Circuit diagrams on page 367*. • List of standards updated, see *Applicable safety standards on page 352*. • Decommissioning chapter added. • The lifetime of certain parts has been updated, see *Expected component life on page 111*. The chapter *Safety* updated with: • Updated safety signal graphics for the levels *Danger* and *Warning*, see *Safety signals in the manual on page 42*. • New safety labels on the manipulators, see *Safety symbols on product labels on page 44*. • Revised terminology: *robot* replaced with *manipulator*.
E	This revision includes the following updates: • Maximum deviation changed, see *Securing the base plate on page 80*.

Continues on next page

Revision	Description
F	This revision includes following updates: • Added index words throughout the manual. • Inspection method of oil level in gearbox, axis 6, is changed, see *Inspecting, oil level gearbox axis 6 on page 117*. • Position numbers in figure corrected, see *Location of dampers on page 132*. • Removed information about lubricating attachment screws, removed tightening torque and screw dimension for axis 2 and 3 and added screw dimension for axis 1, see *Inspecting the additional mechanical stops on page 130*. • Changed tightening torque of fork lift adapters, from 60 Nm to 270 Nm, see *Lifting robot with fork lift on page 69*. • Changed article numbers of robot power cables, see *Robot cable, power on page 104*. • Information about restricting and extending the working range of axis 1 is now separated, see *Mechanically restricting the working range of axis 1 on page 94* and the new section *Extended working range, axis 1 (option 561-1) on page 96*. Also added signal about option 561-1 in section *Inspecting the axis-1 mechanical stop pin on page 128*. • Added detailed information about how to decommission the balancing device, see *Decommissioning of balancing device on page 347*. • Added new safety symbols, see *Safety symbols on product labels on page 44*.
G	This revision includes the following updates: • A new block, about general illustrations, added in section *How to read the product manual on page 16*. • Added a KM10 socket to the list of required equipment and the instructions when replacing the lower rod, see section *Replacing the linkage - lower rod on page 217*. The tool is also added to the list of Special tools in the Reference chapter. • Added instructions for securing parallel arm and lower arm to each other before removing the lower arm, see *Replacing the complete lower arm on page 233*. • Added guide sleeves to hold the axes 2/3 sealing in place when refitting the lower arm, see *Replacing the complete lower arm on page 233*. • Made minor corrections and improvements in the complete instruction for how to replace the lower arm system, see *Replacing the complete lower arm on page 233*. • Made minor corrections and improvements in the complete instruction for how to replace the parallel arm, see *Replacement of parallel arm on page 242*. • Made minor corrections and improvements in the complete instruction for how to replace the axis 1 gearbox, see *Replacing the axis 1 gearbox on page 289*. • Some general tightening torques have been changed/added, see updated values in *Screw joints on page 355*. • Added *WARNING - Safety risks during handling of batteries on page 55*.

Continues on next page

Revision	Description
H	This revision includes the following updates: • The maximum allowed deviation in levelness of the base plate is changed, see *Securing the base plate on page 80*. • 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 *Securing the base plate on page 80*. • Corrections and improvements are made in the instruction for how to replace the axis-2 and axis-3 gearbox, see *Replacing the gearbox, axes 2- 3 on page 301*. • All data about type of lubrication in gearboxes is moved from the manual to a separate lubrication manual, see *Type and amount of oil in gearboxes on page 138*. • Added spare part numbers for the customer connection kits and the base plate, see *Spare parts - option* in *Product manual, spare parts - IRB 660*. • A new SMB unit and battery is introduced, with longer battery lifetime.
J	This revision includes the following updates: • New article number for painted motor added to spare parts, see *Spare parts - frame to lower arm* in *Product manual, spare parts - IRB 660*. • Spare part number on item 102, 104 and 107, frame to base changed. See *Spare parts - frame to Base* in *Product manual, spare parts - IRB 660*. • Added information about risks when scrapping a decommissioned robot, see *Scrapping of robot on page 346*. • *Spare parts and exploded views* are not included in this document but delivered as a separate document. See *Product manual, spare parts - IRB 660*. • Article number for lubrication tool changed, see *Lubricating balancing device bearings and piston rod on page 154*
K	This revision includes the following updates: • The maximum allowed deviation in levelness of the base plate and foundation is changed, see *Securing the base plate on page 80*. • Added tightening torque for R1.SMB and 7th axis connector, ses *Replacing cable harness, lower end (axes 1-3) on page 165*. • Minor corrections.
L	This revision includes the following updates: • Lifting tools updated (guide pin 3HAC7601-086 and guide pin 3HAC7601-087 removed) • Special tools updated (Pressing, inner ring 3HAC023112-008 removed) • Illustrations of SMB battery RMU improved.
M	Published in release R16.2. The following updates are done in this revision: • Drawing of base plate is not available for purchase, faulty information removed in *Securing the base plate on page 80*. • Corrections due to updates in SAP terminology. • New standard calibration method is introduced (Axis Calibration). See *Calibration on page 319*. • Information about grounding point added. See *Robot cabling and connection points on page 104*.

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.

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).
- 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).

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

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 *rear attachment screws, gearbox.*	Shown in the figure *Location of gearbox on page xx*.

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 *sealing, axis 2* to the gearbox.	Art. no. is specified in *Required equipment on page xx.*

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 17*.

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 18*.
- 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 42*.
- 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 50*.

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.

Contents	Examples of content
General information	• safety, service • limitation of liability • related information
Safety risks lists dangers relevant when working with the product. The dangers are split into different categories.	• safety risks during installation or service • risks associated with live electrical parts
Safety actions describes actions which may be taken to remedy or avoid dangers.	• fire extinguishing • safe use of the teach pendant or jogging device
Safety stops describes different types of stops.	• stopping functions • description of emergency stop • description of safety stop

1.2.2 Safety in the robot 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* [i]
- *Product manual*

[i] 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	*Product manual for the robot*	Installation and commissioning
Changing operating modes	*Operating manual - IRC5 with FlexPendant* *Operator's Manual - IRC5P*	Operating modes

Continues on next page

Type of information	Detailed in document	Section
Restricting the working space	*Product manual for the robot*	Installation and commissioning

1.2.3 Safety risks

1.2.3.1 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.

Personal protective equipment

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

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.

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

- 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!	**CAUTION** 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

Safety risk	Description
Removed parts may result in collapse of the robot!	**WARNING** 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	**WARNING** 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!	**CAUTION** 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!	**CAUTION** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!

Balancing device

Safety risk	Description
Dangerous balancing device!	**WARNING** *Do not,* 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!

1.2.3.2 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.	

1.2.3.3 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.

1.2.3.4 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.

1.2.3.5 Safety risks during operational disturbances

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.

1.2.3.6 Risks associated with live electric parts

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

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.

1.2.4 Safety actions

1.2.4.1 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.

1.2.4.2 Fire extinguishing

Note

Use a CARBON DIOXIDE (CO_2) extinguisher in the event of a fire in the robot system (robot or controller)!

1.2.4.3 Emergency release of the robot arm

Description

In an emergency situation, the brakes on the robot axes can be released manually by pushing the brake release buttons.

How to release the brakes is detailed in the section:

- *Manually releasing the brakes on page 77*.

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!

1.2.4.4 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.

1.2.4.5 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".

1.2.4.6 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*.

1.2.4.7 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 33*.
- 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.

1.2.4.8 Signal lamp (optional)

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.

1.2.5 Safety stops

1.2.5.1 What is an emergency stop?

Definition of emergency stop

An emergency stop is a state that takes precedence over all other robot controls, causes all controlled hazards to stop, removes drive power from the robot actuators, remains active until it is reset, and can only be reset by manual action.

An emergency stop state means that all power is disconnected from the robot except for the manual brake release circuits. You must perform a recovery procedure, that is, resetting the emergency stop button and pressing the Motors On button, to return to normal operation.

The robot system can be configured so that the emergency stop results in either:

- A category 0 stop, immediately stopping the robot actions by disconnecting power from the motors.
- A category 1 stop, stopping the robot actions with power available to the motors so that the robot path can be maintained. When completed, power is disconnected from the motors.

The default setting is a category 0 stop. However, category 1 stops are preferred since they minimize unnecessary wear on the robot and the actions needed to return the system back to production. Consult your plant or cell documentation to see how your robot system is configured.

Note

The emergency stop function may only be used for the purpose and under the conditions for which it is intended.

Note

The emergency stop function is intended for immediately stopping equipment in the event of an emergency.

Note

Emergency stop should not be used for normal program stops as this causes extra, unnecessary wear on the robot.

For how to perform normal program stops, see section *Stopping programs* in *Operating manual - IRC5 with FlexPendant*.

Classification of stops

The safety standards that regulate automation and robot equipment define categories in which each type of stop applies:

If the stop is...	... then it is classified as...
category 0 (zero)	uncontrolled

Continues on next page

If the stop is...	... then it is classified as...
category 1	controlled

Emergency stop buttons

In a robot system there are several emergency stop buttons that can be operated in order to achieve an emergency stop. There are emergency stop buttons available on the FlexPendant and on the controller cabinet. There can also be other types of emergency stops on your robot. Consult your plant or cell documentation to see how your robot system is configured.

1.2.5.2 What is a safety stop or protective stop?

Definition of safety stops

A safety stop is a state that stops all robot motion and removes power to the robot drive actuators. There is no recovery procedure. You need only to restore motor power to recover from a safety stop. Safety stop is also called protective stop.

The robot system can be configured so that the safety stop results in either:

- A category 0 stop, immediately stopping the manipulator actions by disconnecting power from the motors.
- A category 1 stop, stopping the manipulator actions with power available to the motors so that the manipulator path can be maintained. When completed, power is disconnected from the motors.

The default setting is a category 1 stop.

Category 1 stops are preferred since they minimize unnecessary wear on the manipulator and the actions needed to return the system back to production. Consult your plant or cell documentation to see how your robot system is configured.

Note

The safety stop function may only be used for the purpose and under the conditions for which it is intended.

Note

Safety stop should not be used for normal program stops as this causes extra, unnecessary wear on the manipulator.

For how to perform normal program stops, see section *Stopping programs* in *Operating manual - IRC5 with FlexPendant*.

Classification of stops

The safety standards that regulate automation and robot equipment define categories in which each type of stop applies:

If the stop is...	... then it is classified as...
category 0 (zero)	uncontrolled
category 1	controlled

Continues on next page

Type of safety stops

Safety stops are activated through special signal inputs to the controller, see *Product manual - IRC5*.

The inputs are intended for safety devices such as cell doors, light curtains, or light beams.

Safety stop:	Description:
Automatic mode stop (AS)	Disconnects drive power in automatic mode. In manual mode this input is inactive.
General stop (GS)	Disconnects drive power in all operating modes.
Superior stop (SS)	Disconnects drive power in all operating modes. Intended for external equipment.

Note

Use normal program stop for all other types of stop.

1.3 Safety signals and symbols

1.3.1 Safety signals in the manual

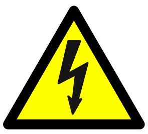
Introduction to safety signals

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 *will* 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 *may* 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 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.
 xx0200000023	ELECTROSTATIC DISCHARGE (ESD)	Warns for electrostatic hazards which could result in severe damage to the product.

Continues on next page

Symbol	Designation	Significance
 xx0100000004	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 44*.

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

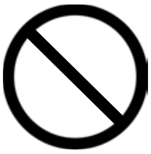
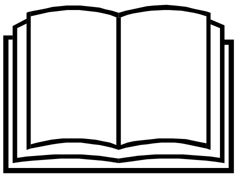
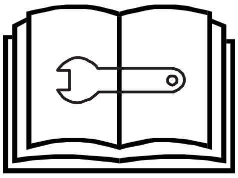
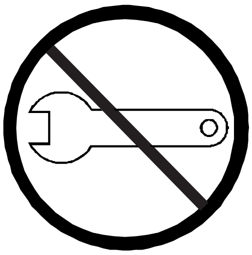
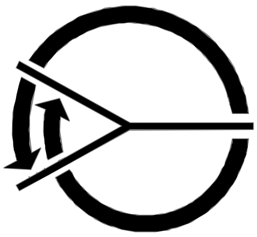
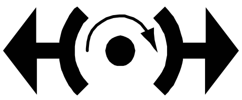
The labels are identified and located on the product as shown in the section:

- *on page ?*

Symbols on safety labels

Symbol	Description
 xx0900000812	**Warning!** Warns that an accident *may* 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	**Caution!** 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.

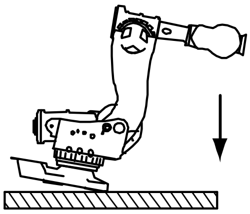
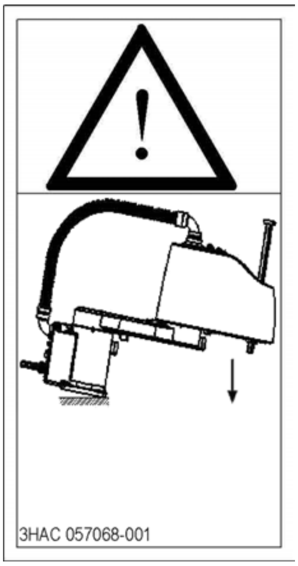
Continues on next page

Symbol	Description
 xx0900000839	**Prohibition** Used in combinations with other symbols.
 xx0900000813	**See user documentation** Read user documentation for details. Which manual to read is defined by the symbol: • No text: *Product manual*. • EPS: *Application manual - Electronic Position Switches*.
 xx0900000816	**Before disassemble, see product manual**
 xx0900000815	**Do not disassemble** Disassembling this part can cause injury.
 xx0900000814	**Extended rotation** This axis has extended rotation (working area) compared to standard.
 xx0900000808	**Brake release** Pressing this button will release the brakes. This means that the robot arm can fall down.

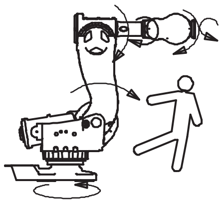
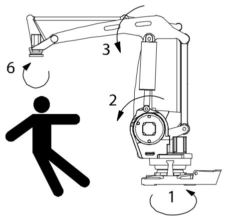
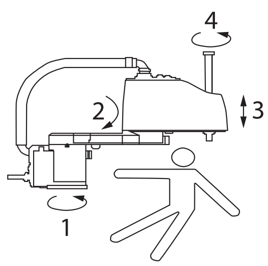
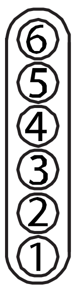
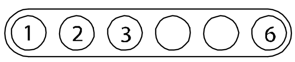
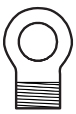
Continues on next page

1.3.2 Safety symbols on product labels

Continued

Symbol	Description
 xx0900000810  xx1500002402	**Tip risk when loosening bolts** The robot can tip over if the bolts are not securely fastened.
 xx0900000817	**Crush** Risk of crush injuries.
 xx0900000818	**Heat** Risk of heat that can cause burns.

Continues on next page

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

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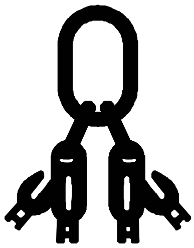
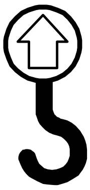
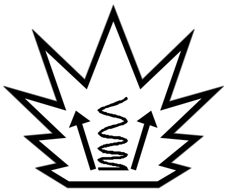
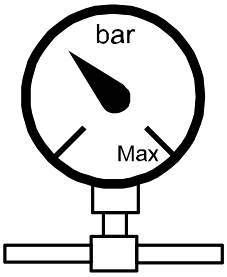
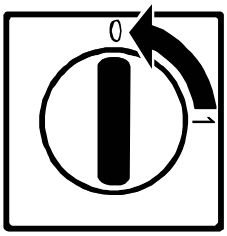
1.3.2 Safety symbols on product labels
Continued

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

Continues on next page

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

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 *How to use the hold-to-run function* in the *Operating manual - IRC5 with FlexPendant*.
3	Make sure no personnel are present within the working range of the robot before pressing the start button.	

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.

	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 the fixture and work piece are well secured, if applicable.
4	Install all safety equipment properly.
5	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.
6	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

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.

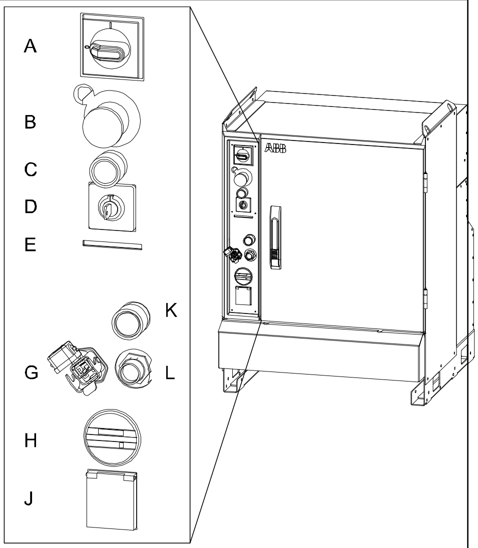
	Action
1	Make sure the power is turned off.
2	Remove the push-button guard, if necessary.
3	Verify that the push-buttons of the brake release unit are working by pressing them down, one by one. Make sure none of the buttons are jammed in the tube.
4	If a button gets jammed in the depressed position,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

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

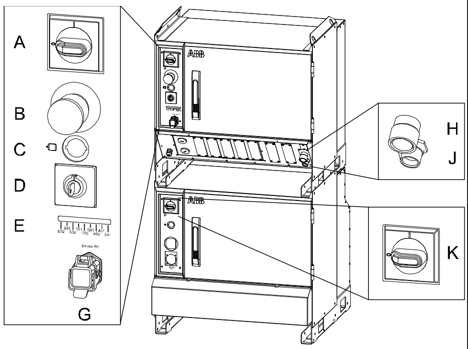
Description

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, Single Cabinet Controller

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

Elimination, Dual Cabinet Controller

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

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.

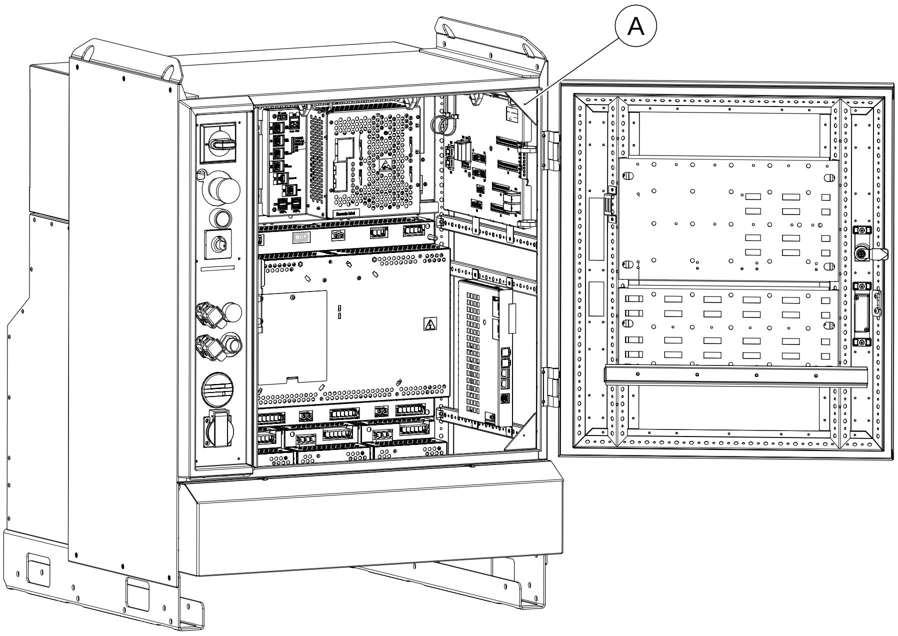
Elimination

	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

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 *Pre-installation procedure on page 60*.
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)

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 **Hot oil or grease**	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 **Allergic reaction**	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 **Possible pressure build-up in gearbox**	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

Warning	Description	Elimination/Action
 xx0100000002 **Do not overfill**	Overfilling of gearbox lubricant can lead to internal over-pressure inside the gearbox which in turn may: • damage seals and gaskets • completely press out seals and gaskets • prevent the robot from moving freely.	Make sure not to overfill the gearbox when filling it with oil or grease! After filling, verify that the level is correct.
 xx0100000002 **Do not mix types of oil**	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!
 xx0100000098 **Heat up the oil**	Warm oil drains quicker than cold oil.	When changing gearbox oil, first run the robot for a time to heat up the oil.
 xx0100000004 **Specified amount depends on drained volume**	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.
 xx0100000003 **Contaminated oil in gear boxes**	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.	

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2 Installation and commissioning

2.1 Introduction

General

This chapter contains assembly instructions and information for installing the IRB 660 at the working site.

More detailed technical data can be found in the *Product specification* for the IRB 660, 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 17* before performing any installation work.

Note

If the IRB 660 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*

2.2 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.

Checking the pre-requisites for installation

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

Installation personnel working with an ABB robot 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.

	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. **Note** 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: *Weight, robot on page 61*
6	If the robot is not installed directly, it must be stored as described in: *Storage conditions, robot on page 62*
7	Make sure that the expected operating environment of the robot conforms to the specifications as described in: *Operating conditions, robot on page 62*
8	Before taking the robot to its installation site, make sure that the site conforms to: • *Loads on foundation, robot on page 61* • *Protection classes, robot on page 63* • *Requirements, foundation on page 62*
9	Before moving the robot, please observe the stability of the robot: *Risk of tipping/stability on page 66*
10	When these prerequisites are met, the robot can be taken to its installation site as described in section: *On-site installation on page 67*
11	Install required equipment, if any. • *Installation of signal lamp (option) on page 91*

Continues on next page

Weight, robot

The table shows the weight of the robot.

Robot model	Weight
IRB 660	1750 kg

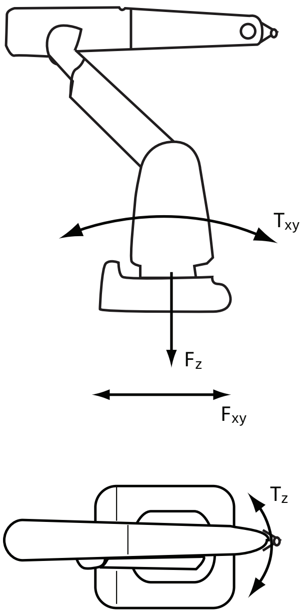
Note

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

Loads on foundation, robot

The illustration shows the directions of the robots stress forces.

The directions are valid for all floor mounted and suspended 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

Floor mounted

Force	Endurance load (in operation)	Max. load (emergency stop)
Force xy	± 8.0 kN	± 11.7 kN
Force z	18.0 ±4.9 kN	18.0 ±8.2 kN
Torque xy	± 23.2 kNm	± 31.2 kNm
Torque z	± 7.7 kNm	± 9.9 kNm

Requirements, foundation

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

Requirement	Value	Note
Maximum deviation from levelness	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°	The limit for the maximum payload on the robot is reduced if the robot is tilted from 0°. Contact ABB for further information about acceptable loads.
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	0° C [i]
Maximum ambient temperature	+50° C
Maximum ambient humidity	95% at constant temperature

i During cold start (0° C - 5° C), see *Start of robot in cold environments on page 103*.

Continues on next page

Protection classes, robot

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

Protection type	Protection class
Manipulator, protection type Standard	IP 67

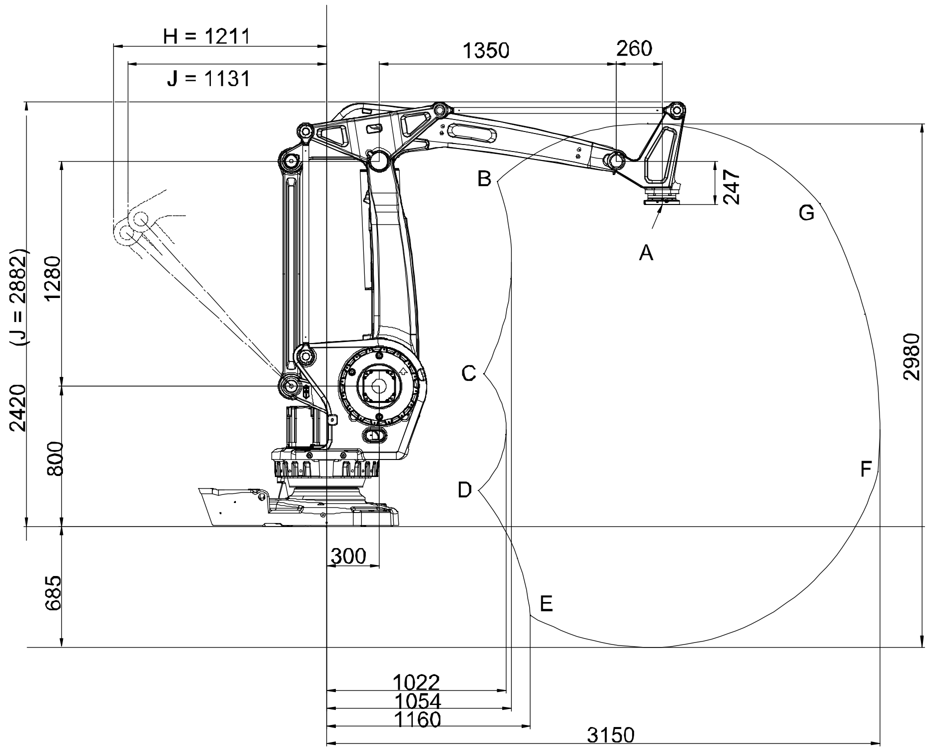
2.2.2 Working range and type of motion

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 660 - 180/3.15 and IRB 660 - 250/3.15

The illustration below shows the unrestricted working range of IRB 660 - 180/3.15 and IRB 660 - 250/3.15.



xx0500002274

H	Mechanical stop
J	Max working range

	Position x (mm)	Position z (mm)	Angle axis 2 (degrees)	Angle axis 3 (degrees)
A	1910	1833	0	0
B	972	1966	-42	-20
C	895	870	-42	28
D	866	207	50	120
E	1160	-505	85	120
F	3139	315	85	15
G	2809	1837	50	-20

Continues on next page

Type of motion

The table below specifies the types and ranges of the robot motion in every axis.

Axis	Type of motion	Range of motion
1	Rotation motion	-180° to +180°
2	Arm motion	-42° to +85°
3	Arm motion	-20° to +120°
2-3	Arm motion	20° to 160°
6	Turn motion	-300° to +300°

2.2.3 Risk of tipping/stability

Risk of tipping

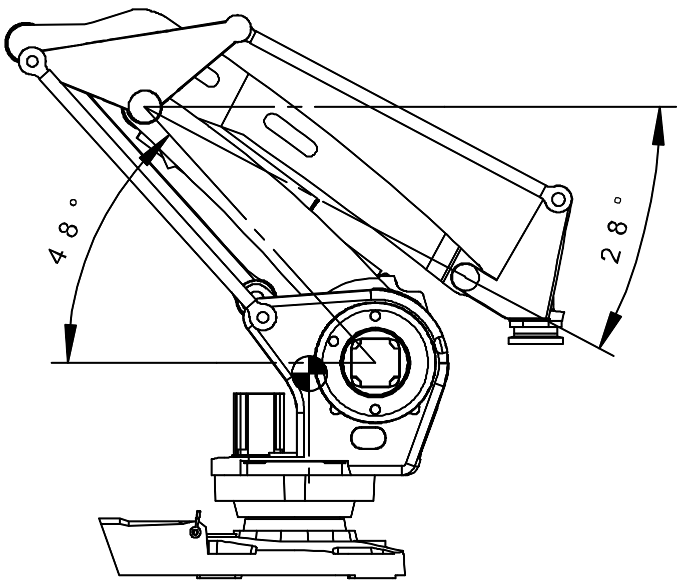
If the robot is not fastened to the foundation and standing still, the robot is not stable in the whole working area. Moving the arms will displace the center of gravity, which may cause the robot to tip over.

The shipping position is the most stable position.

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

Shipping and transport position

This figure shows the robot in its shipping position, which also is a recommended transport position.



xx0500002275

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

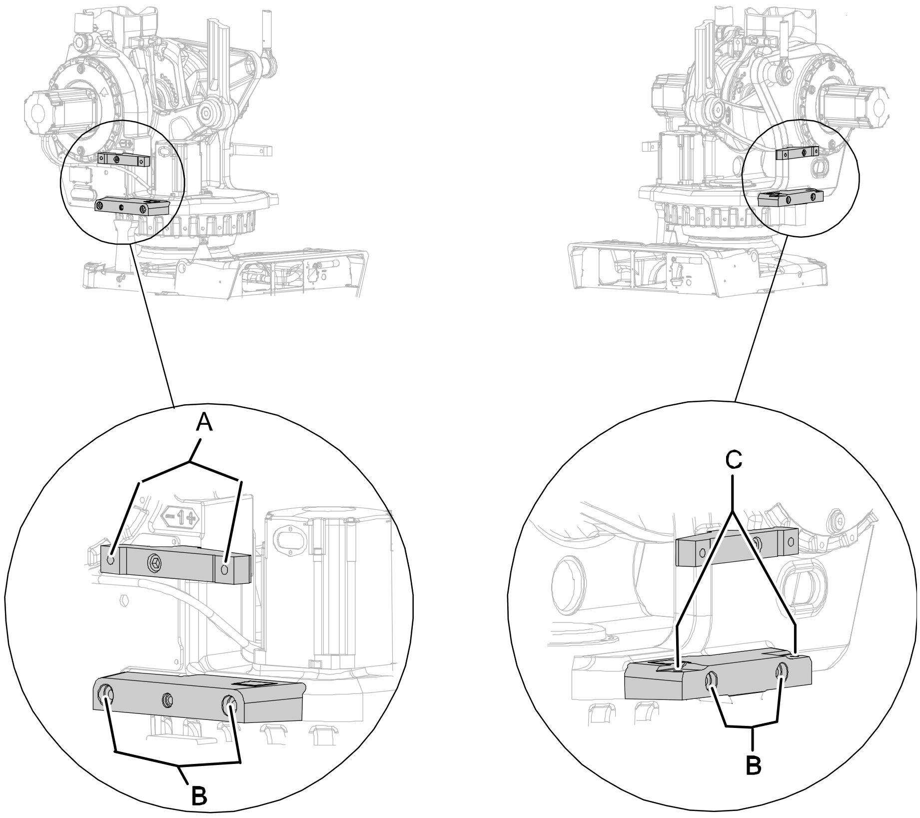
General

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.



xx0500002276

A	Attachment points on adapter and horizontal attachment screws
B	Attachment points, horizontal attachment screws
C	Attachment points, vertical attachment screws

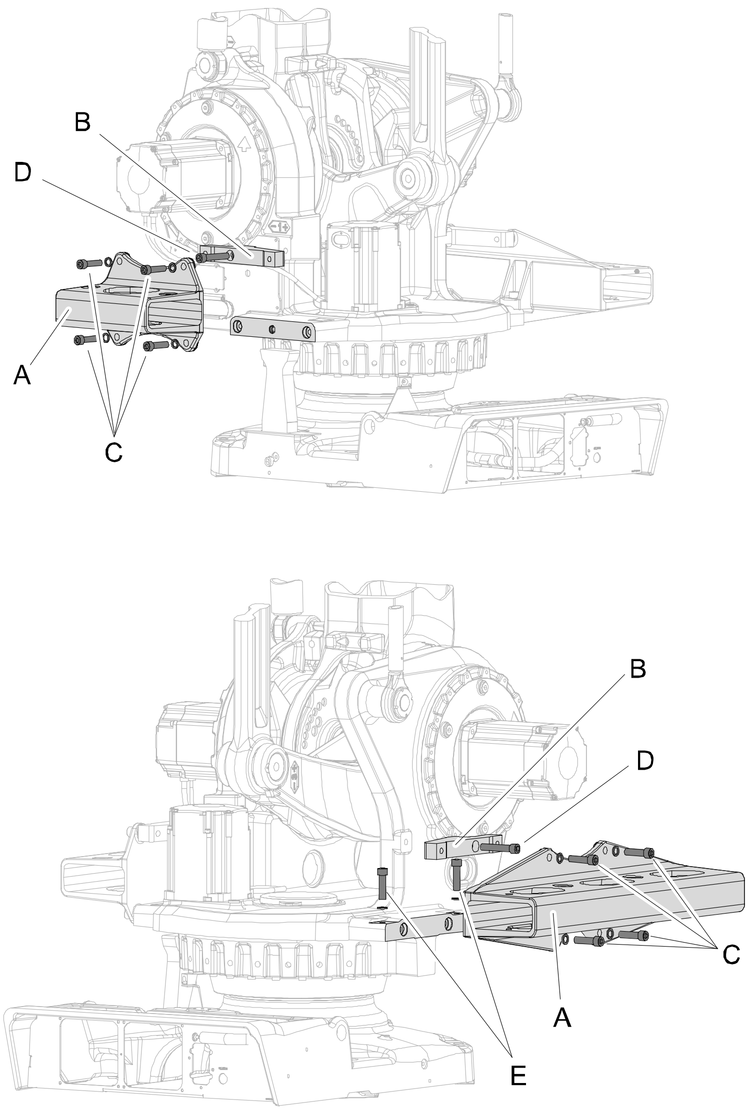
Required equipment

Equipment, etc.	Art. no.	Note
Fork lift set, incl. all required hardware	3HAC023044-001	See figure *Fork lift set, 3HAC023044-001 on page 68*.
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.

Continues on next page

Fork lift set, 3HAC023044-001

The fork lift set 3HAC023044-001, is fitted to the robot as shown in the figure below.



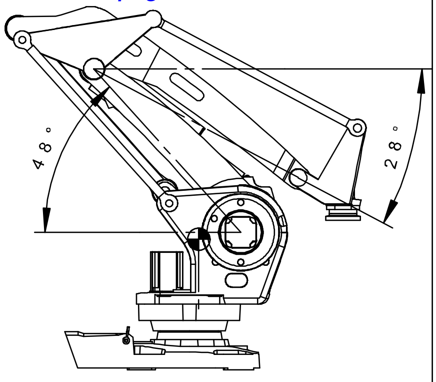
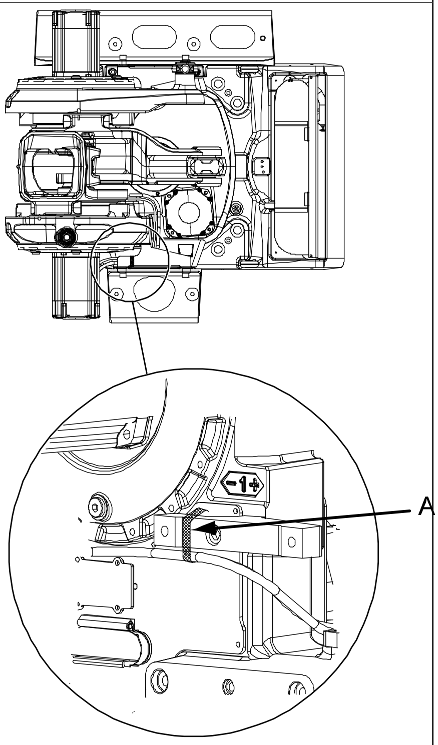
xx0500002277

A	Fork lift pocket (2 pcs, one long and one short)
B	Adapter (2 pcs)
C	Horizontal attachment screws (4 pcs / fork lift pocket)
D	Attachment screw for adapter (1 pc / adapter)
E	Vertical attachment screws (2 pcs)

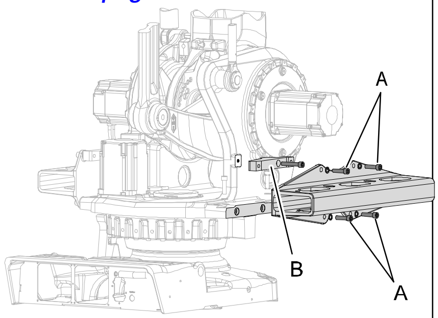
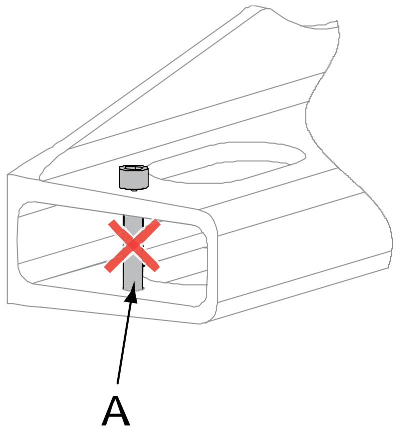
Continues on next page

Lifting robot with fork lift

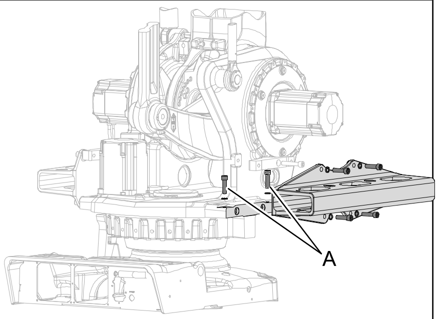
This section details how to secure the fork lift set to the robot in order to lift and move the robot using the fork lift ONLY!

	Action	Note
	If a cooling fan for the axis 1 motor is used, it must be removed in order to use the fork lift device!	
1	Position the robot as shown in the figure to the right!	Release the brakes if required as detailed in section *Manually releasing the brakes on page 77*.  xx0500002275
2	Fit the two adapters to the robot and secure.	Attachment points are shown in figure *Attachment points on robot on page 67*. Attachment screws, 2 pcs, M16 x 90. Tightening torque: 270 Nm.
3	Strap up axis 2 motor cable on the adapter.	 xx0500002278 • A: Strap, velcro

Continues on next page

	Action	Note
4	**CAUTION** The fork lift pocket weighs 60 kg!	
5	Secure the longer *fork lift pocket* to the adapter and frame with four of the horizontal *attachment screws* and *washers*. **Note** 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 *Attachment points on robot on page 67*.  xx0500002279 A Horizontal attachment screws, 4 pcs, M16 x 60. Tightening torque: 60 Nm. B Adapter
6	Make sure the securing screw is removed from the fork lift pocket! It is only used for robot model IRB 6650S.	 xx0700000655 A Securing screw

Continues on next page

	Action	Note
7	Secure fork lift pocket to robot with two *vertical attachment screws* and washers. **Note** Vertically and the horizontally attached screws are identical, but tightened with different torques!	 xx0500002284 A Vertical attachment screws, 2 pcs, M16x60. Tightening torque: 270 Nm. Always use original screws (or replacements of equivalent quality: M16, quality 12.9)! Attachment points on robot are shown in figure *Attachment points on robot on page 67*.
8	**CAUTION** 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 *horizontal attachment screws*.	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 *Attachment points on robot on page 67*.
10	Double-check that pockets are properly secured to the robot! Insert fork lift forks into the pockets.	
11	**CAUTION** The IRB 660 robot weighs 1750 kg. All lifting accessories used must be sized accordingly!	
12	Carefully lift the robot and move it to its installation site.	
13	**WARNING** Personnel must not, under any circumstances, be present under the suspended load!	
	Refit the cooling fan to the motor, if any.	

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	0.605 m 0.8 m 1.0 m (2 pcs)
Roundsling, robot	4 pcs	2 000 kg	2 m
Roundsling, upper arm	1 pc	2 000 kg	1 m 2 m Secures against rotation.

Lifting with roundslings

	Action	Note
1	Position robot in a secure transport position.	
2	Attach roundslings to robot according to figure *Attachment points on page 73*.	
3	**CAUTION** The IRB 660 robot weighs 1750 kg. All lifting accessories used must be sized accordingly!	
4	**WARNING** Personnel must not, under any circumstances, be present under the suspended load!	

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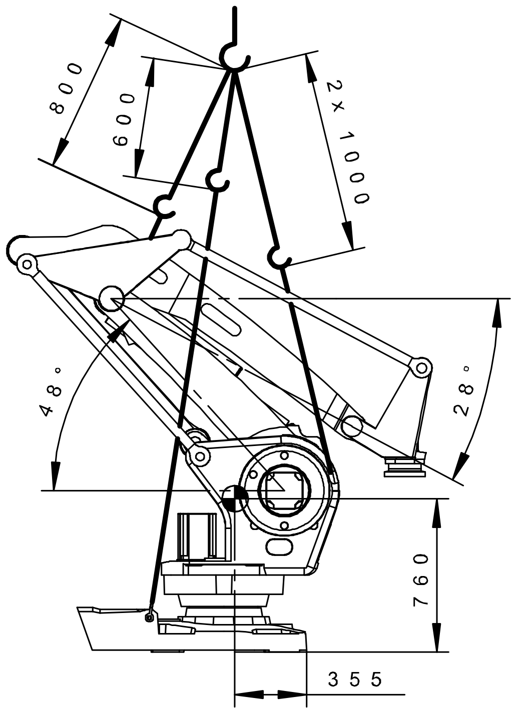
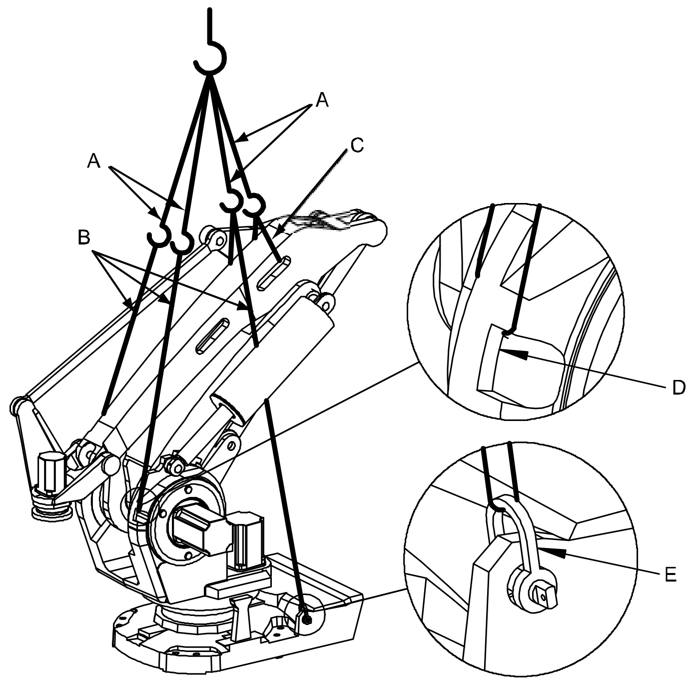
Attachment points

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

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





xx0500002285

A	Chain sling with shortener
B	Roundsling, robot
C	Roundsling, upper arm. Used to secure against rotation.

Continues on next page

D	*Note!* No sharp edges!
E	Shackle

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.

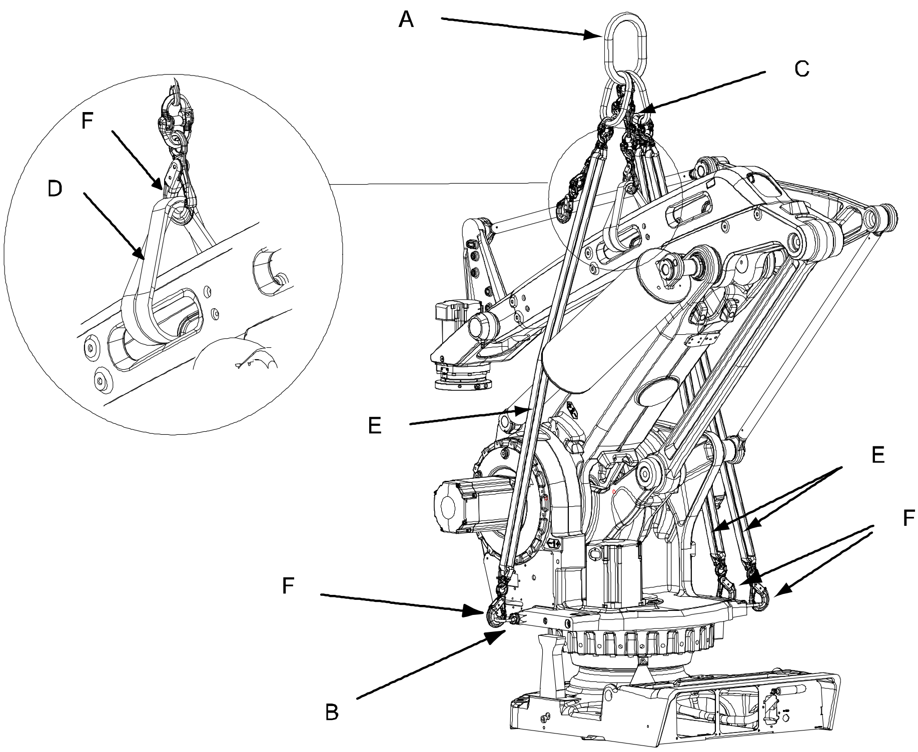
Note

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.



xx0500002460

A	Eye for lifting accessory
B	Swivelling lifting eyes, 3 pcs
C	Chain
D	Lifting sling, short. Secures against rotation.
E	Lifting slings, long
F	Hook

Continues on next page

Required equipment

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

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 *Required equipment on page 76*. Release the brakes if required as detailed in section *Manually releasing the brakes on page 77*.
3	**Note** If the robot is equipped with forklift pockets, it is necessary to remove these in order to reach the lower holes in the frame. These are used to attach the *hooks* of the lifting slings.	Shown in the figure *Illustration, lifting slings on page 75*.
4	Fit the *lifting accessory* to the robot as described in the enclosed instruction!	Art. no. is specified in *Required equipment on page 76*.
5	**CAUTION** The IRB 660 robot weighs 1750 kg. All lifting accessories used must be sized accordingly!	
6	**WARNING** Personnel must not, under any circumstances, be present under the suspended load!	
7	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.

2.3.4 Manually releasing the brakes

Introduction to manually releasing the brakes

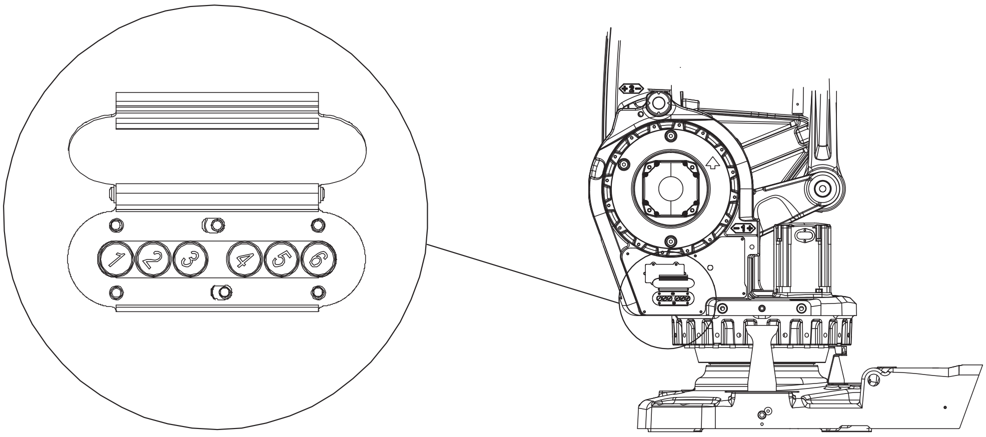
This section describes how to release the holding brakes for the motors of each axis.

Location of brake release unit

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

Note

Axes 4 and 5 do not exist!



xx0500002286

Releasing the brakes

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

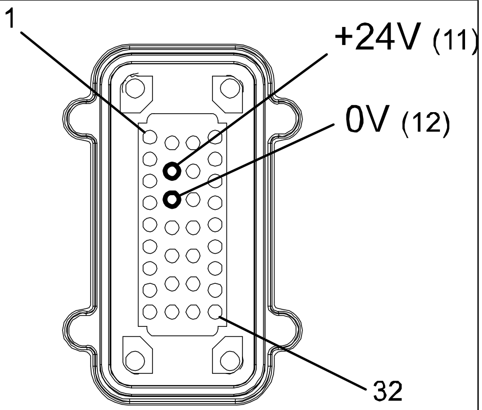
	Action	Note
1	The internal brake release unit is equipped with buttons for controlling the axes brakes. The buttons are numbered according to the numbers of the axes. **Note** Axes 4 and 5 do not exist! If the robot is not connected to the controller, power must be supplied to the connector R1.MP according to the section *Supplying power to connector R1.MP on page 78*.	Buttons are shown in figure *Location of brake release unit on page 77*.
2	**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.	

Continues on next page

	Action	Note
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.	

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.

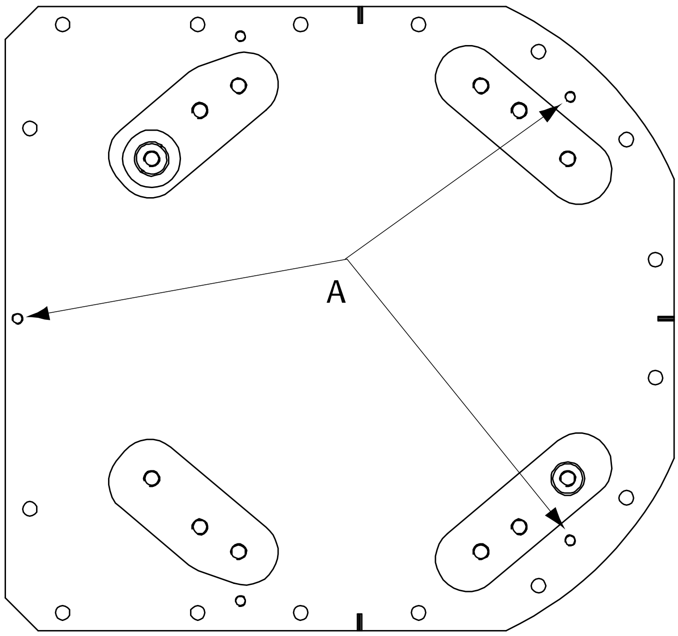
	Action	Note
1	 **DANGER** Incorrect connections, such as supplying power to the wrong pin, may cause all brakes to be released simultaneously!	
2	Supply 0V on pin 12 and 24V on pin 11.	 xx0600002937

2.3.5 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

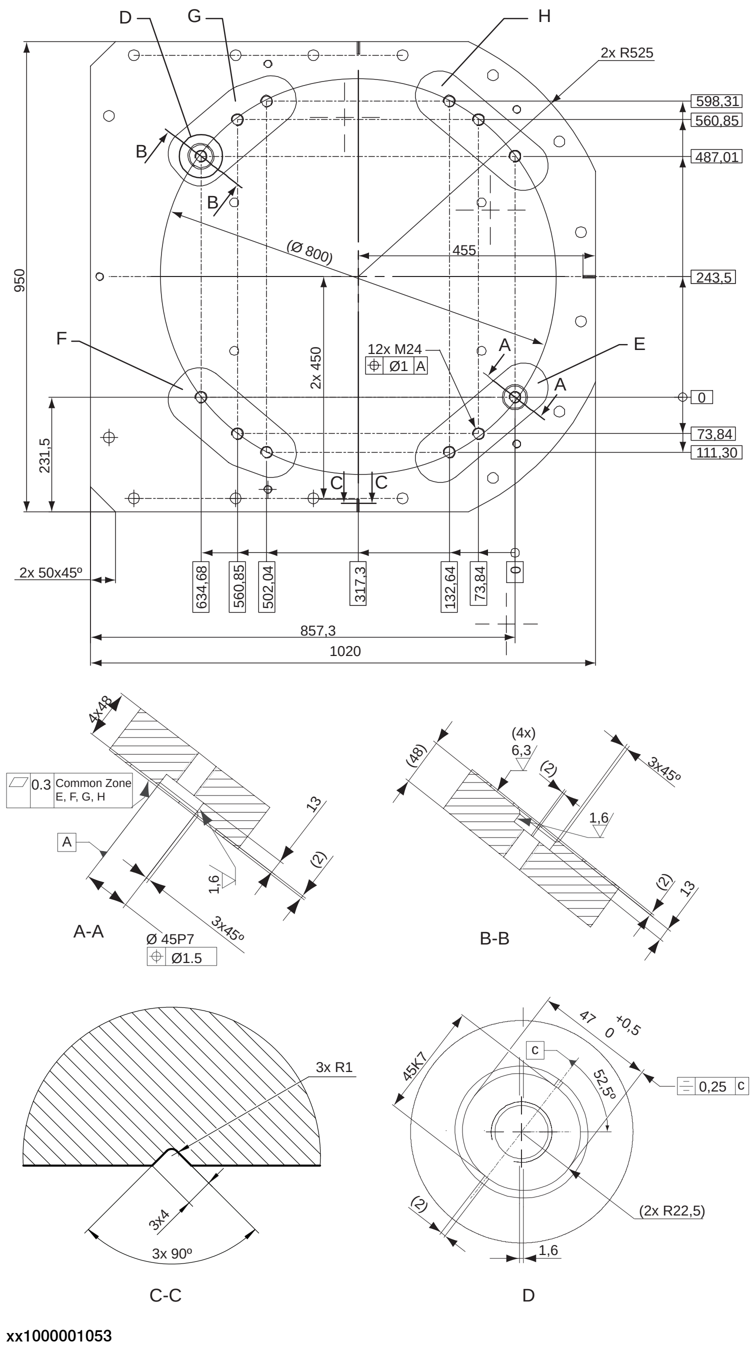
A	Attachment holes for lifting eyes (x3)

Lifting, base plate

	Action	Note
1	**CAUTION** The base plate weighs 353 kg. All lifting accessories used must be sized accordingly.	
2	Fit lifting eyes in specified holes.	Shown in figure *Hole configuration on page 79*.
3	Fit lifting slings to the eyes and to the lifting accessory. **CAUTION** 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



xx1000001053

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

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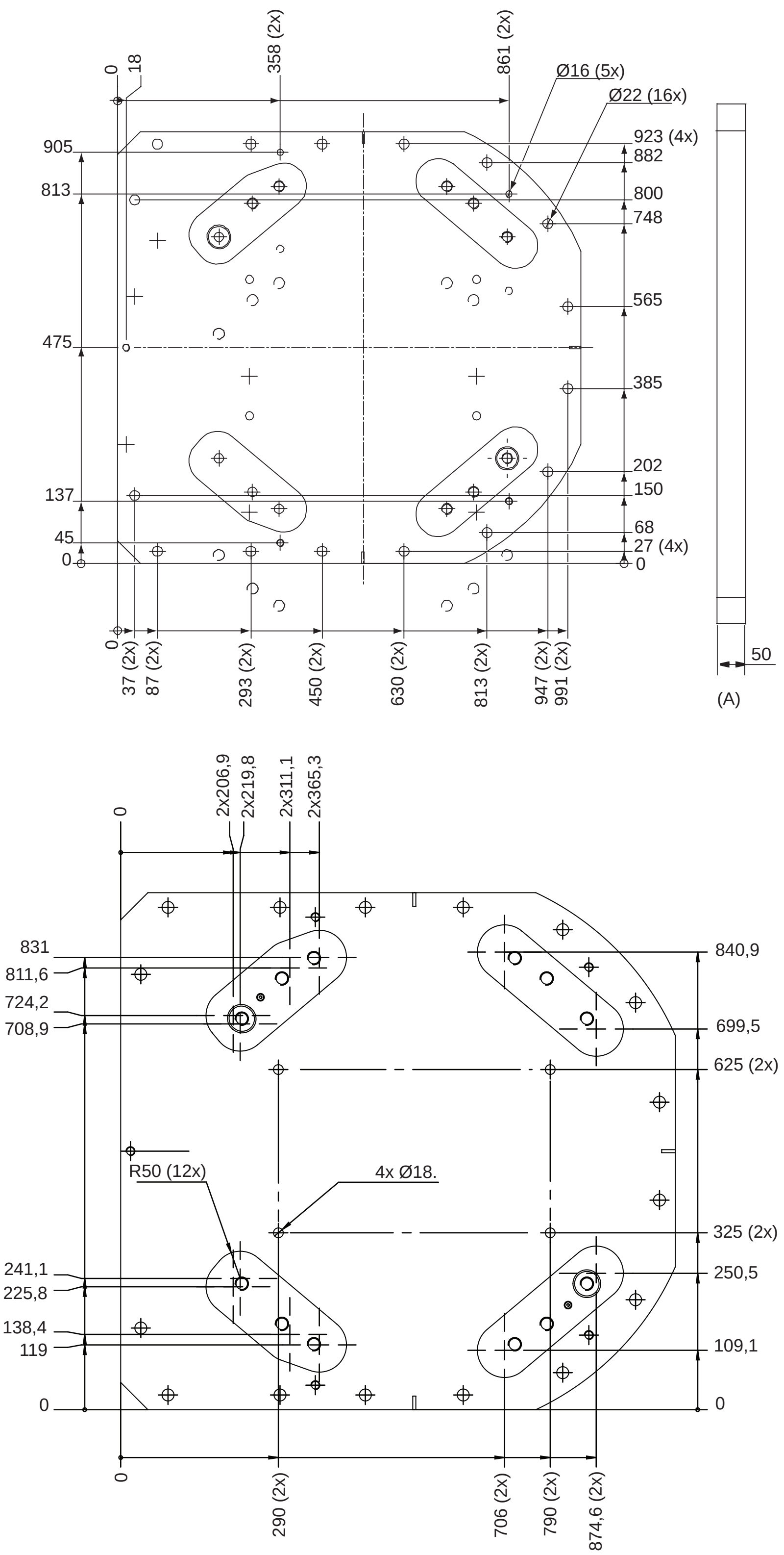

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¤

-	Four holes for alternative clamping, 4x Ø18
A	Color: RAL 9005. Thickness: 80-100 µm

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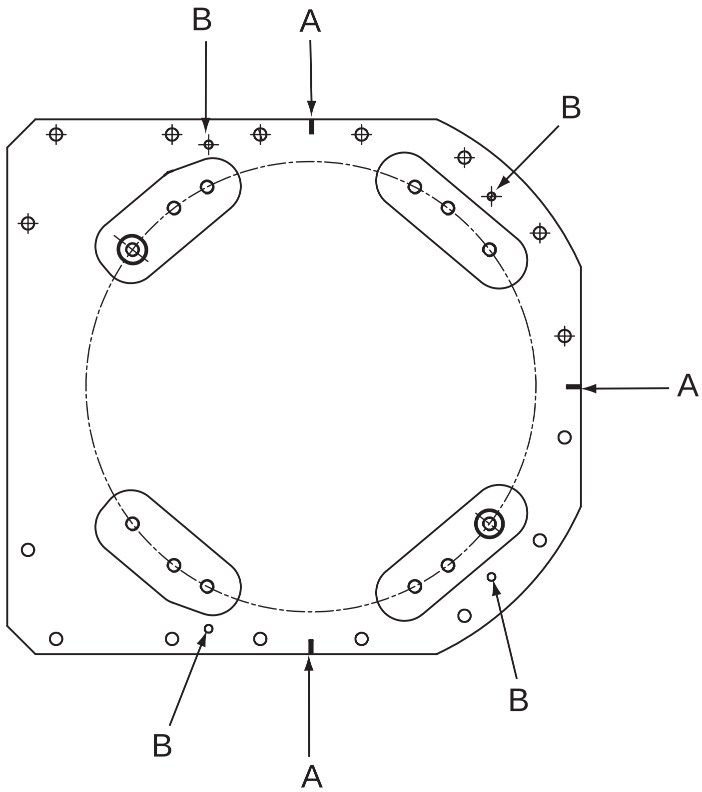
Base plate, orienting grooves and leveling bolts

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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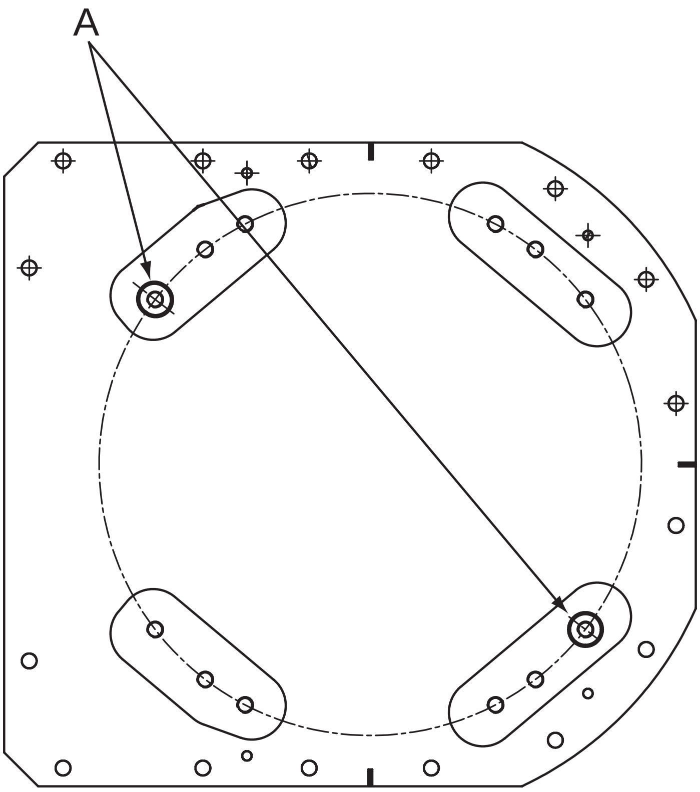
Base plate, guide sleeve holes

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



xx0300000045

A	Guide sleeve holes (2 pcs)

Required equipment

Equipment	Article number	Note
Base plate	3HAC12937-9	Includes • guide sleeves, 3HAC12937-3 • levelling screws, 9ADA120-79 • attachment screws and washers for securing the robot to the base plate.
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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

Recommendations, quality

The table specifies any recommendations made by ABB:

Variable	Recommendation
Recommended bolt quality and dimension	Hilti HDA-P, M20 x 250/50 (maximum thickness of base plate = 50 mm) Hilti HDA-P, M20 x 250/100 (maximum thickness of base plate = 100 mm)
Recommended foundation quality 1	Steel fibre reinforced concrete foundation, 30 kg/m3, class C30 [i]
Recommended foundation quality 2	Sturdy concrete foundation, double reinforced by ø10 mm steel bars, distance 140 mm, class C25 [i]

i See recommended depth of drill hole, minimum base material thickness etc. in standards from the bolt supplier. When choosing bolts from Hilti, see standard AFTM2011.

Base plate

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

	Action	Note
1	Make sure the foundation is levelled.	
2	**CAUTION** 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 *Base plate, orienting grooves and leveling bolts on page 82*.
4	Lift the base plate to its mounting position.	Detailed in section *Lifting the base plate on page 79*.
5	Use the base plate as a template and drill attachment holes as required by the selected bolt dimension.	Attachment holes: 16 pcs. If possible, observe the recommendations specified in section *Recommendations, quality on page 84*. ABB does not assume any responsibility for other foundation qualities, due to great variations in the foundation properties.
6	Fit the base plate and use the levelling bolts to level the base plate.	Shown in figure *Base plate, orienting grooves and leveling bolts on page 82*.
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.

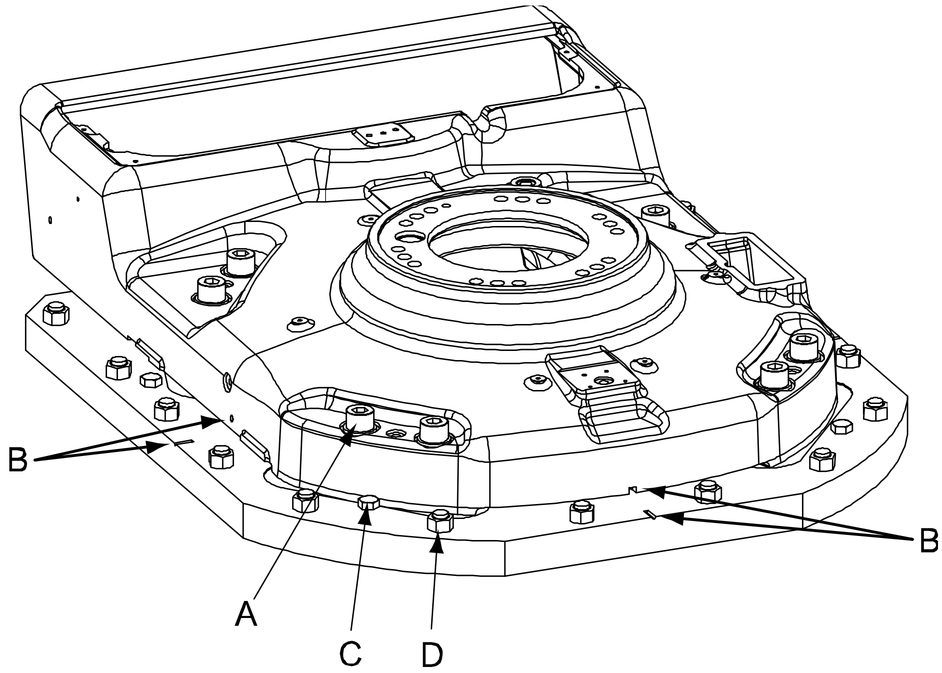
2.3.7 Orienting and securing the robot

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.



xx0300000566

A	Robot attachment bolts and washers, 8 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

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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 *Lifting robot with lifting slings on page 75*. See section *Lifting robot with round-slings on page 72*.
2	Move robot to the vicinity of its installation location.	
3	Fit two guide sleeves to the *guide sleeve holes* in the base plate.	Shown in figure *Base plate, guide sleeve holes on page 83*. **Note** 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 *bolts and washers* in the base attachment holes.	Specified in *Attachment screws on page 85*. Shown in figure *Illustration, robot fitted to base plate on page 85*. **Note** 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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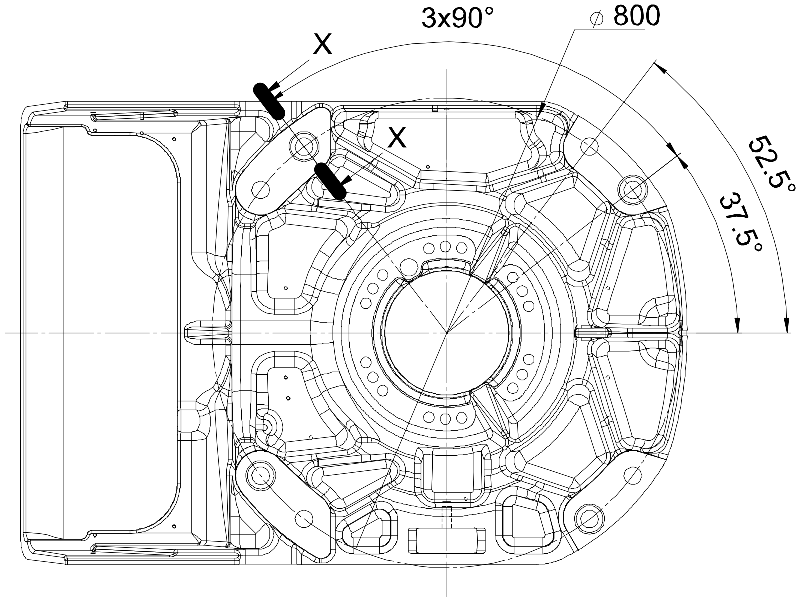
Hole configuration, base

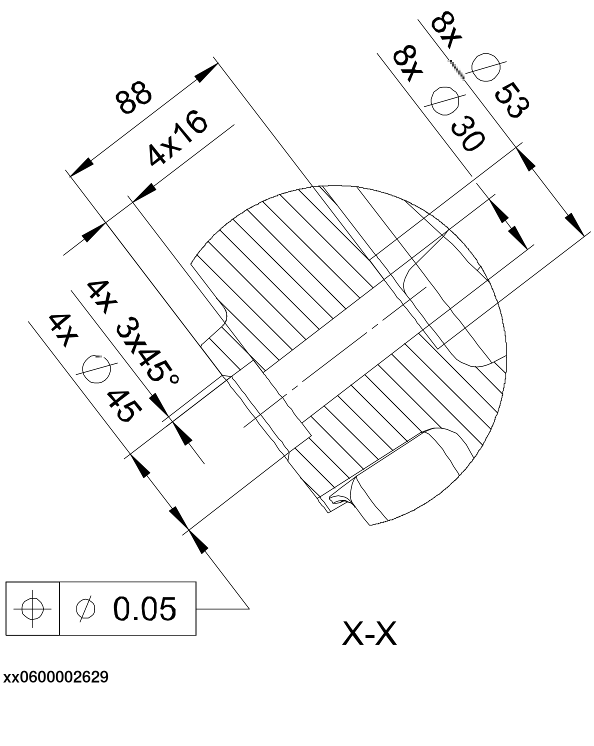
This illustration shows the hole configuration used when securing the robot.



xx0600002628

Cross section, guide sleeve hole

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



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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

No extra equipment may be fitted on the lower arm of the robot.

Illustration, fitting of extra equipment on upper arm

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

For fitting of extra vacuum hose all holes shall be used (6 pcs). These holes can **only** be used for extra vacuum hose!

The max. weight of the vacuum hose and fastening device on the upper arm, is calculated to 10 kg.

Max. extra weight on the upper arm:

- IRB 660 - 180/3.15 = 35 kg
- IRB 660 - 250/3.15 = 35 kg

Note! The weight of the extra equipment on the upper arm must be deducted from the maximal handling capacity.

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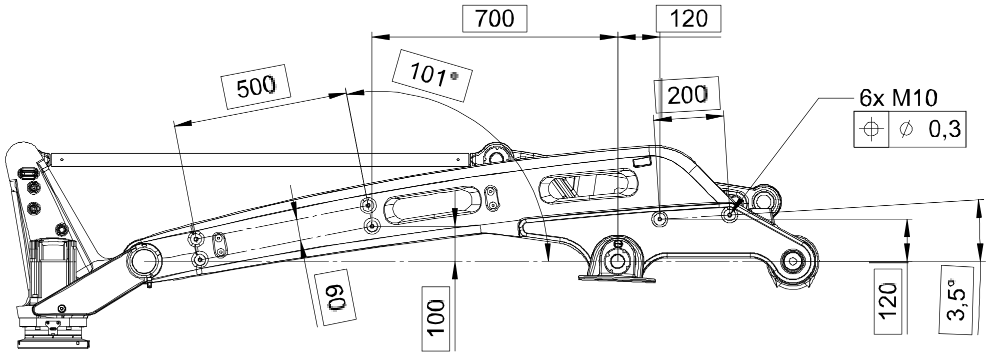
Example: If 35 extra kg is put on the upper arm, this means that the robot only can handle 180 - 35 = 145 kg or 250 - 35 = 215 kg (depending on model).

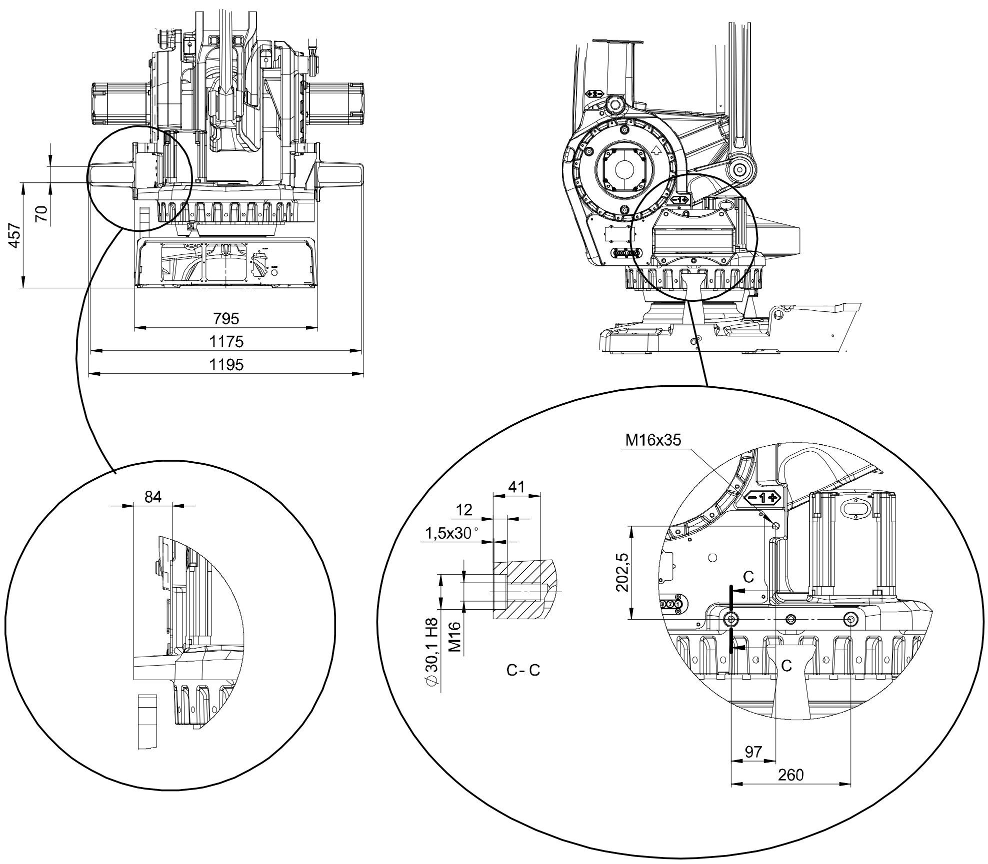


xx0500002289

A	Fitting holes, M10 (2 pcs)
B	Fitting holes, M10 (2 pcs)
C	Fitting holes, M10 (2 pcs)

Illustration, fitting of extra equipment on frame

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



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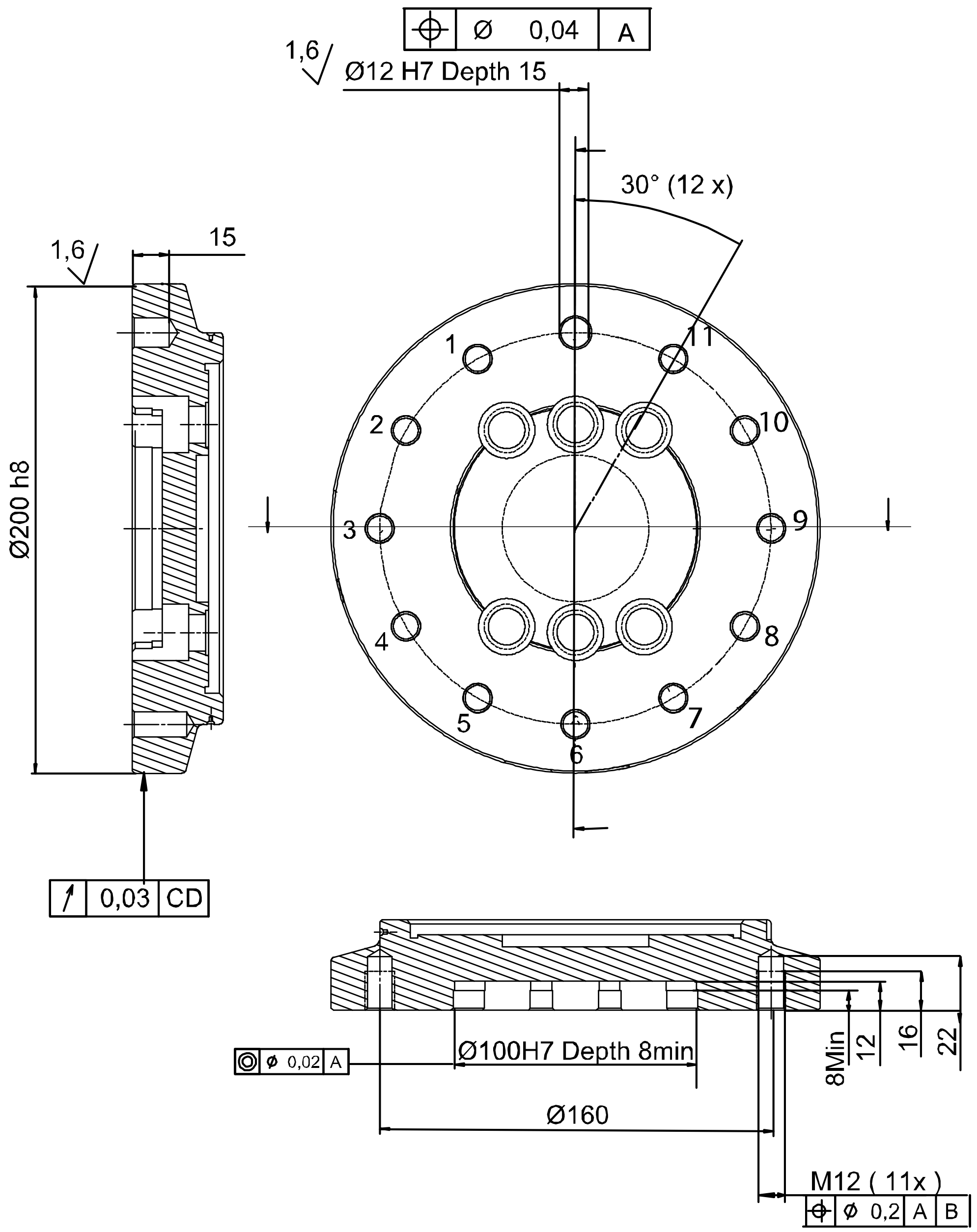
Illustration, fitting on turning disk

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



xx0500002292

-	Mounting flange.

Fastener quality

When fitting tools on the turning disk (see the figures above), only use screws with quality 12.9. When fitting other equipment to mounting holes standard screws with quality 8.8 may be used.

2.3.9 Installation of signal lamp (option)

Signal lamp

See the assembly instruction delivered with the signal lamp.

2.3.10 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:

- *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.

2.4 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)

As standard configuration, axis 1 is allowed to move ± 180º. The working range may however be increased to ± 220º with option 561-1 *Extended working range axis 1*. Note that this option also requires installation of a position switch on axis 1.

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.

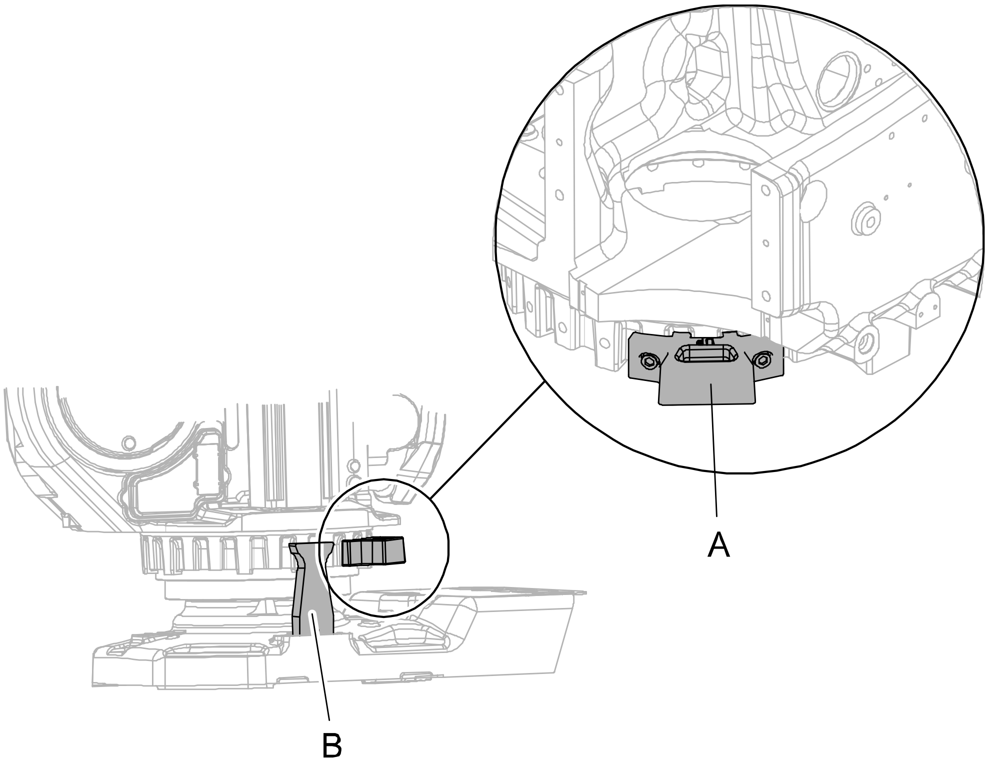
2.4.2 Mechanically restricting the working range of axis 1

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	-	
Technical reference manual - System parameters	-	Article number is specified in section *References on page 10*.

Continues on next page

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.

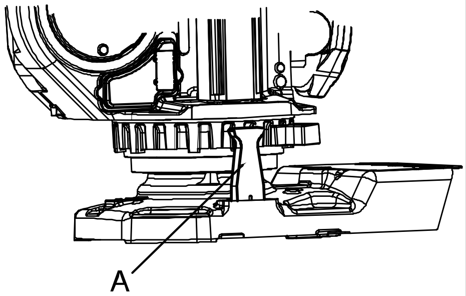
	Action	Note
1	**DANGER** Turn off all: • electric power supply to the robot • hydraulic pressure supply to the robot • air pressure supply to the robot Before entering the robot working area.	
2	Fit the additional mechanical stop to the frame according to the figure *Mechanical stops, axis 1 on page 94*.	Tightening torque: 120 Nm.
3	Adjust the software working range limitations (system parameter configuration) to correspond to the mechanical limitations.	The system parameters that must be changed (*Upper joint bound* and *Lower joint bound*) are described in *Technical reference manual - System parameters*.
4	**WARNING** If the mechanical stop pin is deformed after a hard collision, it must be replaced! Deformed *movable stops* and/or *additional stops* as well as deformed *attachment screws* must also be replaced after a hard collision.	

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 ± 220º.

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 *Electronic Position Switch*es. Configure Electronic Position Switches.	See *Application manual - Electronic Position Switches*.
3	Redefine the software working range limitations in the system parameters, topic *Motion*. The *Arm* parameters *Upper Joint Bound*and *Lower Joint Bound* must be changed to 3.84 respectively -3.84. The values are in radians, that is 3.84 radians = 220 degrees.	The system parameters that must be changed (*Upper joint bound* and *Lower joint bound*) are described in *Technical reference manual - System parameters*.

2.4.4 Installation of position switch, axis 1 (option)

General

Position switches can be installed on axis 1. The position switches include cams as shown in the figure below. The system parameter configuration must also be updated.

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

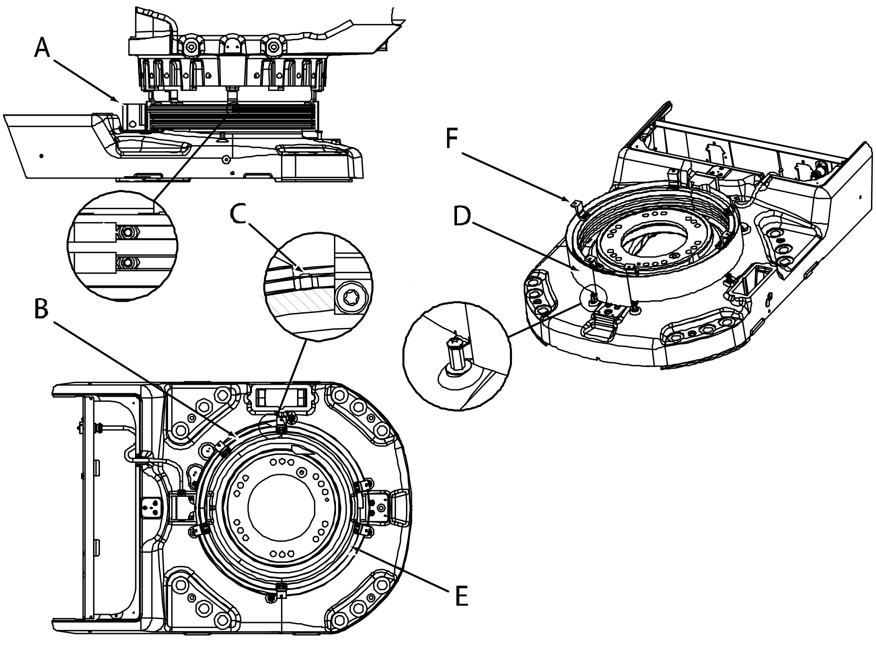
- Fitted by ABB on delivery. In this case, the cams must still be fitted and locked by the user. For axis 1, the cover for the cams must also be fitted.
- As sets to be completely fitted to the robot and adjusted by the user.

Required equipment

Description	Art.no.	Note
Position switch, axis 1	3HAC 15715-1	Includes position switch and plate for customer connections.
Connector kit R1.SW1	3HAC 17252-1	
Plate for customer connections	3HAC 025778-001	An additional connection plate must be fitted to the robot base, if not already installed.
Additional cabling to and inside the controller	-	

Axis 1

The illustration below shows the position switch for axis 1. The switch is connected directly to the connector in the base, R1.SW1.



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

Specifications

Maximum voltage/current for the position switches:

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

Connections

The position switch is 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 set is recommended. Art.no. is specified in *Required equipment on page 97*.

Further information about cables and connection points, see section *Robot cabling and connection points on page 104*.

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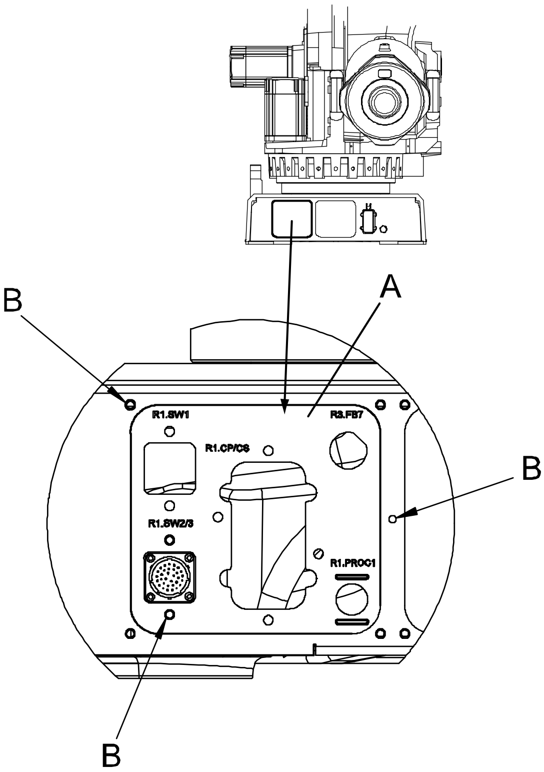
Plate customer connections, at base



xx0500002301

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

Installation of cable harness for position switch

The procedure below details how to fit the complete cable harness for position switch axis 1 to the robot.

	Action	Note
1	Move the robot to its calibration position.	
2	**DANGER** Turn off all: • electric power supply to the robot • hydraulic pressure supply to the robot • air pressure supply to the robot Before entering the robot working area.	

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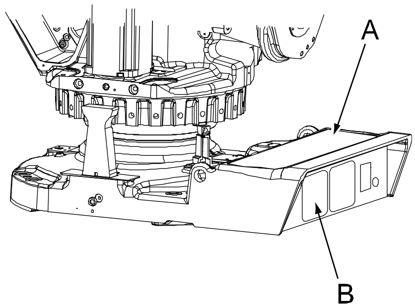
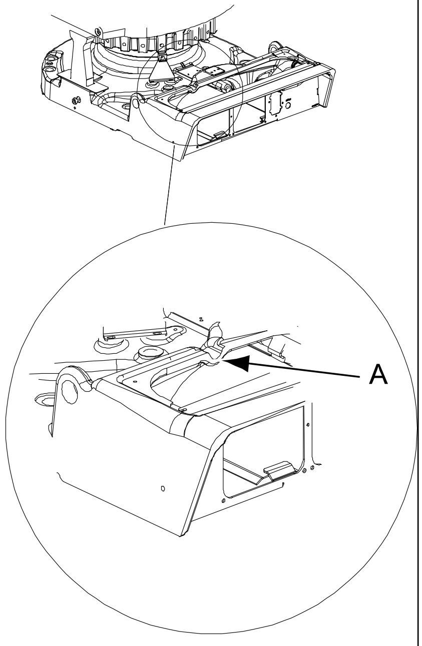
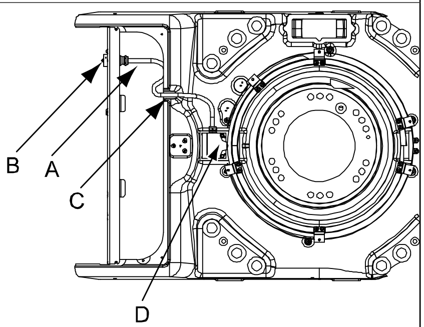
	Action	Note
3	Remove the rear cover (A) from the robot base.	 xx0500002306
4	Fit the position switch to the frame of the robot.	
5	Run the cabling through the notch in the base of the robot next to the rear cover.	 xx0600002625 • A: Notch for pos.switch cable
6	Connect the connector R1.SW1 to the position switch of axis 1 (D).	 xx0600002626 • A: Cable, pos.switch axis 1 • B: Connection point R1.SW1 • C: Notch for cable • D: Position switch, axis 1
7	Connect the connector R1.SW1 to the base of the robot (B).	See figure above!

Continues on next page

	Action	Note
8	Refit the rear cover to the robot base.	
9	Adjust the software working range limitations (system parameter configuration) to correspond to the mechanical limitations.	The system parameters that must be changed (*Upper joint bound* and *Lower joint bound*) are described in *Technical reference manual - System parameters*.
10	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in section *Calibration on page 319*.
11	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

Fitting and adjusting cams and stops

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

	Action	Note
1	Cut the cam to a suitable length.	Use a sharp knife and rubber hammer or similair.
2	Cut the edge of the cam edge to max 30°!	Shown in the figure *Illustration, cutting the cam on page 102*. 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 the figure *Illustration, cutting the cam on page 102*.	
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 the figure *Illustration, adjust and secure cams on page 102*.

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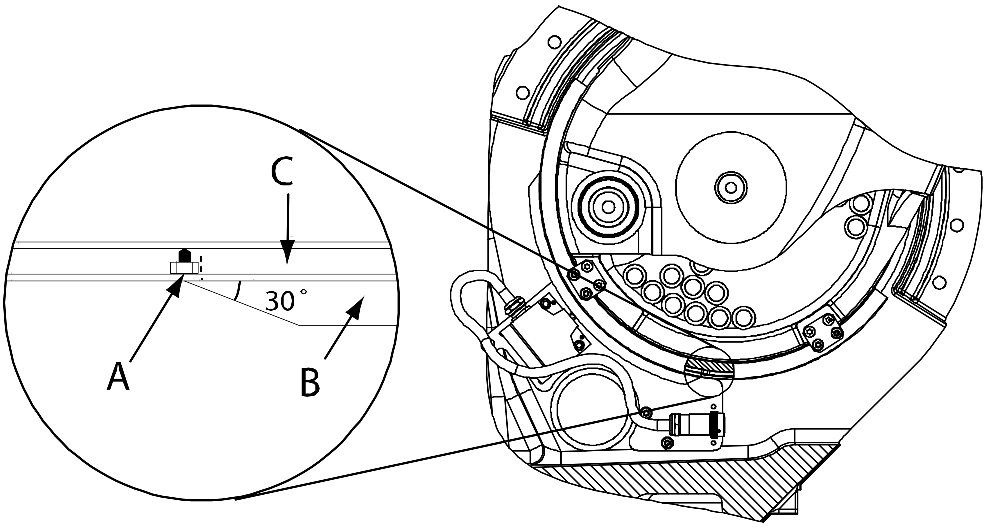
Illustration, adjust and secure cams

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

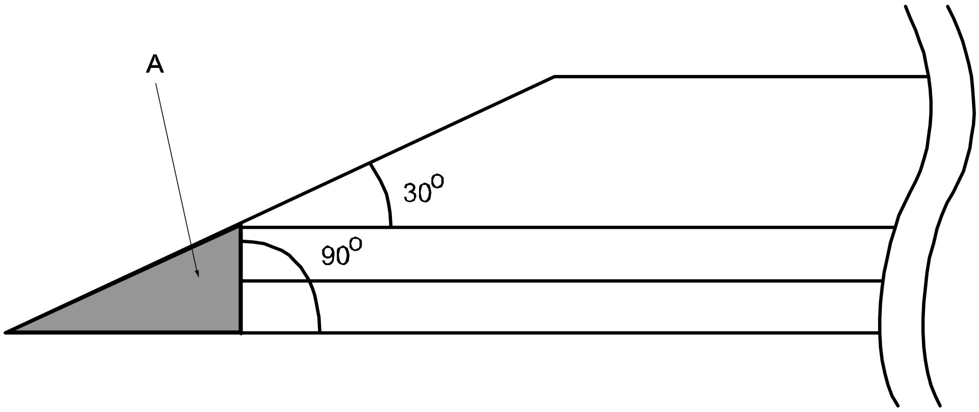


xx0100000113

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

Illustration, cutting the cam

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



xx0100000114

A	Remove the gray section

2.5 Robot in cold environments

2.5.1 Start of robot in cold environments

Introduction

This procedure describes how to start the robot in a cold environment.

Starting in cold environment

	Action	Note
1	Start the robot the normal way. Proceed to next step, if the robot does not start.	
2	Start the robot with its normal program but with reduced speed (<25%). Increase the speed to 100% after a couple of minutes.	The speed can be regulated with the RAPID instruction `AccSet`.

Adjusting the speed

Depending on how cold the environment is and the program being used, the ramping up of speed has to be adjusted. The table shows examples of how to adjust the speed:

Work cycles	`AccSet`	Speed/velocity
3 Work cycles	20.20	100
5 Work cycles	40.40	400
5 Work cycles	60.60	600
5 Work cycles	100.100	1000
More than 5 Work cycles	100.100	Max.

If the program consists of large wrist movements, it is possible that the reorientation velocity, which is always high in predefined velocities, needs to be included in the ramping up.

2.6 Electrical connections

2.6.1 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 *Robot cables on page 104*.
Position switch cables (option)	Handles supply to and feedback from any position switch on the robot. Specified in the table *Position switch cables, robot base to controller (option) on page 105*.
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 *References on page 10*.
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 *Application manual - Additional axes and stand alone controller (M2004)*, see document number in *References on page 10*.

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

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

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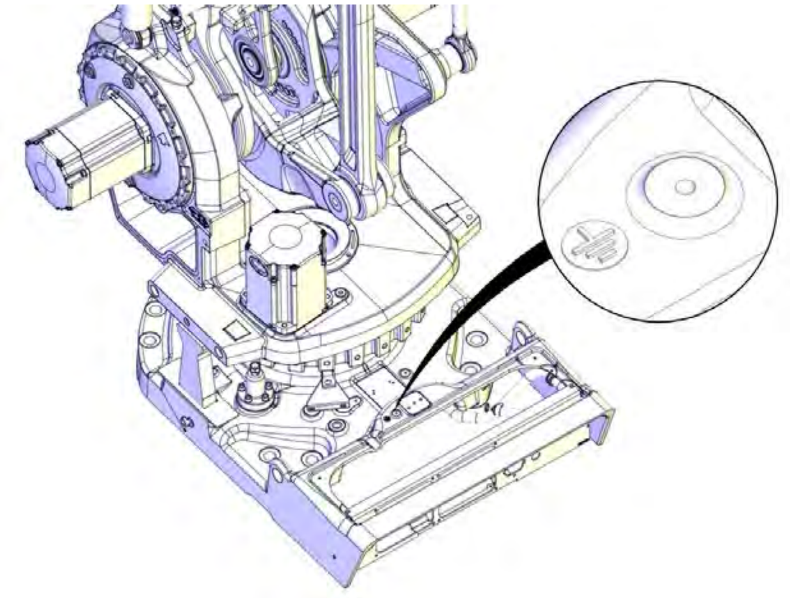
Robot cable, signals

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.



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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.

Cabling to be installed on the robot is specified in section *Installation of position switch, axis 1 (option) on page 97*.

Cabling between robot base and controller

In a M2004 robot system, the cables below are only used for position switch axis 1.

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

Continues on next page

Cable	Art. no.	Connection point, robot	Connection point, cabinet
Position switch cable, axis 1, 22 m	3HAC13175-3	R1.SW	XS8
Position switch cable, axis 1, 30 m	3HAC13175-4	R1.SW	XS8

Cabling inside control cabinet

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

Cable	Art. no.	Connection point 1 inside cabinet	Connection point 2 inside cabinet
Bracket in the cabinet wall (M2004)	3HAC020813-082	-	-
Harness position switch axis 1 (M2004)	3HAC021117-001	XS8	XT8.1 and XT8.2

3 Maintenance

3.1 Introduction

Structure of this chapter

This chapter describes all the maintenance activities recommended for the IRB 660.

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 17* before performing any service work!

Note

If the IRB 660 is connected to power, always make sure that the IRB 660 is connected to protective earth before starting any maintenance work!

For more information see:

- *Product manual - IRC5*

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 660:

- 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 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 table below.

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 111*

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

- *Inspection activities on page 112*
- *Replacement/changing activities on page 138*
- *Cleaning activities on page 157*

Activities and intervals, standard equipment

The table below specifies the required maintenance activities and intervals.

Maintenance activity	Equipment	Interval
Cleaning	Robot	-
Inspection	Axis-1 gearbox, oil level	Every: • 12 months months
Inspection	Axes-2 and -3 gearboxes, oil level	Every: • 12 months months
Inspection	Axis-6 gearbox, oil level	Every: • 12 months months
Inspection	Balancing device	Every: • 12 months
Inspection	Robot harness	Every: • 12 months[i]
Inspection	Information labels	Every: • 12 months
Inspection	Mechanical stop, axis 1	Every: • 12 months
Inspection	Dampers	Every: • 12 months
Changing	Axis-1 gear oil	First change when DTC[ii] reads: • 6,000 hours Second change when DTC [ii] reads: • 24,000 hours Following changes: • Every 24,000 hours

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Maintenance activity	Equipment	Interval
Changing	Axis 2 gear oil	First change when DTC [ii] reads: • 6,000 hours Second change when DTC [ii] reads: • 24,000 hours Following changes: • Every 24,000 hours
Changing	Axis-3 gear oil	First change when DTC [ii] reads: • 6,000 hours Second change when DTC [ii] reads: • 24,000 hours Following changes: • Every 24,000 hours
Changing	Axis-6 gear oil	First change when DTC [ii] reads: • 6,000 hours Second change when DTC [ii] reads: • 24,000 hours Following changes: • Every 24,000 hours
Overhaul	Robot	40,000 hours
Replacement	Battery pack, measurement system of type RMU101 or RMU102 (3-pole battery contact)	36 months or battery low alert [iii]
Replacement	Battery pack, measurement system with 2-pole battery contact, e.g. DSQC633A	Battery low alert [iv]
Lubrication	Balancing device bearings	Every 12,000 hours

i Replace when damage or cracks are detected or life limit is approaching as specified in section *Expected component life on page 111*.

ii DTC = Duty Time Counter. Shows the operational time of the robot.

iii 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.

iv 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.

Activities and intervals, optional equipment

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

Maintenance activity	Equipment	Interval
Inspection	Signal lamp	Every: 12 months
Inspection	Additional mechanical stop axis 1	Every: 12 months
Inspection	Position switches, axis 1	Every: 12 months

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 [i]	40,000 hours [ii]	Not including: • Possible SpotPack harnesses • Optional upper arm harnesses
Cable harness Extreme usage [iii]	20,000 hours [ii]	Not including: • Possible SpotPack harnesses • Optional upper arm harnesses
Balancing device	40,000 hours [iv]	
Gearboxes [v]	40,000 hours	

i Examples of "normal usage" in regard to movement: most material handling applications.
See the note in the Product specification about warrenty, when running the robot in a cold environment (0°C to 5°C).

ii Severe chemical or thermal environments, or similar environments, can result in shortened life expectancy.

iii Examples of "extreme usage" in regard to movement: press tending, very severe palletizing applications, major use of axis 1 movement.

iv 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!

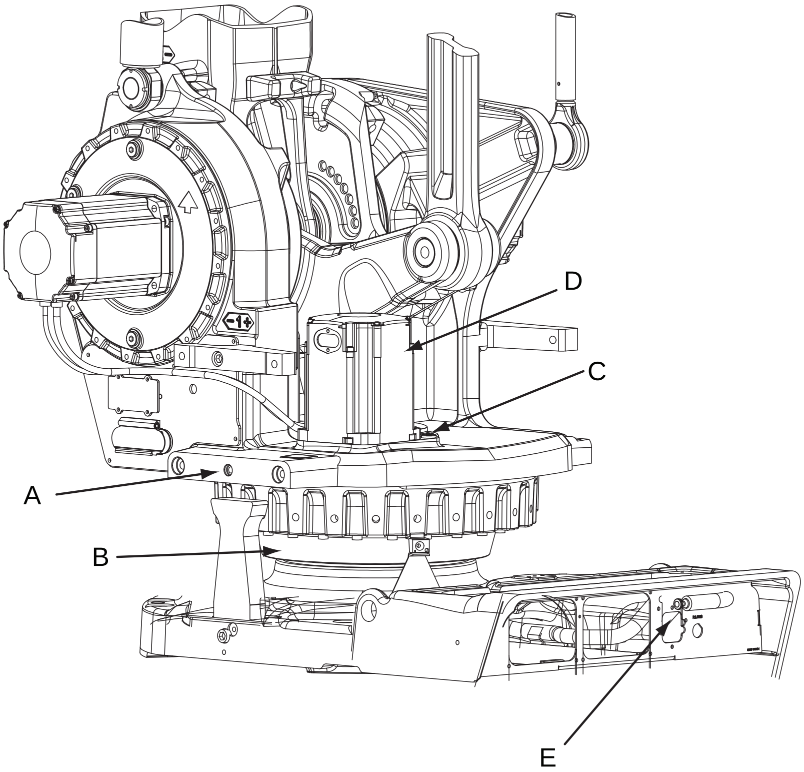
v Depending on application, the lifetime can vary. The Service Information System (SIS) that is integrated in the robot software can be used as guidance when planning gearbox service for the individual robot. This applies to gearboxes on axes 1, 2, 3 and 6. The lifetime of gearbox axes 4 and 5 is not 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*.

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.



xx0500002479

A	Oil plug, inspection
B	Gearbox, axis 1
C	Oil plug filling
D	Motor, axis 1
E	Drain hose (Behind cover)

Required equipment

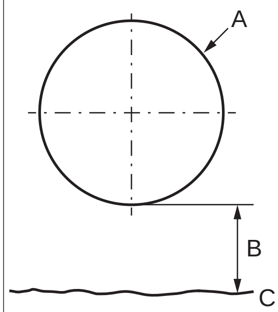
Equipment	Art. no.	Note
Lubricating oil	See *Type and amount of oil in gearboxes on page 138*.	**Note** Do not mix with other oils!
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.

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.

Inspecting the oil level in axis-1 gearbox

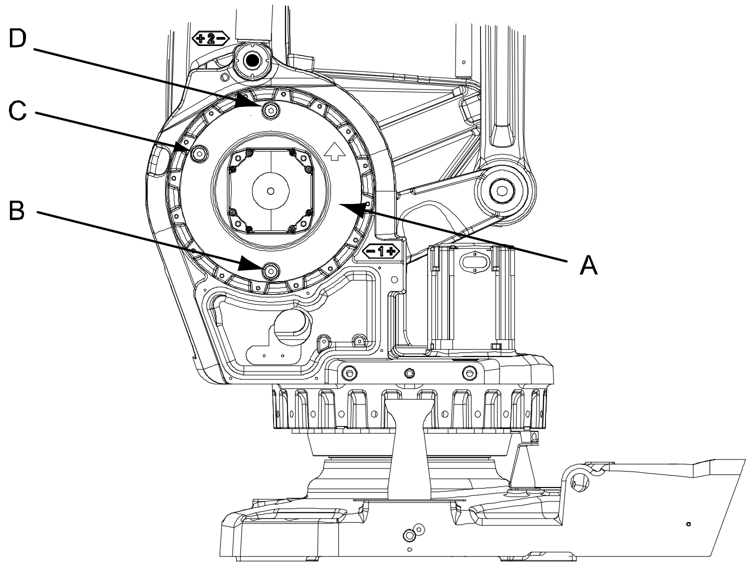
Use this procedure to inspect the oil level in the axis-1 gearbox.

	Action	Note
1	**WARNING** Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section *WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 56*.	
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, 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 *oil plug, inspection*.	Shown in figure *Location of gearbox on page 112*.
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 *Type of lubrication in gearboxes on page 138*. Further information about how to fill with oil is found in section *Changing oil, axis-1 gearbox on page 140*.
7	Refit the oil plug.	Tightening torque:

3.3.2 Inspecting, oil level gearbox axes 2 - 3

Location of gearbox, axes 2-3

The gearboxes axes 2-3 are located in the lower arm rotational center, underneath the motor attachment.



xx0500002482

A	Gearbox, axis 2
B	Oil plug, draining
C	Oil plug, filling
D	Ventilation hole, gearbox axis 2

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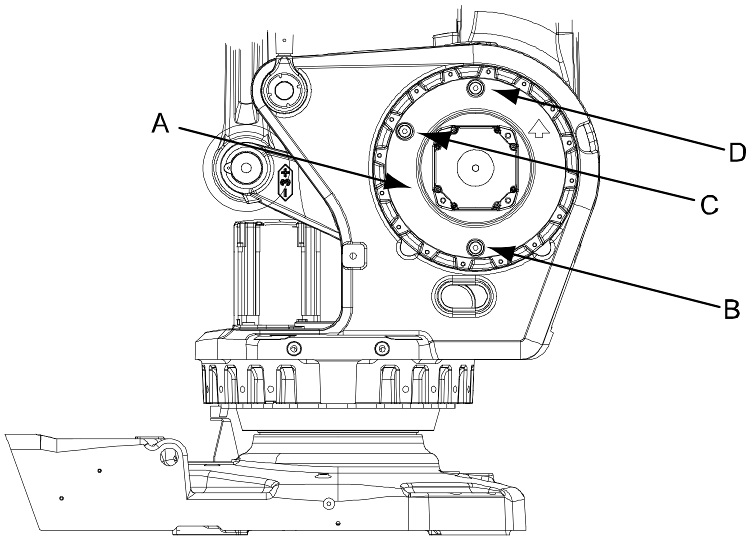


xx0500002483

A	Gearbox, axis 3
B	Oil plug, draining
C	Oil plug, filling
D	Ventilation hole, gearbox axis 3

Required equipment

Equipment etc.	Art.no.	Note
Lubricating oil	See *Type and amount of oil in gearboxes on page 138*.	**Note** Do not mix with other oils!
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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, oil level gearbox 2 - 3

Use this procedure to inspect the oil level in gearbox axes 2 - 3.

	Action	Note
1	**WARNING** Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section *WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 56*.	

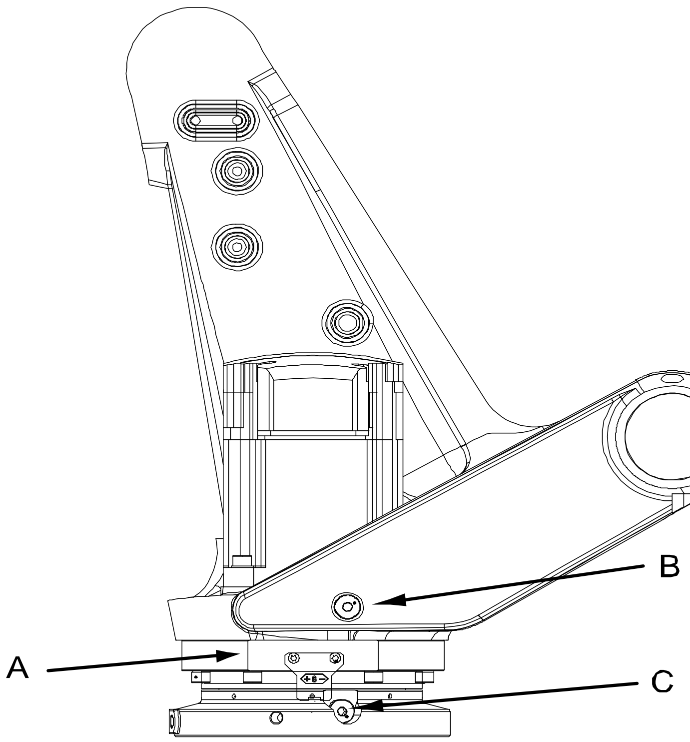
Continues on next page

	Action	Note
2	**DANGER** Turn off all: • electric power supply to the robot • hydraulic pressure supply to the robot • air pressure supply to the robot Before entering the robot working area.	
3	Open *oil plug, filling*	See *Location of gearbox, axes 2-3 on page 114*.
4	Measure oil level at the oil plug, filling. Required oil level: max. 5 mm below oil plug hole.	
5	Add *oil* if required.	Art.no. is specified in *Required equipment on page 115*. Filling of oil is detailed further in section *Changing oil, gearbox axes 2 and 3 on page 143*.
6	Refit oil plug, filling.	Tightening torque: 24 Nm.

3.3.3 Inspecting, oil level gearbox axis 6

Location of gearbox

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



xx0500002484

A	Gearbox, axis 6
B	Oil plug, filling
C	Oil plug, draining

Required equipment

Equipment	Art. no.	Note
Lubricating oil	3HAC0860-1	Optimol Optigear BM 100
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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

Inspection, oil level axis-6 gearbox

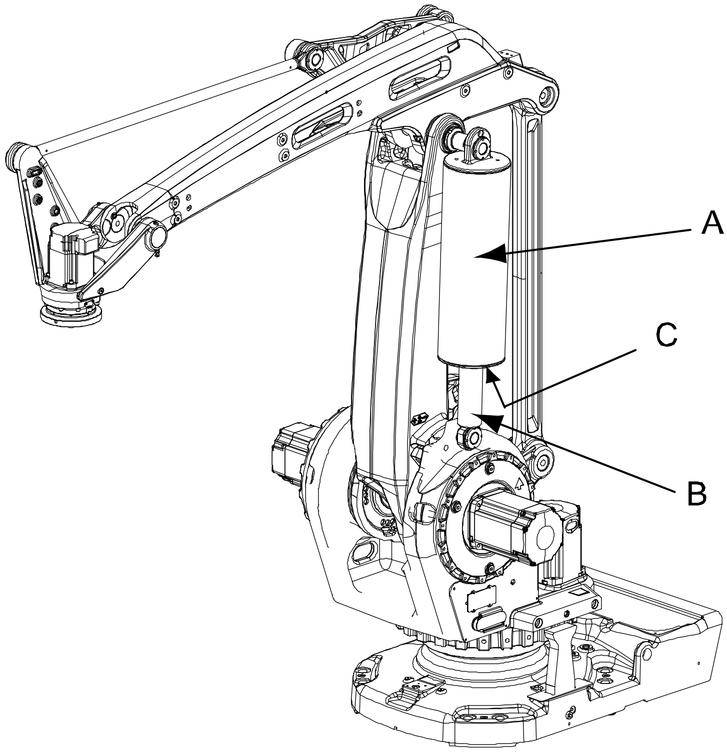
Use this procedure to inspect the oil level in the axis-6 gearbox.

	Action	Note
1	**WARNING** Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section *WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 56*.	
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Open *oil plug, filling*.	Shown in figure *Location of gearbox on page 117*.
4	Required oil level: max. 5 mm below the oil plug hole.	
5	Add *oil* if required.	Art. no. is specified in *Required equipment on page 117*. Further information about how to fill the oil may be found in the section *Changing oil, gearbox axis 6 on page 147*.
6	Refit oil plug, filling.	Tightening torque: 24 Nm.

3.3.4 Inspecting, balancing device bearings and piston rod guide ring

Location of balancing device

The figure shows the location of the balancing device.



xx0500002495

A	Balancing device
B	Piston rod
C	Guide ring (not visible in this figure)

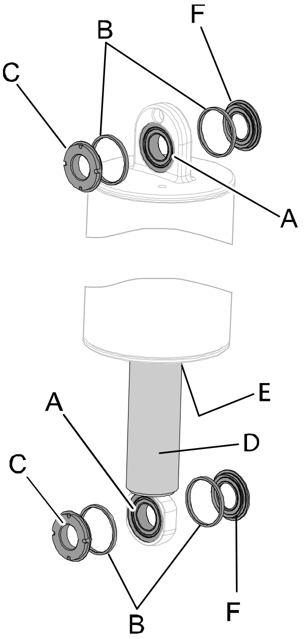
Required equipment

Equipment	Art.no	Note
Grease	3HAB3537-1	
Locking liquid	-	Loctite 243
Auxiliary shaft, upper	3HAC5276-1	
Auxiliary shaft, lower	3HAC5275-1	
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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.

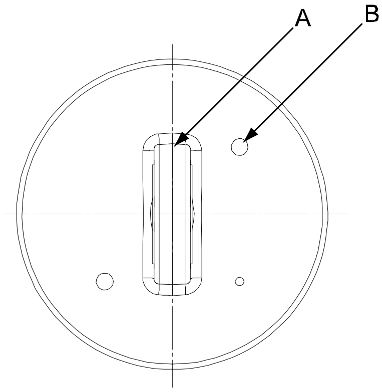
Continues on next page

Inspecting, bearings

Use this procedure to inspect the bearings, balancing device.

	Action	Note
1	Move axis 2 to calibration position.	
2	 **DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Remove locknuts (KM10), sealing rings and support washers.	 xx0500002496 A Ear (adjustable needle bearing located inside) B Support washer C Lock nut KM10 (with sealing ring) D Piston rod E Guide ring (not visible in this view) F Inner ring
4	Fit the *auxiliary shafts* on upper and lower axes of balancing device. The shafts should be tightened to their bottom position.	Art. no. is specified in *Required equipment on page 119*.

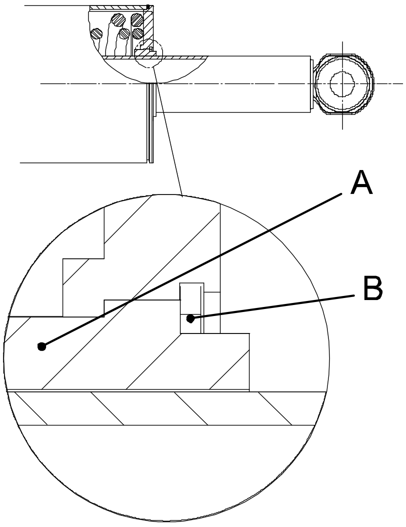
Continues on next page

	Action	Note
5	Remove the protection hood from the M12 hole on top of the balancing device.	 xx0600002687 A Attachment (seen from above) B Protection hood
6	Unload the bearings using a M12x50 screw, in the hole for the protective hood, at the cylinder top.	
7	Pull out the cylinder a little, in order to be able to inspect the *inner rings* without removing the balancing cylinder.	Shown in previous figure in this procedure.
8	Wipe the inner rings clean and check that there are no pressure marks or other similar deformations.	**Note** It is quite normal for the bearing races to have a darker color than the surrounding material.
9	Inspect the *bearings*, *support washers* and *sealing rings*.	Shown in previous figure.
10	If any of the parts looks abnormal, replace.	Detailed in section *Replacing the balancing device on page 249*.
11	Lubricate the shafts, if needed.	
12	Push the cylinder back in.	Make sure that the inner support washers and sealing rings get in the correct position.
13	Remove the auxiliary shafts.	
14	Remove the M12x50 screw. Put back the protection hood in the hole.	**Note** Don´t forget to remove the screw! If the screw isn´t removed it may damage the balancing device, when the robot starts operating.
15	Apply *locking liquid* on the lock nuts (KM10) and refit them.	Tightening torque on the lock nuts: • 120 Nm

Continues on next page

Inspecting, piston rod guide ring

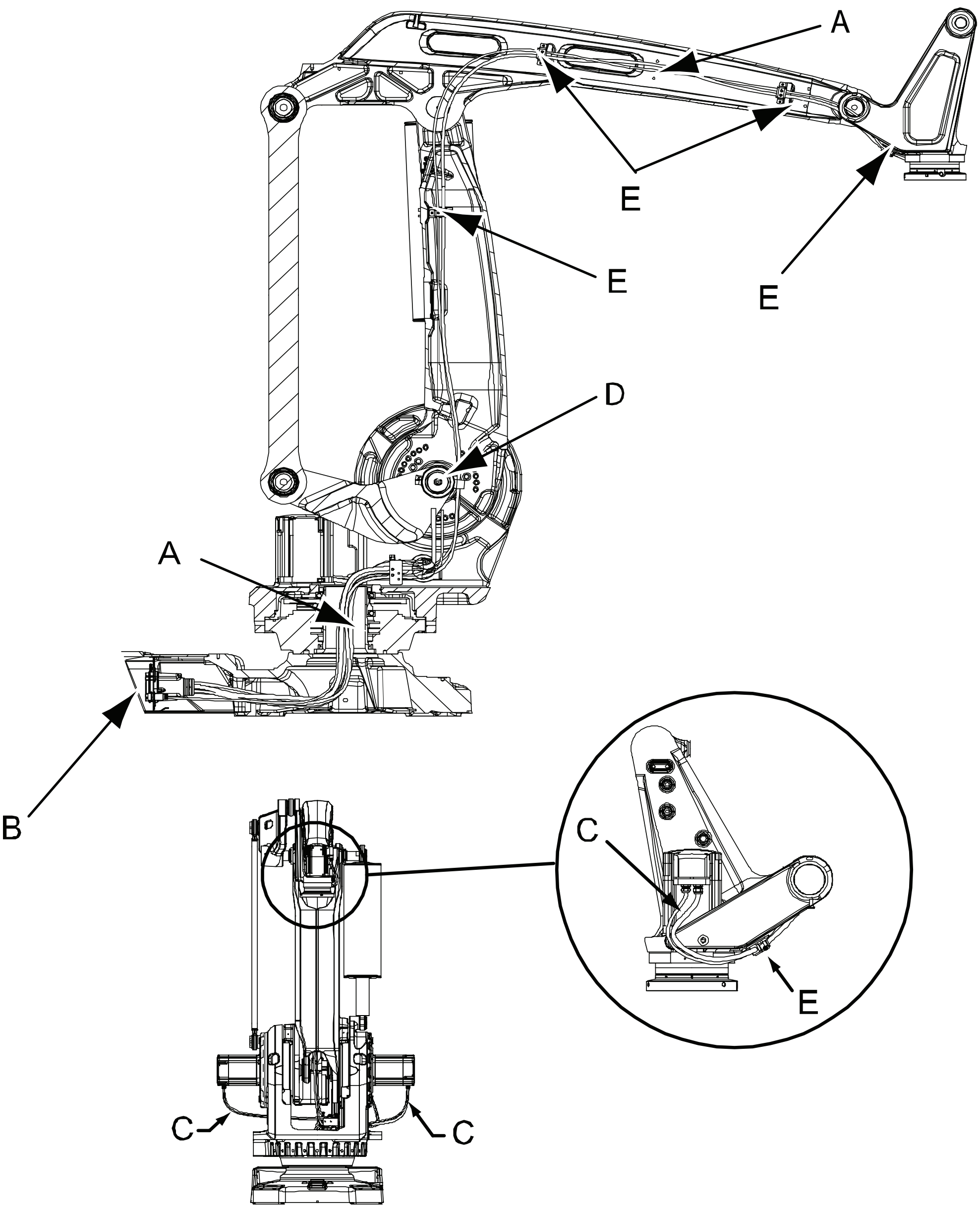
Use this procedure to inspect the piston rod guide ring for wear.

	Action	Note
1	Move axis 2 to a position where the balancing device is in a horizontal position.	
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Check the guide ring for wear. Replace if necessary.	 xx0600002689 A Guide ring B Circlip
4	**Note** If there is a risk of metallic contact between the piston rod and the end cover, the guide ring must be replaced!	

3.3.5 Inspecting, cable harness

Location of cable harness, axes 1-6

The axes-1-6 cable harness is shown below.



xx0500002497

A	Cable harness robot, axes 1-6
B	Connectors at base
C	Motor cables
D	Cable guide, axis 2
E	Metal clamps

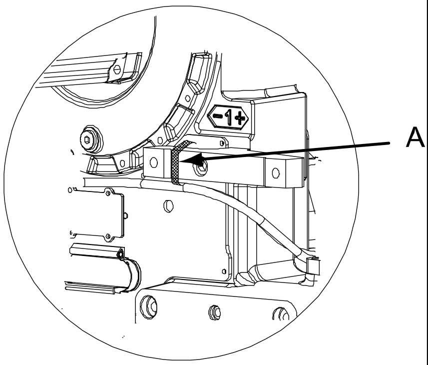
Continues on next page

Required equipment

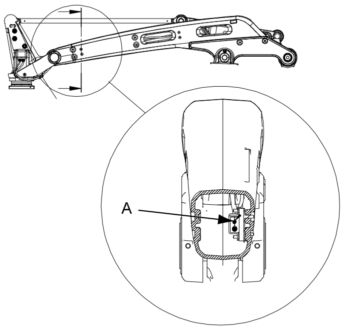
Visual inspection, no tools are needed.

Inspecting cable harness, axes 1-6

Use this procedure to inspect cable harness of axes 1-6.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
2	Make an overall inspection of the cable harness in order to detect wear and damage.	
3	Check the *connectors at the base*.	Shown in figure *Location of cable harness, axes 1-6 on page 123*
4	Check the *motor cables*.	Shown in figure *Location of cable harness, axes 1-6 on page 123*.
5	If the robot is equipped with a fork lift device, check that the velcro strap that holds the motor cable is properly attached to the adapter.	 xx0600002691 Velcro strap
6	Check the *cable guide axis 2*. Replace if damaged.	Shown in figure *Location of cable harness, axes 1-6 on page 123*.
7	Check the *metal clamps* on the lower arm.	Shown in figure *Location of cable harness, axes 1-6 on page 123*

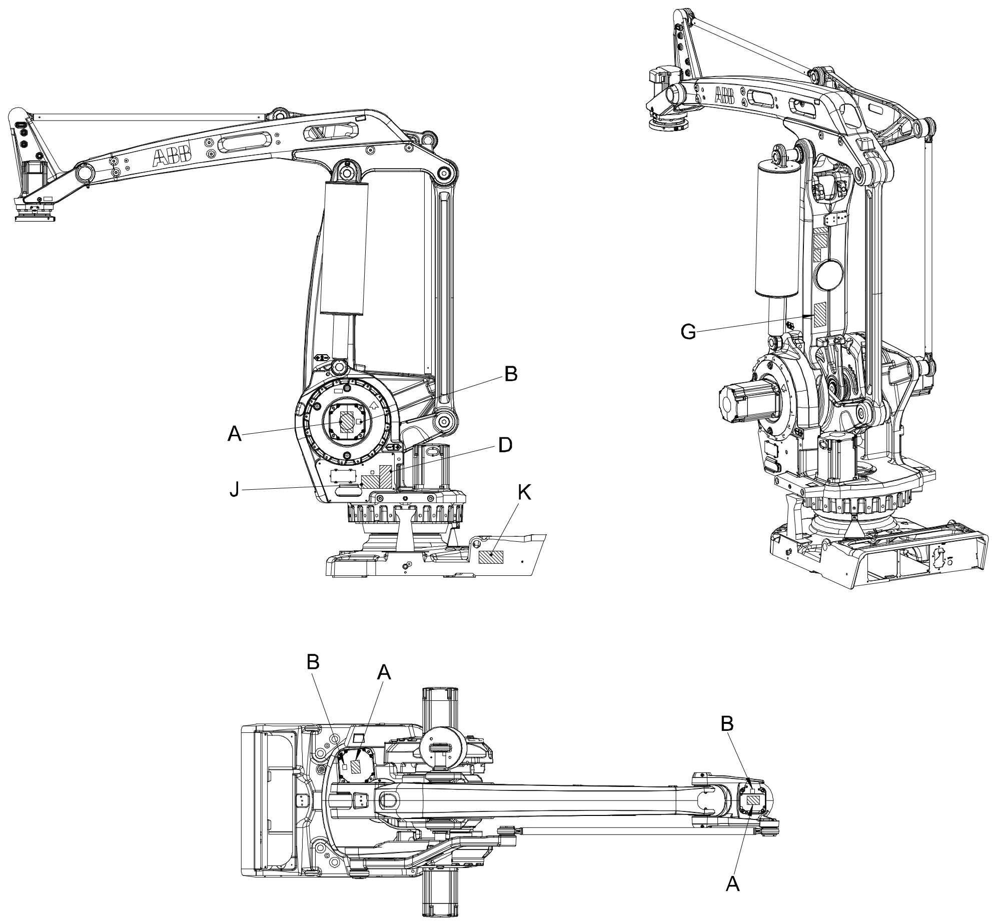
Continues on next page

	Action	Note
8	Check the metal clamps holding the cable harness inside the upper arm, as shown in figure to the right.	 xx0500002498 A: Metal clamp inside upper arm
9	Check the metal clamp holding the motor cable on axis 6.	Shown in figure *Location of cable harness, axes 1-6 on page 123*.
10	Replace the cable harness if wear or damage is detected!	Detailed in section: *Replacing cable harness, lower end (axes 1-3) on page 165*. *Replacing the cable harness, upper end (incl. axis 6) on page 173*.

3.3.6 Inspecting the information labels

Location of labels

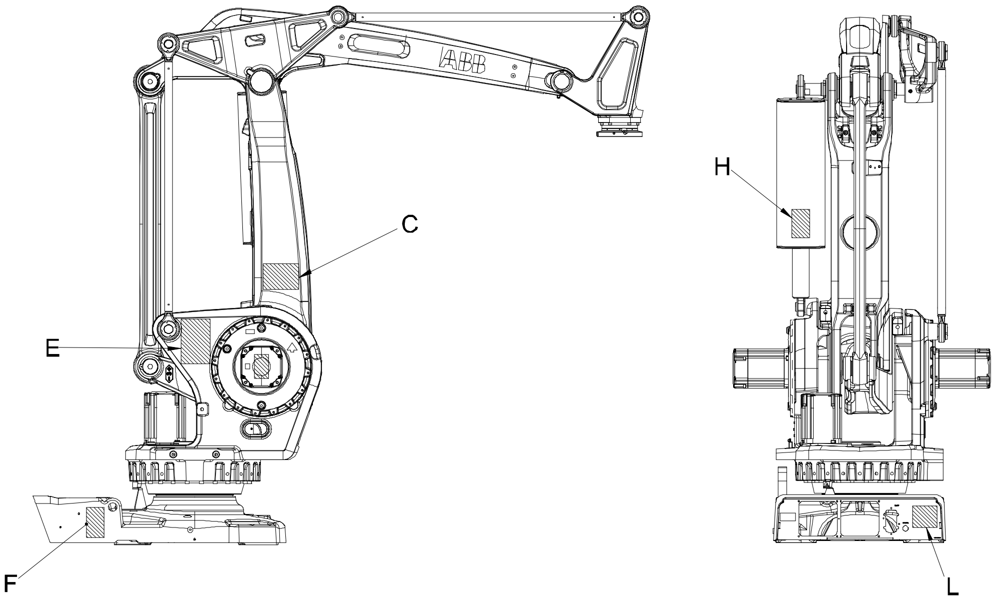
These figures show the location of the information labels to be inspected. The symbols are described in section *Safety symbols on product labels on page 44*.



xx0500002499

A	Warning label concerning high temperature (located on motor cover) (4 pcs)
B	Warning label, symbol of flash (located on motor cover) (4 pcs)
D	Warning label concerning brake release
G	Warning label
J	Warning label
K	Warning label concerning extended working range (option)
-	Information labels at gearboxes and at robot base, specifying which oil is used in gearboxes.

Continues on next page



xx0500002500

C	Instruction label
E	Instruction label concerning lifting the robot
F	Warning label concerning risk of tipping
H	Warning label concerning stored energy
L	Information label at base, Kyodo Yushi TMO 150 in gearboxes

Required tools and equipment

Visual inspection, no tools are required.

Inspecting, labels

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply 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 *Spare part lists on page 365*.

3.3.7 Inspecting the axis-1 mechanical stop pin

WARNING

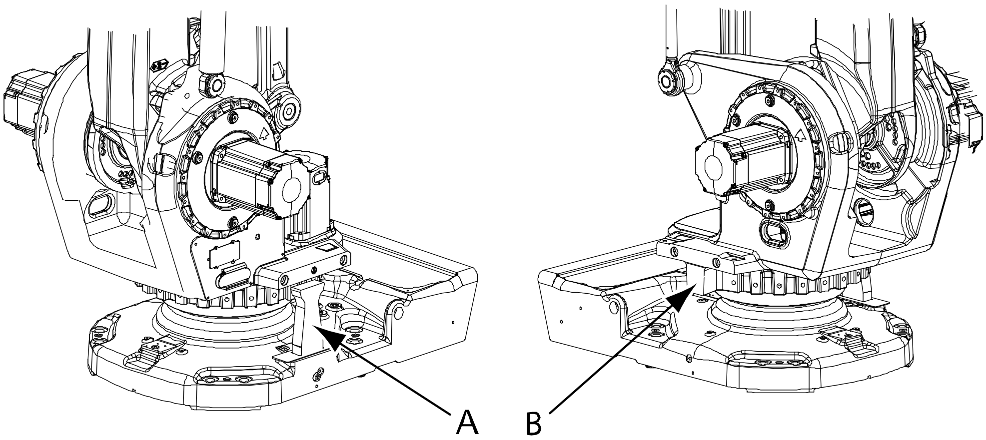
Mechanical stop pin can not be fitted onto robot if option 810-1 *Electronic Position Switch* is used.

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 at the base as shown in the figure.



xx0600002695

A	Mechanical stop pin
B	Fixed stop

Required equipment

Visual inspection, no tools are required.

Inspecting, mechanical stop pin

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

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	

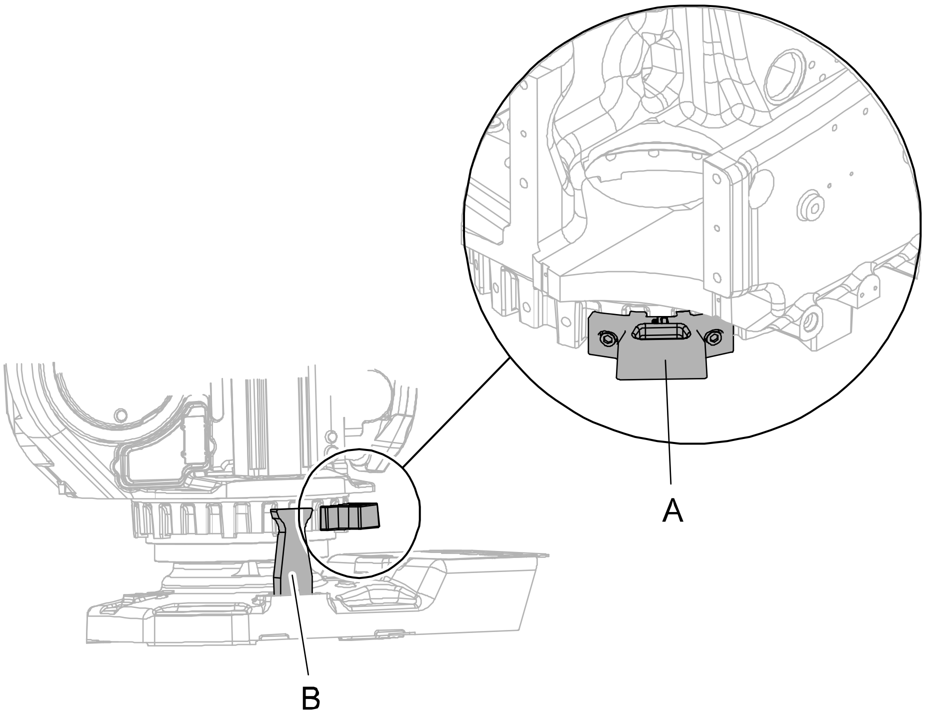
Continues on next page

	Action	Note
2	Inspect the axis-1 mechanical stop pin. If the mechanical stop pin is bent or damaged, it must be replaced! **Note** The expected life of gearboxes can be reduced as a result of collisions with the mechanical stop.	Shown in figure *Location of mechanical stop pin on page 128*.
3	Make sure the mechanical stop pin can move in both directions.	

3.3.8 Inspecting the additional mechanical stops

Location of mechanical stops

This figure shows the location of the additional mechanical stops on axis 1. (The figure shows IRB 7600 but the location on axis 1 is the same on IRB 660.)



xx0300000049

A	Additional mechanical stop
B	Stop pin

Required equipment

Equipment etc.	Article number	Note
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.

Inspecting, mechanical stops

Use this procedure to inspect the additional mechanical stops.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	

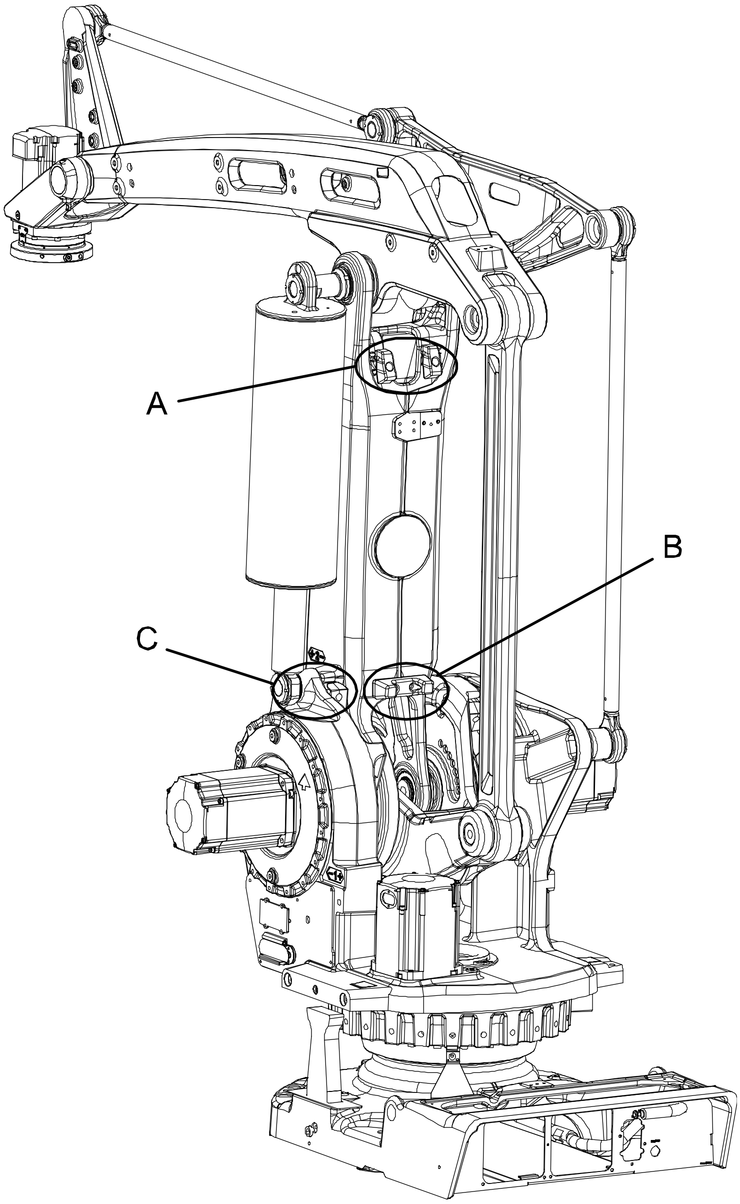
Continues on next page

	Action	Note
2	Make sure no additional stops are damaged.	Shown in figure *Location of mechanical stops on page 130*.
3	Make sure the stops are properly attached. Correct tightening torque, additional mechanical stops: • Axis 1 = 115 Nm	
4	If any damage is detected, the mechanical stops must be replaced! Correct attachment screws: • Axis 1: M16 x 35, quality 12.9.	Article number is specified in *Required equipment on page 130*.

3.3.9 Inspection, dampers

Location of dampers

This figure shows the location of dampers.



xx0500002501

A	Damper, lower arm, upper (2 pcs)
B	Damper, lower arm, lower (1 pc)
C	Damper, axis 2 (2 pcs)
-	Damper, axis 3 (2 pcs). Not visible in this view.

Continues on next page

Required equipment

Equipment	Art.no.	Note
Damper lower arm, upper	See *Spare part lists on page 365*.	To be replaced if damaged.
Damper lower arm, lower	See *Spare part lists on page 365*.	To be replaced if damaged.
Damper axis 2, 3	See *Spare part lists on page 365*.	To be replaced if damaged.

Inspecting, dampers

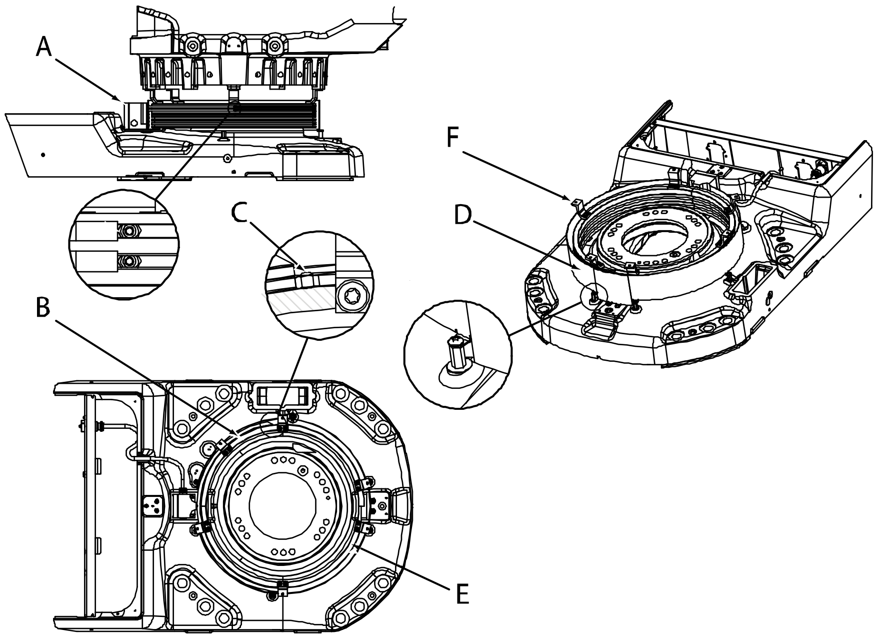
Use this procedure to inspect the dampers.

	Action	Note
1	**DANGER** Turn off all: • electric power supply to the robot • hydraulic pressure supply to the robot • air pressure supply to the robot Before entering the robot working area.	
2	Check all *dampers* for damage, cracks or existing impressions larger than 1 mm.	Shown in figure *Location of dampers on page 132*.
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 *Required equipment on page 133*.

3.3.10 Inspection, position switch axis 1

Position switch, axes 1

The illustration below shows the position switch for axis 1.



xx0100000158

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

Required equipment

Equipment	Art.no	Note
Position switch, axis 1	3HAC 024854-001	
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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

Inspection, position switch

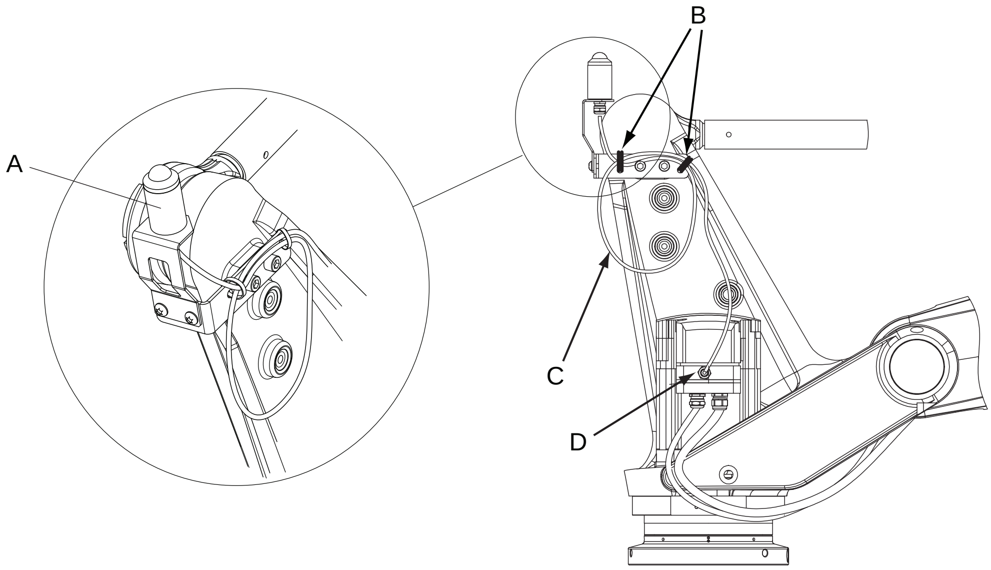
The procedure below details how to inspect the position switch, axis 1.

	Action	Note
1	**DANGER** Turn off all: • electric power supply to the robot • hydraulic pressure supply to the robot • air pressure supply to the robot Before entering the robot working area.	
2	Check the position switch! • Check that the rollers are easy to push in and that they roll freely.	
3	Check the rail! • Check that the rail is firmly attached with the attachment screws.	
4	Check the cams! • Check that the rollers have not caused any impressions on the cams. • Check that the cams are clean. Wipe them if necessary! • Check that the set screws holding the cams in position are firmly attached.	
5	Check the protection sheets on axis 1! • Check that the three sheets are in position and not damaged. Deformation can result in rubbing against the cams! • Check that the area inside of the sheets is clean enough not to interfere with the function of the position switch.	
6	If any damage is detected, the position switch must be replaced!	

3.3.11 Inspecting the signal lamp (option)

Location of signal lamp

The signal lamp is located as shown in this figure.



xx0500002466

A	Signal lamp
B	Cable straps, outdoor
C	Cable
D	Connection point to cable gland

Required tools and equipment

Equipment	Article number	Note
Signal lamp kit	See *Spare part lists on page 365*.	To be replaced if damage is detected.
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.

Inspecting, signal lamp

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

	Action	Note
1	Inspect that signal lamp is lit when motors are put in operation ("MOTORS ON").	

Continues on next page

	Action	Note
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	If the lamp is not lit, trace the fault by: • inspecting whether the signal lamp is broken. If so, replace it. • inspecting cable connections. • measuring the voltage in the connectors of motor axis 6 (=24V). • inspecting the cabling. Replace the cabling if a fault is detected.	Article number is specified in *Required tools and equipment on page 136*.

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

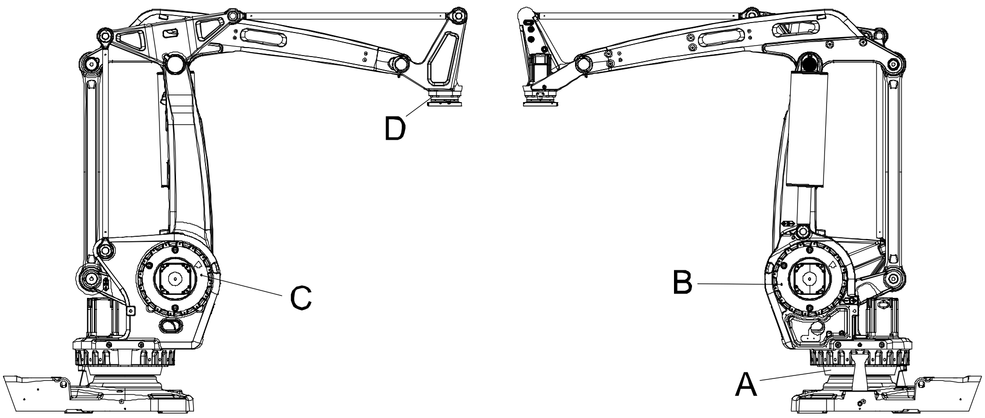
Information about the *type of lubrication*, *article number* as well as the *amount* in the specific gearbox can be found in *Technical reference manual - Lubrication in gearboxes* on the Documentation DVD (released twice a year). The revision of the manual published on the Documentation DVD will contain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



xx0500002467

A	Gearbox, axis 1
B	Gearbox, axis 2
C	Gearbox, axis 3
D	Gearbox, axis 6

Continues on next page

Equipment

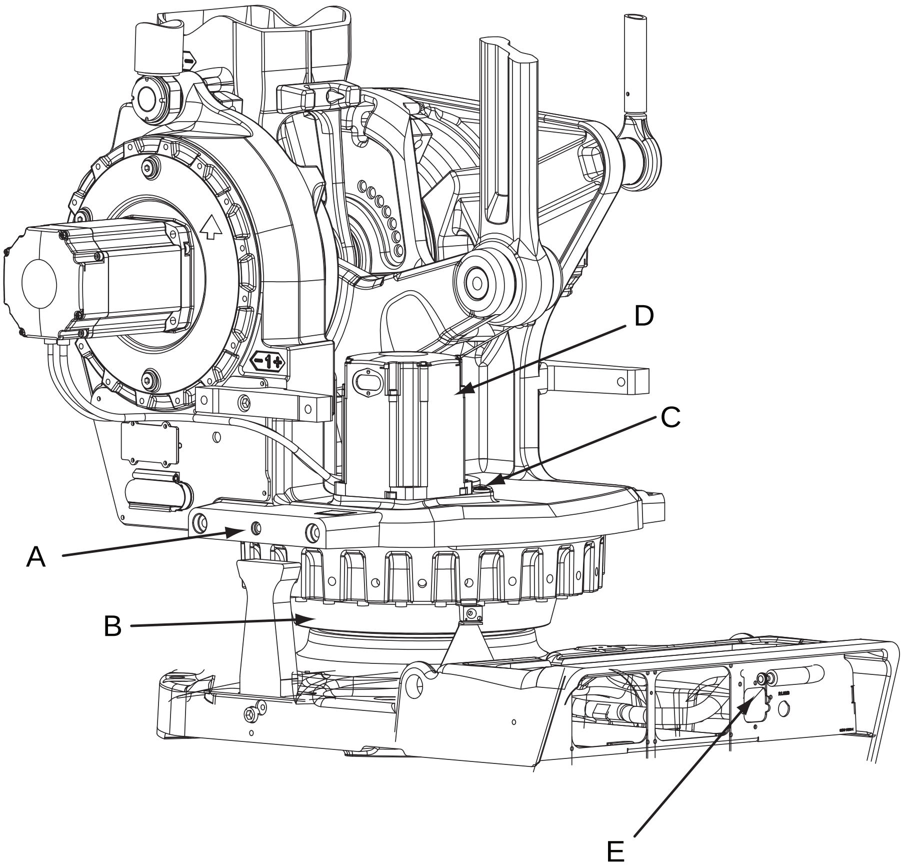
Equipment	Note
Oil dispenser	Includes pump with outlet pipe. Use the suggested dispenser or a similar one: • Orion OriCan art. no. 22590 (pneumatic)
Nipple for quick connect fitting, with o-ring	

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.

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



xx0500002479

A	Oil plug, inspection
B	Gearbox axis 1
C	Oil plug, filling
D	Motor, axis 1
E	Drain hose

Required equipment

Equipment, etc.	Art. no.	Amount	Note
Lubricating oil	See *Type and amount of oil in gearboxes on page 138*.	See *Type and amount of oil in gear-boxes on page 138*.	**Note** Do not mix with other oils!
Oil collecting vessel	-		Capacity: 8,000 ml.

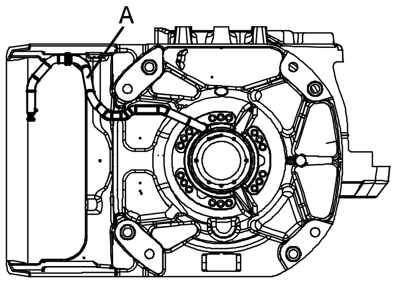
Continues on next page

Equipment, etc.	Art. no.	Amount	Note
Oil exchange equipment	3HAC021745-001		Content is defined in section *Special tools on page 360*.
Standard toolkit	-		Content is defined in section *Standard tools on page 359*.

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 140*.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
2	**WARNING** Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section *WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 56*.	
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 *Required equipment on page 140*.
6	Remove *oil plug, filling* in order to drain oil quicker!	Shown in figure *Location of oil plugs on page 140*.

Continues on next page

	Action	Note
7	Open the hose end and drain the oil into a vessel. **CAUTION** Drain as much oil as possible. See *WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 56*.	**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.

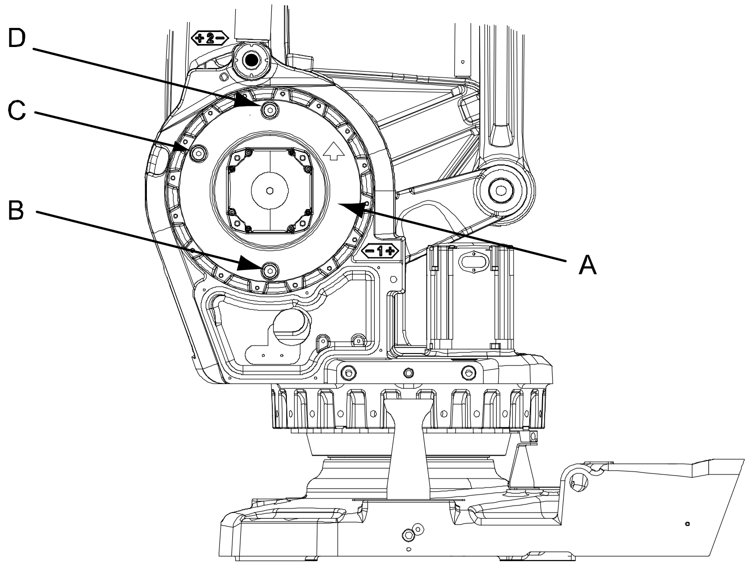
	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
2	**WARNING** Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section *WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 56*.	
3	Open the *oil plug, filling.*	Shown in figure *Location of oil plugs on page 140*.
4	Refill the gearbox with clean *lubricating oil.* The correct oil level is detailed in section *Inspecting the oil level in axis-1 gearbox on page 112*.	Where to find type of oil and total amount is detailed in *Type and amount of oil in gearboxes on page 138*.
5	Refit the oil plug, filling.	Tightening torque: 24 Nm.

3.4.3 Changing oil, gearbox axes 2 and 3

Location of oil plugs

Gearboxes, axes 2 and 3, are located in lower arm rotational center, underneath motor attachment.

The figure shows the position of gearbox, axis 2.

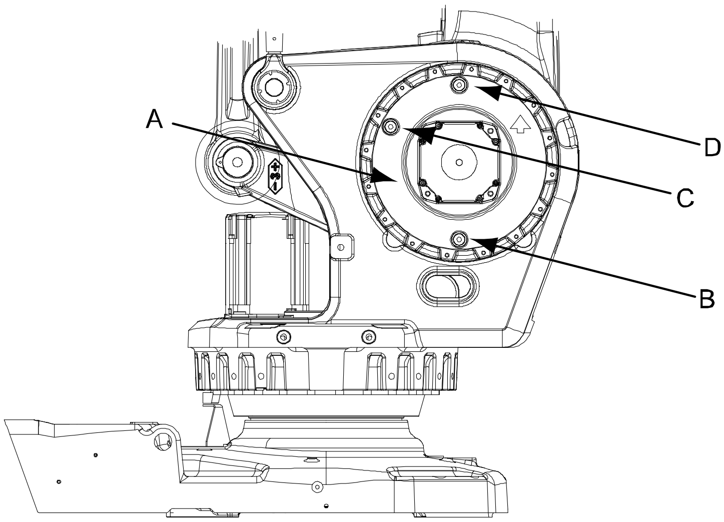


xx0500002482

A	Gearbox axis 2
B	Oil plug, draining
C	Oil plug, filling
D	Ventilation hole plug, gearbox axis 2

Continues on next page

The figure shows position of gearbox, axis 3.



xx0500002483

A	Gearbox, axis 3
B	Oil plug, draining
C	Oil plug, filling
D	Ventilation hole plug, gearbox axis 3

Required equipment

Equipment etc.	Art. no.	Amount	Note
Lubricating oil	See *Type and amount of oil in gearboxes on page 138*.	See *Type and amount of oil in gearboxes on page 138*.	**Note** Do not mix with other oils!
Oil collecting vessel			Capacity: 6,000 ml
Oil exchange equipment	3HAC021745-001		Content is defined in section *Special tools on page 360*.
Standard toolkit	-		Content is defined in section *Standard tools on page 359*.

Continues on next page

Draining, axes 2 and 3

Use this procedure to drain oil in gearbox axes 2 and 3.

When using oil change equipment, follow the instructions enclosed with kit.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
2	**WARNING** Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section *WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 56*.	
3	Remove the *ventilation hole plug.*	Shown in *Location of oil plugs on page 143*.
4	Remove the *oil plug, draining*, and drain gearbox using a hose with a nipple and an oil collecting vessel.	Shown in *Location of oil plugs on page 143*. Vessel capacity is specified in *Required equipment on page 144*. Draining is time-consuming. Elapsed time varies depending on the temperature of the oil.
5	Refit the oil plug, draining.	Tightening torque: 24 Nm.

Filling, axes 2 and 3

Use this procedure to fill gearboxes of axes 2 and 3 with oil.

When using oil change equipment, follow the instructions enclosed with kit.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	

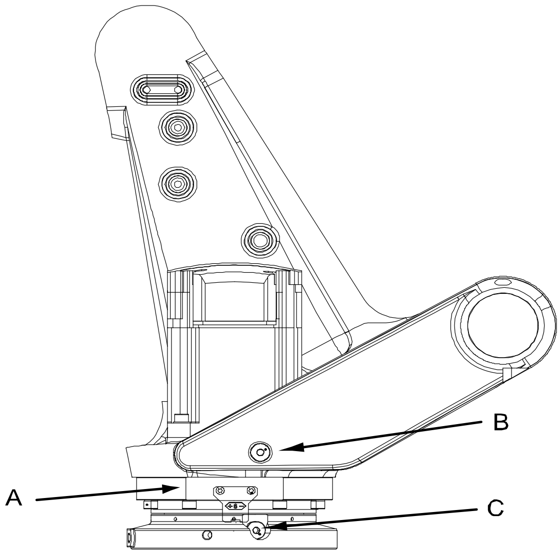
Continues on next page

	Action	Note
2	**WARNING** Handling gearbox oil involves several safety risks. Before proceeding, please read the safety information in the section *WARNING - Safety risks during work with gearbox lubricants (oil or grease) on page 56*.	
3	Remove the *oil plug, filling*. (*Ventilation hole plug* should also be removed.)	Shown in *Location of oil plugs on page 143*. Tightening torque: 24 Nm.
4	Refill gearbox with *lubricating oil*. The *amount of oil* to be filled depends on the amount that was previously drained.	Art.no. and total amount are specified in *Required equipment on page 144*.
5	Refit *oil plug,filling* and *ventilation hole plug*.	Shown in *Location of oil plugs on page 143*. Tightening torque: 24 Nm.

3.4.4 Changing oil, gearbox axis 6

Location of oil plugs

Gearbox axis 6 is located in the center of the tilt house unit.



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A	Gearbox, axis 6
B	Oil plug, filling
C	Oil plug, draining

Required equipment

Equipment, etc.	Art. no.	Amount	Note
Lubrication oil	3HAC032140-001	250 ml	Kyodo Yushi TMO 150 Do not mix with other oil types!
Oil exchange equipment	3HAC021745-001		
Oil collecting vessel			Vessel capacity: 400 ml.
Standard toolkit		-	Content is defined in section *Standard tools on page 359*.

Draining, oil

Use this procedure to drain oil from gearbox axis 6.

When using oil change equipment, follow the instructions enclosed with kit.

	Action	Note
1	Put tilt house in a suitable position.	

Continues on next page

	Action	Note
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Drain oil from gearbox into a vessel by removing *oil plug, draining*. Also remove *oil plug, filling*.	Shown in figure *Location of oil plugs on page 147*. Vessel capacity is specified in *Required equipment on page 147*.
4	Refit oil plugs, draining and filling.	Tightening torque: 24 Nm.

Filling, oil

Use this procedure to fill gearbox axis 6 with oil.

When using oil change equipment, follow the instructions enclosed with kit.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
2	Remove the *oil plug, filling*.	Shown in figure *Location of oil plugs on page 147*.
3	Refill the gearbox with *lubricating oil*. Amount of oil to be refilled depends on the amount that was previously drained. Correct oil level is detailed in section *Inspection, oil level axis-6 gearbox on page 118*.	Art. no. and the total amount are specified in *Required equipment on page 147*.
4	Refit the oil plug.	Tightening torque: 24 Nm.

3.4.5 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

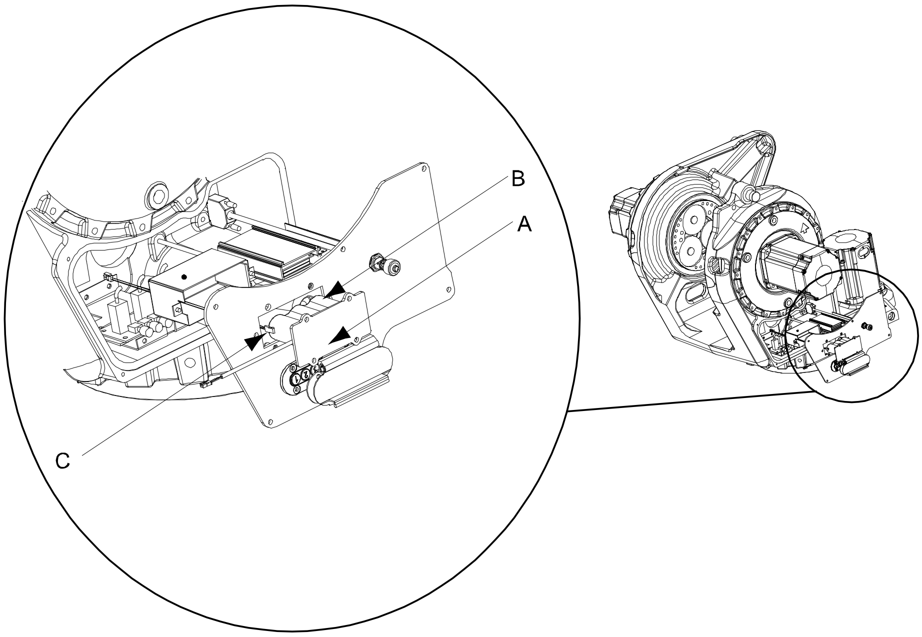
See instructions for batteries, *WARNING - Safety risks during handling of batteries on page 55*.

Continues on next page

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)



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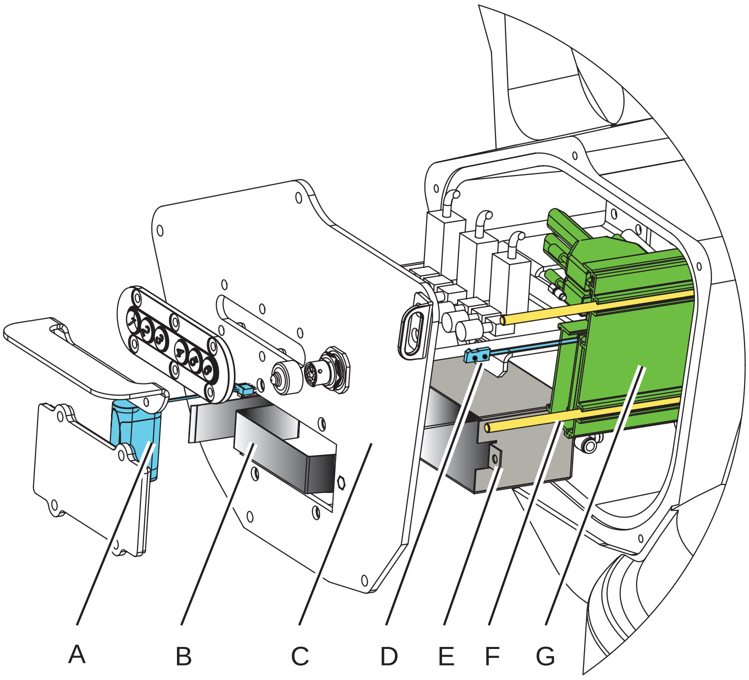
A	SMB battery cover
B	SMB battery pack
C	Battery cable

Continues on next page

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



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A	Battery pack RMU
B	Holder for battery
C	SMB cover
D	Battery cable
E	Battry 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: • *Spare part lists on page 365*	Battery includes protection circuits. Only replace with a specified spare part or an ABB-approved equivalent.
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.

Continues on next page

Equipment, etc.	Spare part no.	Note
Circuit diagram	-	See chapter *Circuit diagrams on page 367*.

Removing, battery

Use this procedure to remove the SMB battery.

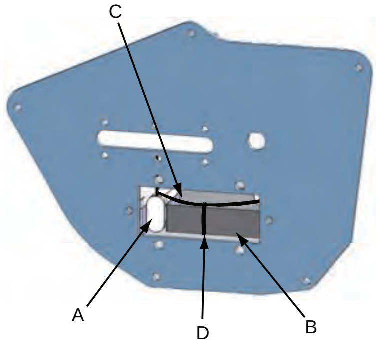
	Action	Note
1	Move the robot to its calibration position.	This is done in order to facilitate updating of the revolution counter.
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	**ELECTROSTATIC DISCHARGE (ESD)** The unit is sensitive to ESD. Before handling the unit please read the safety information in the section *WARNING - The unit is sensitive to ESD! on page 54*	
4	Remove the *SMB battery cover* by unscrewing the attachment screws.	Shown in figure *Location of SMB battery on page 150*.
5	Pull out the battery and disconnect the *battery cable*.	Shown in figure *Location of SMB battery on page 150*.
6	Remove the *SMB battery.* Battery includes protection circuits. Only replace with a specified spare part or with an ABB- approved equivalent.	Shown in figure *Location of SMB battery on page 150*.

Refitting, battery

Use this procedure to refit the SMB battery.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	

Continues on next page

	Action	Note
2	**ELECTROSTATIC DISCHARGE (ESD)** The unit is sensitive to ESD. Before handling the unit please read the safety information in the section *WARNING - The unit is sensitive to ESD! on page 54*	
3	Reconnect the *battery cable* and install the battery pack into the SMB/battery recess. **Note** 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.	Art. no. is specified in *Required equipment on page 151*. Shown in figure *Location of SMB battery on page 150*.  xx1300000307 A Battery pack RMU B Battery holder C Battery cable D Strap
4	Secure the *SMB battery cover* with its attachment screws.	Shown in figure *Location of SMB battery on page 150*.
5	Update the revolution counters.	Detailed in chapter Calibration - section *Updating revolution counters on page 326*.
6	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

3.5 Lubrication activities

3.5.1 Lubricating balancing device bearings and piston rod

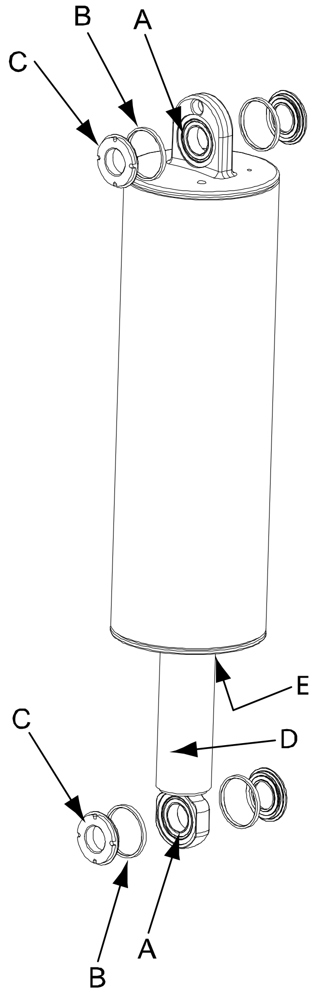
Overview

This procedure details how to lubricate the balancing device´s bearings and piston rod.

Location of bearings and piston rod

This figure shows the location of bearings and piston rod.

Note! Balancing device must be fitted on robot when lubricating bearings!



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A	Ear (bearing located inside)
B	Support washer
C	Lock nut
D	Piston rod
E	Guide ring (not visible in this view)

Continues on next page

Required equipment

Equipment	Art. no.	Note
Lubrication tool	3HAC039296-001	
Bearing grease	3HAB3537-1	Equivalent: • Shell Alvania WR 2
Cleaning agent	-	Isopropanol
Piston rod grease	-	Choose any of following equivalents: • Shell: SRS Grease 4000 • Preem: Novatex Heavy EP 2 • Castrol: Entrepenadfett • Statoil: Uniway 2X2N
Locking liquid	-	Loctite 243
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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.

Lubricating, bearings

Use this procedure to lubricate the balancing device bearings.

	Action	Note
1	Move axis 2 to calibration position.	
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Remove the locknut.	Be careful not to loose the support washer in the process.
4	Fit the lubricating tool. It should be tightened to the bottom, by hand only.	
5	Grease through nipple on the lubricating tool.	
6	Continue filling grease until clean grease exudes behind the inner sealing ring. Repeat this procedure at the other bearing!	
7	Remove the lubricating tool and clean the threads on the shaft ends of grease.	Also clean of old grease on the inner side!
8	Apply some grease to the support washers.	
9	Apply locking liquid on the lock nuts (KM10). **Note** Do not apply locking liquid on the shafts!	Tightening torque on lock nuts: • 120 Nm

Continues on next page

	Action	Note
10	Check play between support washer and bearings at both bearings.	Minimum play: • 0.1 mm

Lubricating, piston rod

Use this procedure to lubricate the balancing device piston rod.

	Action	Note
1	Position axis 2 so that the balancing device is horizontal and the piston rod is extended to the greatest extent possible.	
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Clean piston rod with isopropanol before applying new grease.	
4	Apply new grease.	Type of grease is specified in *Required equipment on page 155*.

3.6 Cleaning activities

3.6.1 Cleaning the IRB 660

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 660 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 660.

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 112*.
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 above! 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
Standard	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

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).[1]

The following list defines the prerequisites:

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

i Typical tap water pressure and flow

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.

1 See *Cleaning methods on page 158* for exceptions.

4 Repair

4.1 Introduction

Structure of this chapter

This chapter describes all repair activities recommended for the IRB 660 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.

The procedures are gathered in sections, divided according to the component location on the IRB 660.

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 351*.

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 17* before commencing any service work.

Note

If the IRB 660 is connected to power, always make sure that the IRB 660 is connected to earth before starting any repair work.

For more information see:

- *Product manual - IRC5*

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 *leak-down tester*. 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. **CAUTION** 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

- 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: • The seal is of the correct type (provided with cutting edge). • There is no damage to the sealing edge (feel with a fingernail).	
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 *Equipment on page 163*.
4	Mount the seal correctly with a mounting tool. Never hammer directly on the seal as this may result in leakage.	

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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, lower end (axes 1-3)

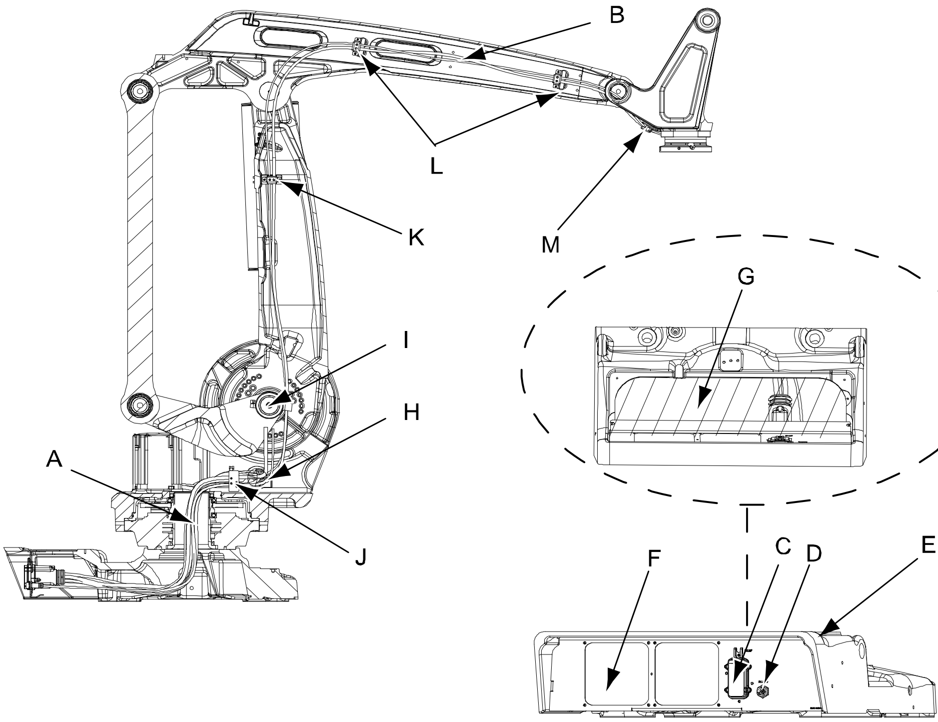
Overview

The cable harness 1-6 is undivided.

How to replace the cable harness is described in two steps - lower end (axes 1-3) and upper end (axis 6). This procedure describes how to replace the lower end of the cable harness. How to replace the upper end can be found in section *Replacing the cable harness, upper end (incl. axis 6) on page 173*.

Location of cable harness - lower end (axes 1-3)

The cable harness, lower end (axes 1-3) is located throughout the base, frame and lower arm as shown in the figure.



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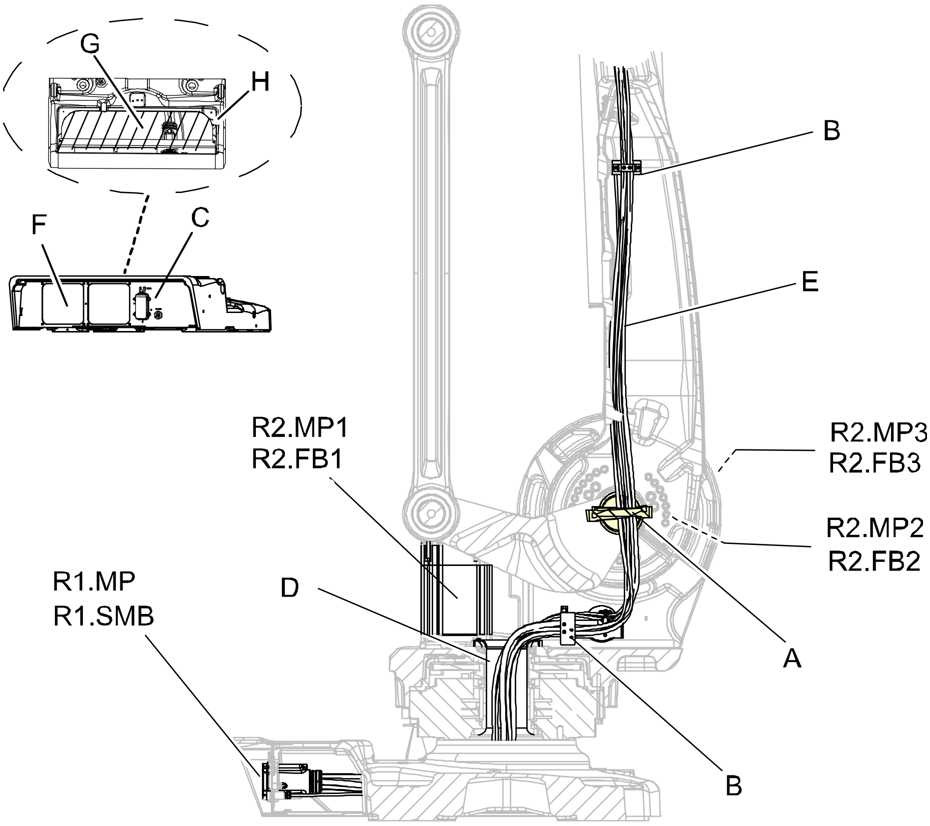
A	Cable harness, lower end
B	Cable harness, upper end
C	Connector R1.MP
D	Connector R1.SMB
E	Attachment point for earth lug
F	Cover plate
G	Rear cover plate
H	Cable gland, SMB
I	Cable guide, axis 2

Continues on next page

J	Metal clamp, frame
K	Metal clamp, lower arm
L	Metal clamp, upper arm
M	Metal clamp, tilthouse



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A	Cable guide, axis 2
B	Metal clamp
C	Connector at base
D	Cable guide, axis 1
E	Cable harness, axes 1-6
F	Cover plate
G	Rear cover plate
H	Attachment point for earth lug

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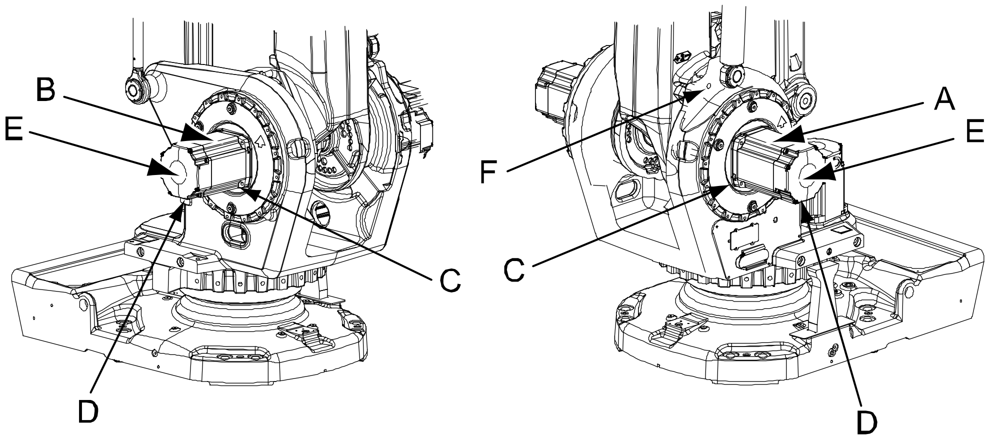
The motors axes 2-3 are located on either side of the robot as shown in the figure below.



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A	Motor, axis 2
B	Motor, axis 3
C	Motor attachment screws and washers
D	Cable gland cover (located on the lower side of the motor)
E	Motor cover

Required equipment

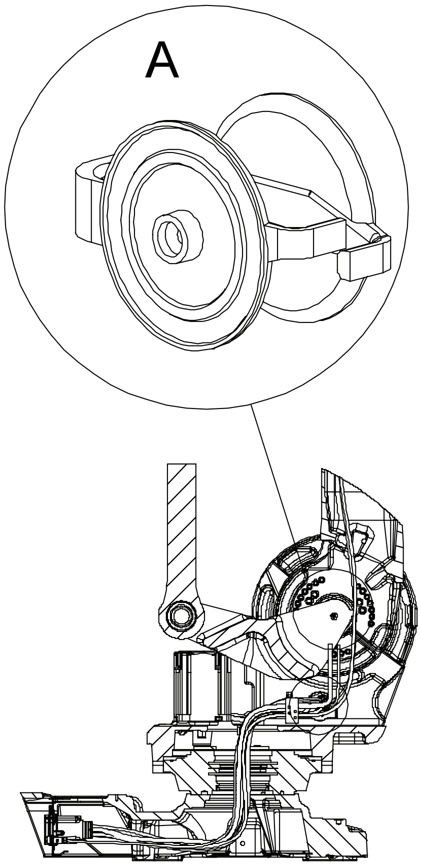
Equipment, etc.	Art.no.	Note
Cable harness 1-6	For spare part no. see: • *Spare part lists on page 365*	
Gasket	3HAC3537-1	Motor, axes 1-3 Replace if damaged.
Standard toolkit	-	The content is defined in the section *Standard tools on page 359*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.	-	These procedures include references to the tools required.
Circuit diagram	-	See *Circuit diagrams on page 367*.

Removing the cable harness - lower end (axes 1-3)

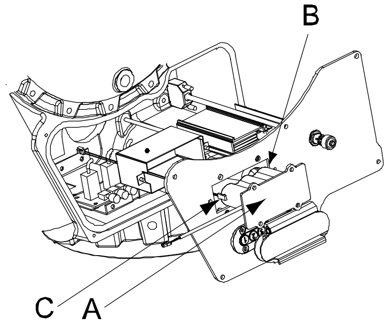
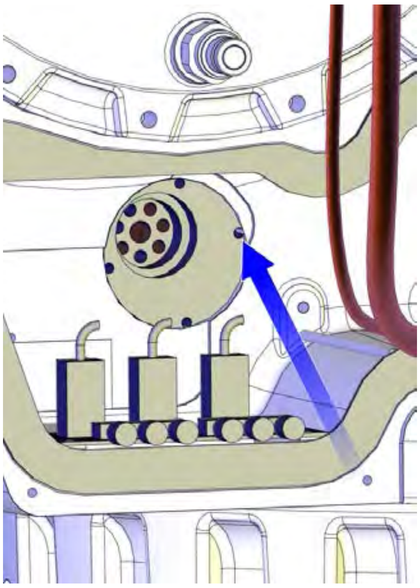
Use this procedure to remove the cable harness, lower end (axes 1-3).

	Action	Note
1	Move the robot to the calibration position.	This is done in order to facilitate updating of the revolution counter.

Continues on next page

	Action	Note
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Remove the *rear cover plate* from the robot by removing its attachment screws.	Shown in *Location of cable harness - lower end (axes 1-3) on page 165*.
4	Disconnect the *earth cable*.	Shown in *Location of cable harness - lower end (axes 1-3) on page 165*.
5	Disconnect the connectors *R1.MP* and *R1.SMB*.	See the figure *Location of cable harness - lower end (axes 1-3) on page 165*.
6	Unscrew the screws of the *cable guide axis 2* inside the lower arm and loosen the cable guide.	 xx0600002698 • A: Cable guide ax 2
7	Unscrew the screws in the *metal clamps* holding the cable harness in the frame and lower arm.	Shown in *Location of cable harness - lower end (axes 1-3) on page 165*.
8	Unscrew the screws of the motor covers for axes 1, 2 and 3 and lift away the covers. This is done in order to reach the motor connectors.	

Continues on next page

	Action	Note
9	Disconnect all connectors at motors for axes 1, 2 and 3.	See sections: • *Replacing motor, axis 1 on page 264* • *Replacing motors, axes 2 and 3 on page 271*
10	Open the SMB *cover* carefully.	 xx0600002700
11	Disconnect connector R1.G on the *battery cable* between the battery and the SMB unit. **Note** This causes a necessary updating of the revolution counter after refitting!	
12	Disconnect connectors R2.SMB, R1.SMB1-3, R1.SMB6 from the SMB unit.	
13	Disconnect X8, X9 and X10 from the brake release unit.	
14	Remove the SMB cover and put somewhere safe.	
15	Unscrew the screws for the *cable gland SMB* from inside the SMB recess and lift the cable gland out. Perform this removal with care, in order not to damage any of the components inside the SMB recess.	 xx1000001330

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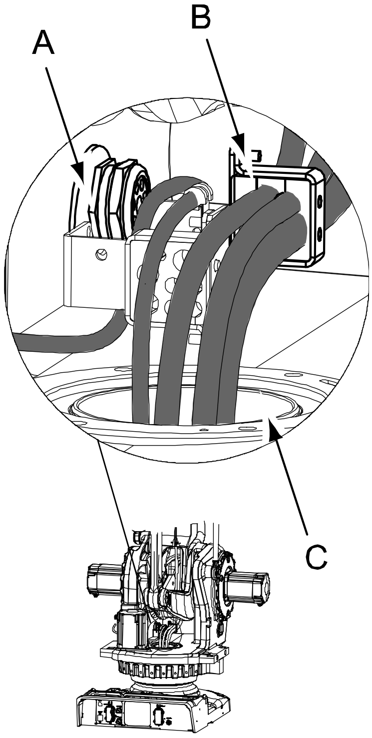
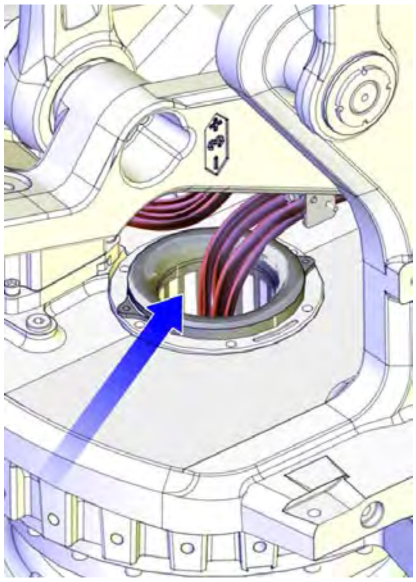
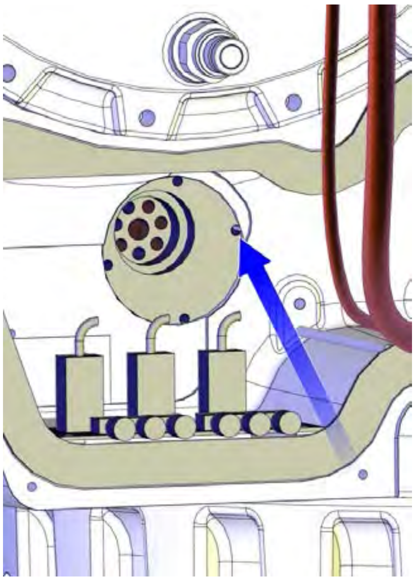
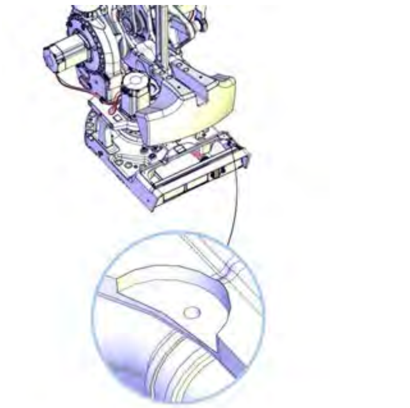
	Action	Note
16	Gently pull the cable harness out from the base through the *cable guide*, axis 1 and frame.	 xx0600002699
17	Continue removing the cable harness in the upper arm.	See section *Replacing the cable harness, upper end (incl. axis 6) on page 173*.

Refitting, cable harness - lower end (axes 1-3)

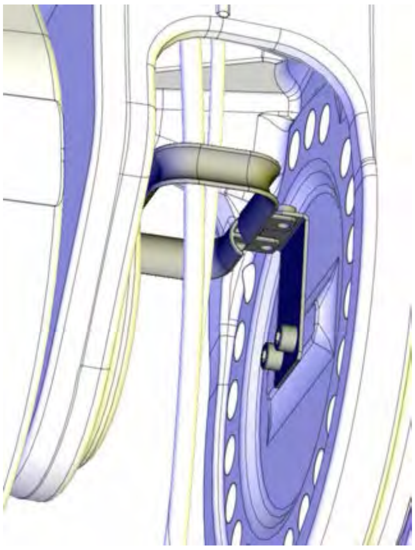
Use this procedure to refit the cable harness, lower end (axes 1-3).

	Action	Note
1	Push the cable harness and connectors down through the cable guide axis 1 in the center of the frame. **CAUTION** Make sure the cables are not twisted with each other or with customer harness (if any)!	 xx1000001331

Continues on next page

	Action	Note
2	Pull out the cables and connectors of the SMB unit through the frame and refit the *cable gland* with its *attachment screws* from inside the SMB recess. Perform this refitting with care, in order not to damage any of the components inside the SMB recess.	 xx1000001330
3	Reconnect connectors *R1.MP* and *R1.SMB* at the robot base.	Tightening torque for R1.SMB: 10 Nm. Attachment points are shown in the figure *Location of cable harness - lower end (axes 1-3) on page 165*.
4	Reconnect the *earth cable*.	 xx1000001314
5	Refit the *rear cover plate* to the robot base with its attachment screws.	Shown in *Location of cable harness - lower end (axes 1-3) on page 165*.
6	Reconnect all connectors at *motors axes 1, 2* and *3* and refit the motor covers.	See sections: • *Replacing motor, axis 1 on page 264* • *Replacing motors, axes 2 and 3 on page 271*
7	Reconnect connectors R2.SMB, R1.SMB1-3, R1.SMB6 of the SMB unit. Reconnect X8, X9 and X10 to the brake release unit. Reconnect R1.G.	

Continues on next page

	Action	Note
8	Secure the *SMB cover* with its attachment screws. If cabling is used for 7th axis (option), refit the connector R2.FB7 to the SMB cover and tighten with 6 Nm.	
9	**WARNING** Before continuing any service work, please observe the safety information in section *WARNING - The brake release buttons may be jammed after service work on page 52*!	
10	Push the cable harness up through the lower arm.	
11	Refit the *metal clamps* holding the cable harness in the frame and lower arm with its attachment screws.	Shown in *Location of cable harness - lower end (axes 1-3) on page 165*.
12	Refit the *cable guide, axis 2*.	 xx1100000157
13	Continue refitting the cable harness in the upper arm.	See section *Replacing the cable harness, upper end (incl. axis 6) on page 173*.
14	Update the revolution counter!	See section *Updating revolution counters on page 326*.
15	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

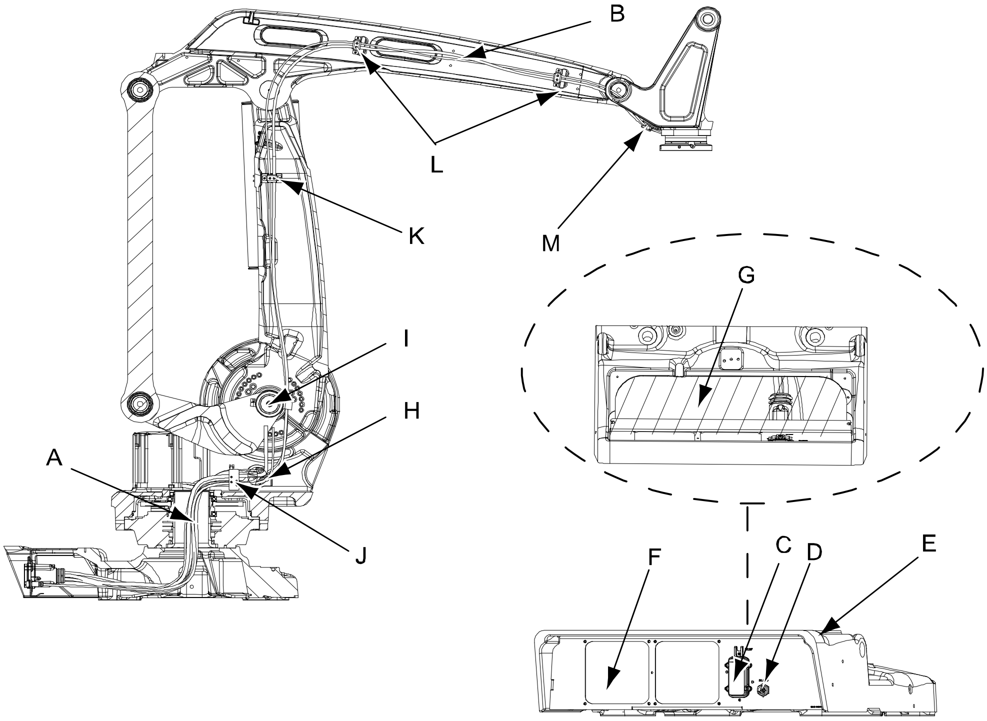
4.3.2 Replacing the cable harness, upper end (incl. axis 6)

Overview

Replacement of the cable harness is detailed in two steps - lower end (axes 1-3) and upper end. The procedure below details replacement of the cable harness in the upper end (incl. axis 6). The procedure for replacing the lower end (axis 1-3) is detailed in section *Replacing cable harness, lower end (axes 1-3) on page 165*.

Location of cable harness, upper end

The upper end of the cable harness is located as shown in the figure.



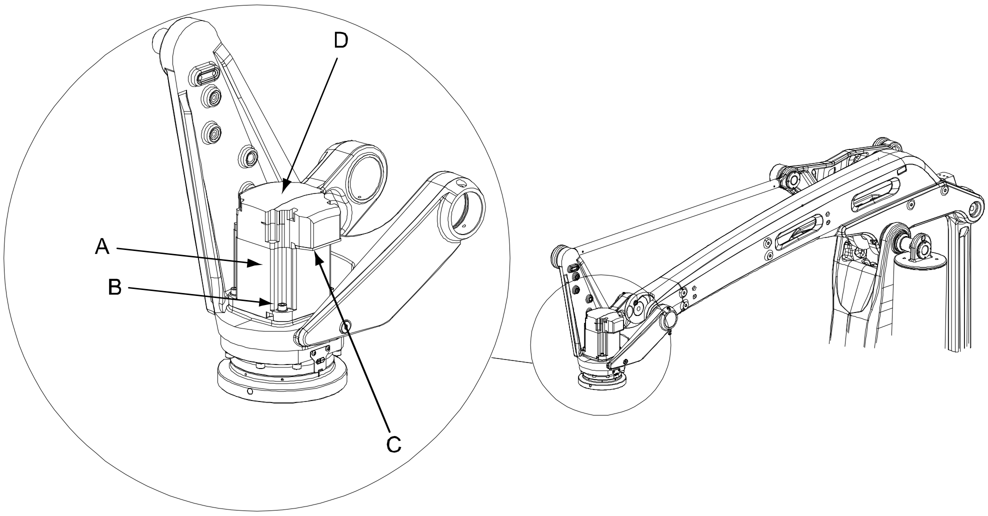
xx0600002608

A	Cable harness, lower end
B	Cable harness, upper end
C	Connector R1.MP
D	Connector R1.SMB
E	Attachment point for earth lug
F	Cover plate
G	Rear cover plate
H	Cable gland, SMB
I	Cable guide, axis 2
J	Metal clamp, frame
K	Metal clamp, lower arm
L	Metal clamp, upper arm

Continues on next page

M	Metal clamp, tilthouse

The motor axis 6 is located as shown in the figure below.



xx0600002600

A	Motor, axis 6
B	Attachment screws and washers
C	Cable gland cover
D	Motor cover

Required equipment

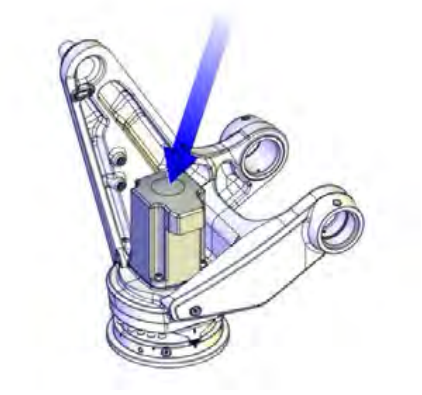
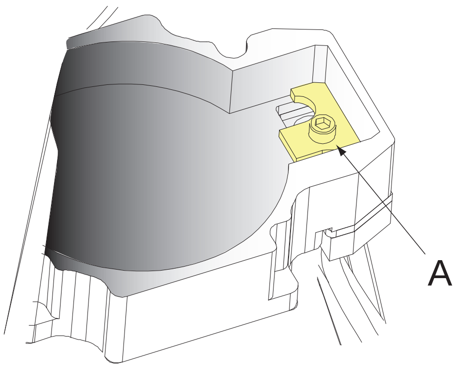
Equipment, etc	Art.no.	Note
Cable harness, 1-6	For spare part no. see: • *Spare part lists on page 365*	
Gasket	-	Motor, axis 6
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.
Circuit diagram	See chapter *Circuit diagrams on page 367*.	

Removing cable harness, upper end (incl. axis 6)

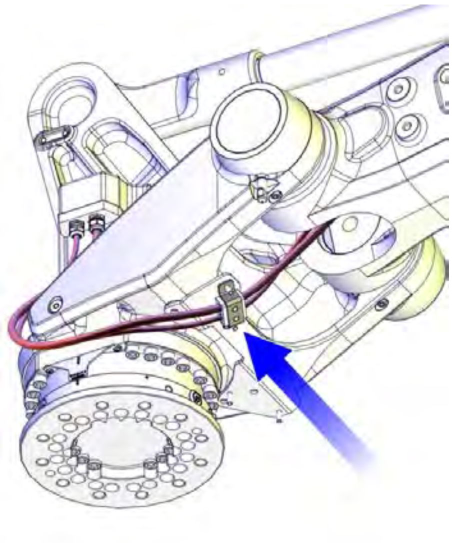
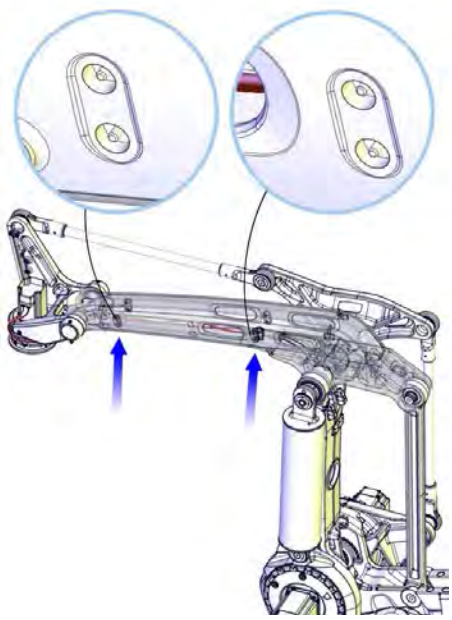
Use this procedure to remove the cable harness, upper arm (incl. axis 6).

	Action	Note
1	Move the robot to the calibration position.	This is done in order to facilitate updating of the revolution counter.

Continues on next page

	Action	Note
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	If the complete cable harness is being replaced, start removal by removing the *cable harness, lower end*.	Detailed in section *Replacing cable harness, lower end (axes 1-3) on page 165*.
4	Remove the axis 6 motor cover by removing its attachment screws, in order to reach the connectors.	 xx1000001106
	Remove the *cable gland cover* at the cable exit by unscrewing its *attachment screw* on the inside. **Note** Make sure the gasket is not damaged!	 xx0600002694 • A: Screw securing the cable gland
5	Disconnect connectors at axis 6 motor.	

Continues on next page

	Action	Note
6	Remove the metal clamp that holds the cable at the tilt house, by removing its nuts.	 xx1000001336
7	Carefully pull the cable harness out of motor axis 6.	
8	Remove the nuts (on the outside of the upper arm) that secure the cable harness metal clamps inside the upper arm (2 + 2 pcs).	 xx1000001338
9	Carefully pull out the cable harness from the upper and lower arm.	

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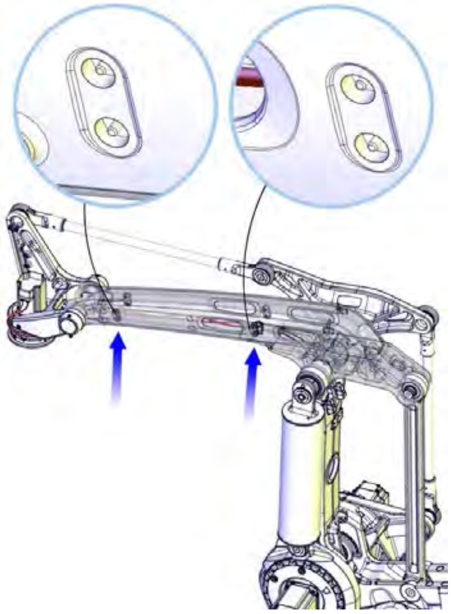
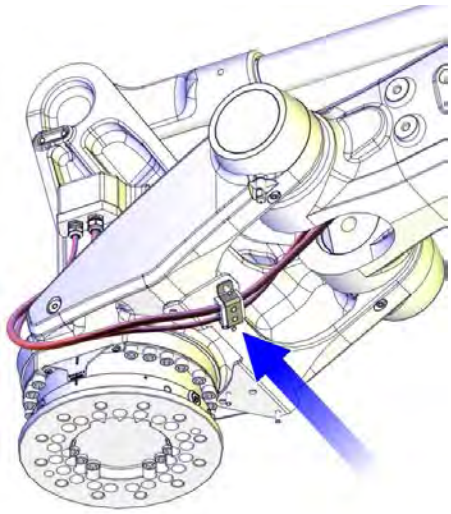
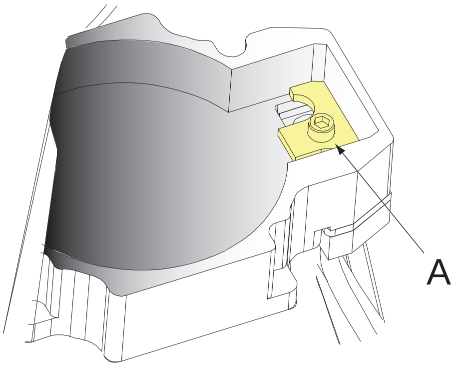
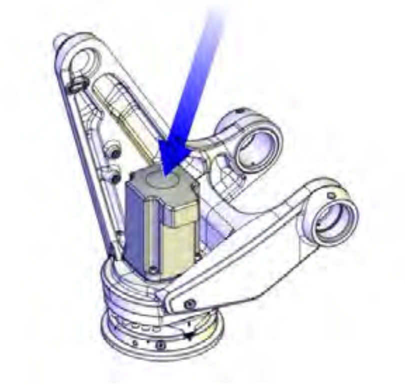
Refitting cable harness, upper end

Use this procedure to refit the cable harness, upper end.

	Action	Note
1	Start by fitting the cable harness, lower end if it has been removed.	Detailed in section *Replacing cable harness, lower end (axes 1-3) on page 165*
2	Push the cable harness through the upper arm tube.	
3	Refit the cable harness inside the upper arm by refitting the cable clamps with the nuts (2 + 2 pcs) from the outside of the upper arm.	 xx1000001338
4	Refit the *metal clamp* at the tilthouse with its nuts.	 xx1000001336

Continues on next page

	Action	Note
5	Push the axis 6 motor cables carefully through the cable gland. **Note** Do not twist the cables!	
6	Reconnect all connectors in motor axis 6.	
7	Check the *gasket*. If damaged, replace it.	
8	Refit the cable gland with its *attachment screw*.	 xx0600002694 • A: Screw holding the cable gland Make sure the gasket is not damaged! Replace if damaged.
9	Refit the *cover*, motor axis 6 with its *attachment screws* and *washers*. Make sure the cabling is placed correctly when refitting the cover and does not get jammed. **Note** Make sure the cover is tightly sealed!	 xx1000001106
10	Update the revolution counter!	Detailed in section *Updating revolution counters on page 326*.
11	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.3.3 Replacing the base, including axis 1 gearbox

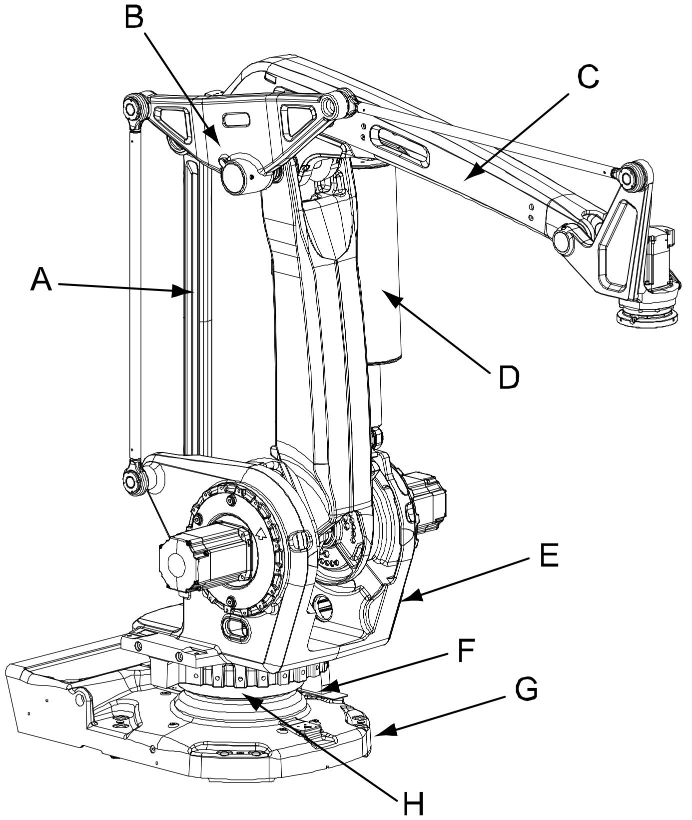
Introduction

The term *complete arm system* used in this procedure is defined as the complete robot excluding:

- base
- gearbox axis 1

Location of the base

The location of the base, including gearbox axis 1, is shown in the figure. It also shows the complete arm system as defined above.



xx0600002612

A	Parallel rod
B	Linkage
C	Complete upper arm (incl. tilthouse)
D	Balancing device
E	Frame
F	Gearbox, axis 1
G	Base
H	Base attachment screws

Continues on next page

Required equipment

Equipment, etc.	Art. no.	Note
Guide pins M12 x 130	3HAC022637-001	Used to guide the complete arm system when refitting. Always use the guide pins in pairs! Guide pins that are longer than 140 mm will not be possible to remove because the lack of space.
Lifting accessory	3HAC15607-1	Includes: • user instructions, 3HAC15971-2
Roundsling		1 pc: 1,5 m Lifting capacity 1,000 kg
Hoisting block	-	Used to adjust the length of the lifting chain.
Power supply	-	24 VDC, max. 1.5 A For releasing the brakes.
Crank	-	Used to turn the gear when mating it to the frame.
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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 *Circuit diagrams on page 367*.

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.

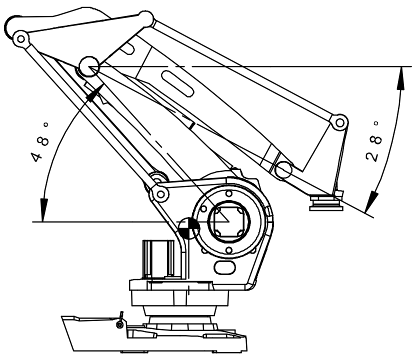
	Action	Note
1	Decide which calibration routine to use for calibrating the robot. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	

Continues on next page

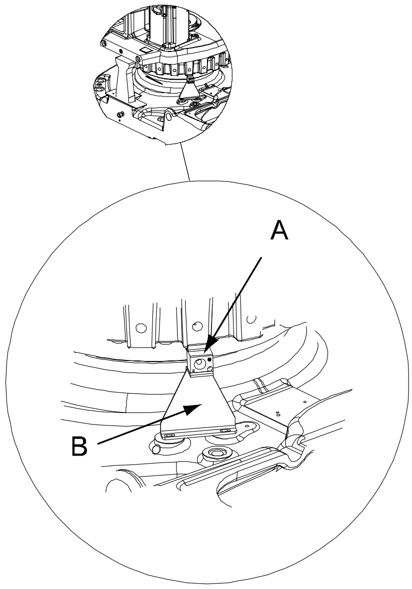
	Action	Note
	If the robot is to be calibrated with reference calibration: Find previous reference values for the axis or create new reference values. These values are to be used after the repair procedure is completed, for calibration of the robot. If no previous reference values exist, and no new reference 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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

Removing the complete arm system

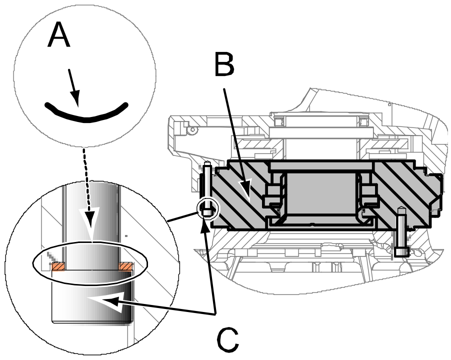
Use this procedure to remove the complete arm system.

	Action	Note
1	Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2	Move the robot to the transport position.	 xx0500002275
3	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
4	Run an overhead crane to a position above the robot.	

Continues on next page

	Action	Note
5	Remove the *block for calibration* and the *axis 1 calibration plate*.	 xx0600002734 A Block for calibration B Calibration plate axis 1
6	Drain the axis 1 gearbox.	See *Changing oil, axis-1 gearbox on page 140*.
7	Loosen the cable connectors from the base and pull up the cabling from the base, through the hole in the center of the frame.	See *Replacing cable harness, lower end (axes 1-3) on page 165*.
8	Remove the axis 1 motor.	See *Replacing motor, axis 1 on page 264*.
9	**CAUTION** The robot arm system weighs 245 kg. All lifting accessories used must be sized accordingly!	
10	Fit the lifting accessories and adjust it as described in the enclosed user instructions.	Make sure the lift is done completely level. This is detailed in section *Lifting robot with lifting slings on page 75*.

Continues on next page

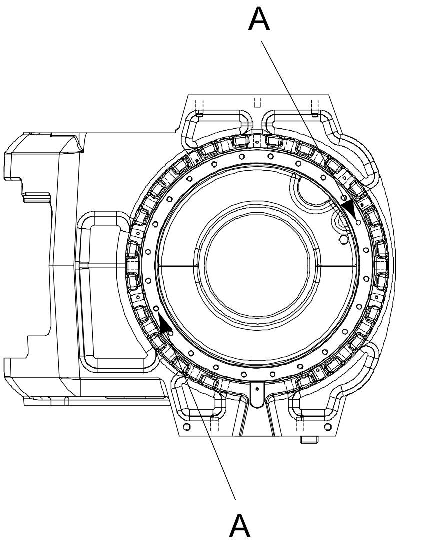
	Action	Note
11	Unfasten the arm system from the base by unscrewing the attachment screws.	 xx0600003070 A Serrated lock washer B Axis 1 gearbox C Attachment screws M12x80
12	Fit two *guide pins* in the holes. This will facilitate the removal of the complete arm system and prevent damage on the gearbox.	Article number is specified in *Required equipment on page 180*.
13	Lift the *complete arm system* carefully and secure it in a safe area. **Note** Continue lifting even if the arm system turns out to be unbalanced despite earlier adjustments! The risk of damaging the interface is bigger if the load is lowered unbalanced! **CAUTION** Always move the robot at very low speed, making sure it does not tip!	**Note** 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.
14	If needed, continue to remove the axis 1 gearbox from the base.	See *Replacing the axis 1 gearbox on page 289*.

Refitting the complete arm system

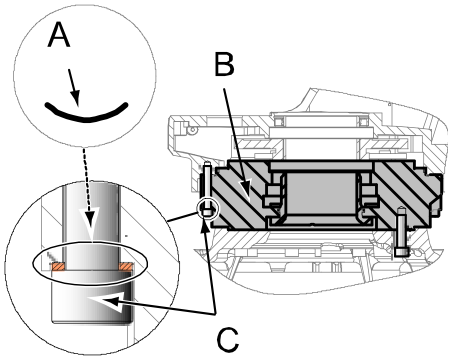
Use this procedure to refit the complete arm system.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
2	Refit the axis 1 gearbox, if it has been removed.	See *Replacing the axis 1 gearbox on page 289*.

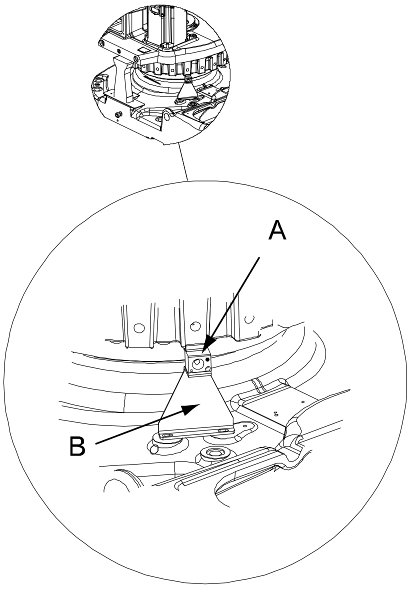
Continues on next page

	Action	Note
3	**CAUTION** The robot arm system weighs 245 kg. All lifting accessories used must be sized accordingly!	
4	Fit the *lifting accessories* and adjust it as described in the enclosed user instructions. Also fit a *hoisting block* to the front chain, used to adjust the balance of the arm system in order to lift it completely level!	Article number is specified in *Required equipment on page 180*. Make sure the lift is done completely level! How to adjust the lift is described in the enclosed instruction to the lifting accessory! **Follow the instructions before lifting!** This is detailed in section *Lifting robot with lifting slings on page 75*.
5	Lift the complete arm system and move it at very low speed to the mounting site, making sure it does not tip! **Note** The refitting must be made completely level! Make sure the roundslings are adjusted prior to refitting the arm system.	**Note** 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.
6	Fit two *guide pins* in opposite holes in the frame. **Tip** In order to make 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 after refitting because of lack of space.	 xx0600002632 The figure above shows the frame, view from below. • A: Attachment holes for the guide pins, M12 Dimension is specified in *Required equipment on page 180*. **Note** Always use guide pins in pairs.

Continues on next page

	Action	Note
7	Look through the empty mounting hole of the axis 1 motor to assist in aligning the assembly during refitting of the complete arm system.	
8	Lower the complete arm system with guidance from the guide pins previously fitted to the axis 1 gearbox. **Note** The refitting must be made completely level! Make sure the roundslings are adjusted prior to refitting the arm system.	**CAUTION** This is a complex task to be performed with utmost care in order to avoid injury or damage! Use a crank to turn the gearbox in order to find the right position for the holes.
9	Place the *serrated lock washers* on the attachment screws. **Note** Check that the *serrated lock washers* are turned the correct way. See figure!	Reused screws can be used providing they are lubricated as described in *Screw joints on page 355*.  xx0600003070 Parts: A Serrated lock washer (24 pcs) B Axis 1 gearbox C Attachment screws M12x110 quality 12.9 gleitmo (24 pcs)
10	Fit 22 of the 24 attachment screws before the arm system is completely lowered. This is done in order to be able to attach all screws into the threads correctly.	
11	Replace the guide pins with the remaining attachment screws and secure the complete arm system to the base with its attachment screws and washers.	
12	Lower the arm system completely.	
13	Secure the complete arm system with its *attachment screws*.	Tightening torque: • 115 Nm.
14	Refit the cable harness in the base and the frame.	See *Replacing cable harness, lower end (axes 1-3) on page 165*.
15	Refit the axis 1 motor.	See *Replacing motor, axis 1 on page 264*.

Continues on next page

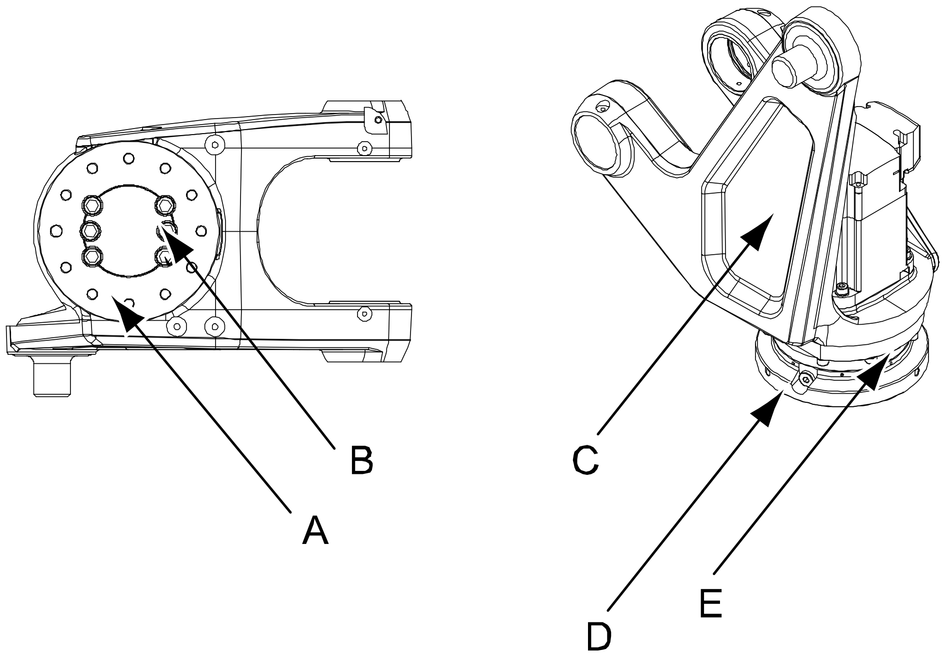
	Action	Note
16	Refit the *block for calibration* and the *axis 1 calibration plate*.	 xx0600002734 A Block for calibration B Calibration plate axis 1
17	Perform a leak-down test of the axis 1 gearbox.	See *Performing a leak-down test on page 160*.
18	Refill the axis 1 gearbox with lubricating oil.	See *Changing oil, axis-1 gearbox on page 140*.
19	Recalibrate the robot.	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.
20	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

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.



xx0600002627

A	Turning disk
B	Attachment screws (6 pcs) turning disk
C	Tilthouse unit
D	Gearbox, axis 6
E	Attachment screws, axis 6

Required equipment

Equipment, etc.	Art. no.	Note
Turning disk	For spare part no. see: *Spare part lists on page 365*.	O-rings are not included!
O-ring Wrist, type 1	3HAB3772-65 (1pc) 21520431-20 (6 pcs)	For robot v. IRB 660 180/3.15, 250/3.15 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 *Standard tools on page 359*.

Continues on next page

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.

Removing, turning disk

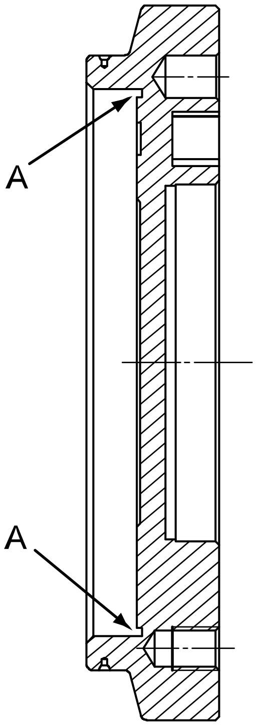
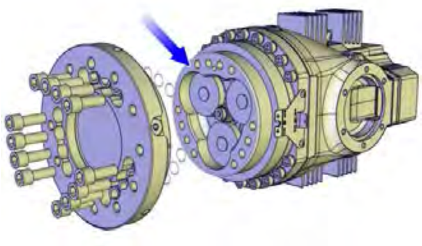
Use this procedure to remove the turning disk.

	Action	Note
1	Run the robot to a position where the tilthouse is best positioned for the turning disk to be replaced.	
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply 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 • *Changing oil, gearbox axis 6 on page 147*
5	Remove the *attachment screws* that secure the turning disk.	Shown in the figure *Location of turning disk on page 187*.
6	Remove the *turning disk*.	
7	*Foundry Plus:* Remove old flange sealant residues and other contamination from the contact surfaces.	

Continues on next page

Refitting, turning disk

Use this procedure to refit the turning disk.

	Action	Note
1	Lubricate the *o-ring* of the turning disk with *grease* and fit it to the turning disk. Also fit the six o-rings, when refitting the attachment screws.	Art. no. is specified in *Required equipment on page 187*.  xx0200000218 • A: Sealing surface, o-ring
2	*Foundry Plus:* Apply Loctite 574 flange sealant on the contact surface.	 xx1400000995
3	Secure the turning disk with its *attachment screws*.	6 pcs M14 x 25, 12.9 quality. Tightening torque: 175 Nm Reused screws may be used, providing they are lubricated as detailed in section *Screw joints on page 355* before fitting.
4	Perform a *leak-down test* of the gearbox axis 6.	Detailed in the section *Performing a leak-down test on page 160*.
5	Refill the axis 6 gearbox with oil.	See section • *Changing oil, gearbox axis 6 on page 147*
6	Refit any equipment removed during disassembly to the turning disk.	

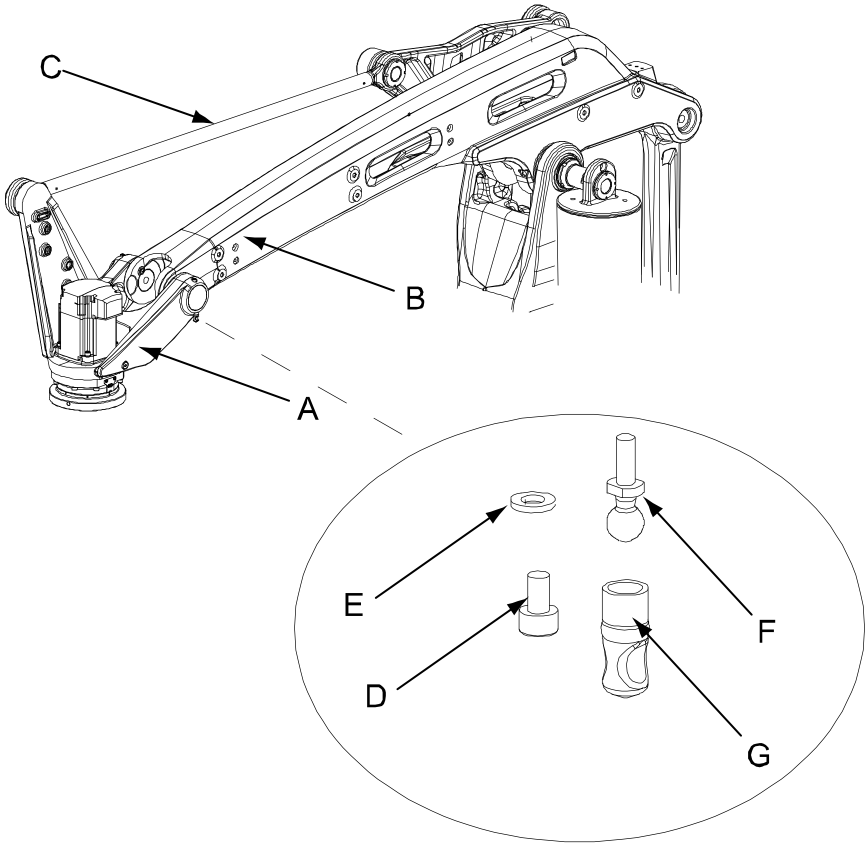
Continues on next page

	Action	Note
7	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.4.2 Replacement of tilthouse unit

Location of tilt house

The tilthouse unit is located as shown in the figure below.



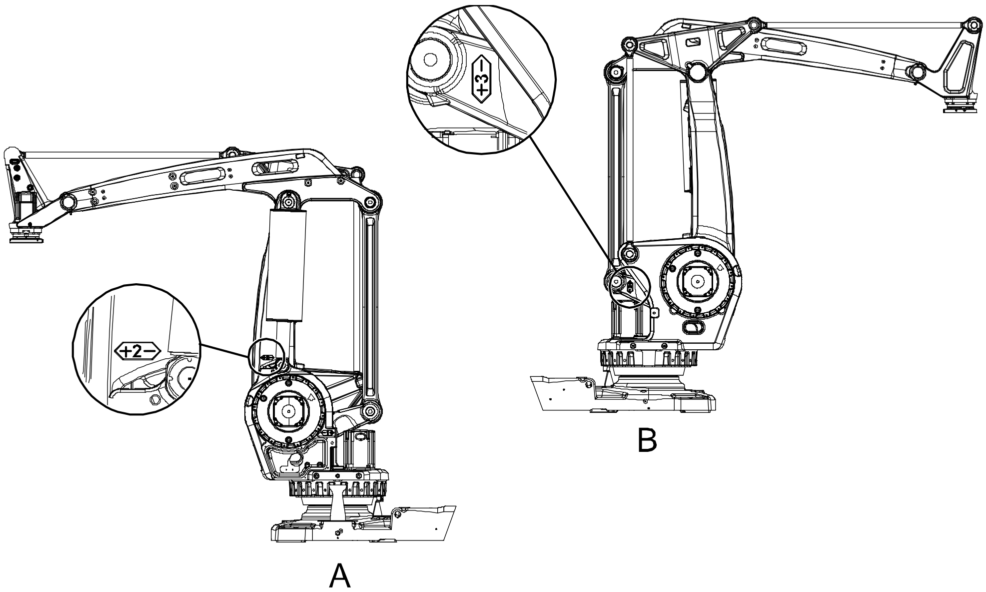
xx0600002616

A	Tilthouse unit
B	Upper arm
C	Upper rod
D	Screw M6x10
E	Washer 6.4x12x1.6
F	Ballplug
G	Protection cap

Continues on next page

Location of axes 2 and 3 sides of the robot

The figure below shows the location of the axes 2 and 3 sides of the robot. See markings on the lower arm (axis 2) and the parallel arm (axis 3).

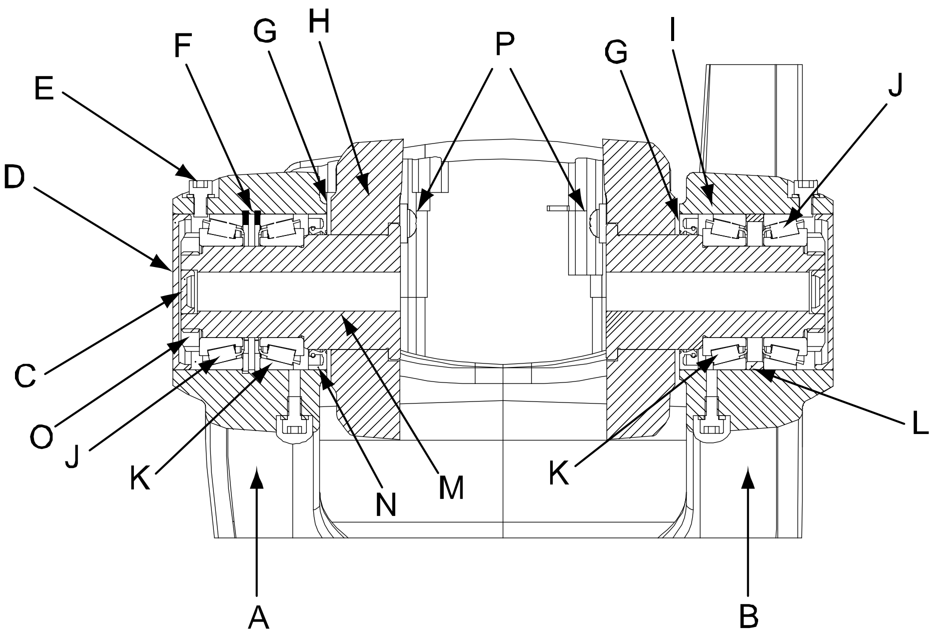


xx0600002743

A	Axis 2 side of the robot
B	Axis 3 side of the robot

Cut away view of the assembly of the tilthouse unit

The figure below shows a cut away view of how the tilthouse unit is fitted to the upper arm. The letters in the figure are being referred to in the step by step procedures below.



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A	Axis 2 side
B	Axis 3 side
C	VK cover, VK 19 x 6, 2 pcs
D	VK cover, VK 68 x 8, 2 pcs
E	Screw M6 x 10 Steel 8.8-A2F + Washers, 4 + 4 pcs (for filling bearing grease)
F	Retaining ring fore bores, 2 pcs
G	Rust protection, Dinitrol 490
H	Upper arm
I	Tilthouse
J	Bearing, 2 pcs (on the outside of the tilthouse)
K	Bearing, 2 pcs (on the inside of the tilthouse)
L	Ring
M	Shaft, 2 pcs
N	Radial seal with dustlip, 2 pcs
O	Lock nut, KM7 2 pcs
P	Screw M6x16 + washer (for locking the shafts), 2 + 2 pcs

Required equipment

Equipment, etc.	Spare part no.	Art.no.	Note
Press tool, premounting bearing		3HAC023075-001	
Press tool, mounting axis 6		3HAC023080-001	
Shims			Width = 3 mm
Grease		3HAB3537-1	
Rust protection			Dinitrol 490
Locking liquid			Loctite 243
Standard toolkit		-	Content is defined in section *Standard tools on page 359*.
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 *Circuit diagrams on page 367*.

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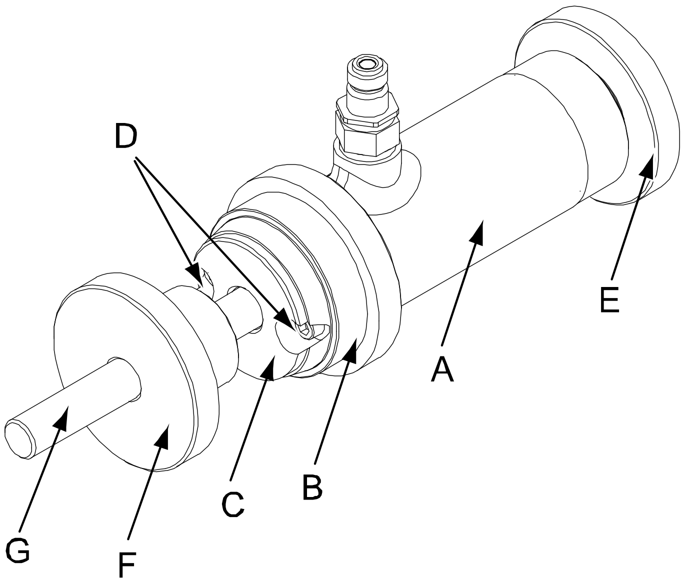
Press tool premounting bearing

The press tool for premounting the bearing race, bearing complete, radial seal with dustlip and ring in the tilthouse, is assembled with the parts shown in the figure below.



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Note! The parts cannot be ordered separatly, but are inluded when ordering the complete tool. The article numbers are given only for identification.

A	Hydraulic cylinder, 3HAC 11731-1
B	Mounting washer, 3HAC 023075-004
C	Bushing, 3HAC 023075-006
D	Screw M6x25, 2 pcs (MC6S)
E	Threaded washer, 3HAC 5507-1
F	Press washer, 3HAC 023075-002
G	Threaded bar, M16 L = 300 mm

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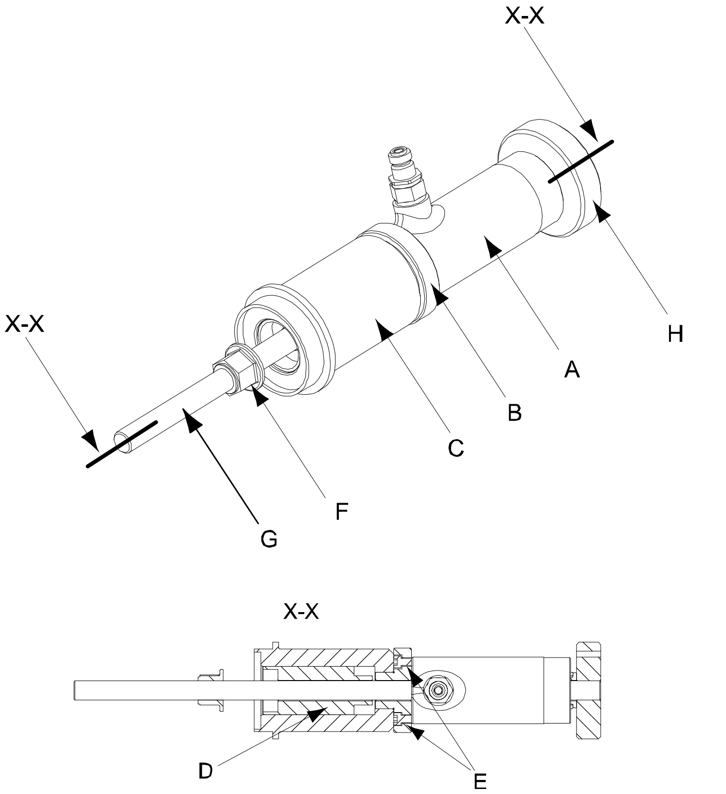
Press tool mounting axis 6

The press tool for mounting the tilthouse on the upper arm, is assembled with the parts shown in the figure below.



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Note! The parts cannot be ordered separatly, but are included when ordering the complete tool. The article numbers are given only for identification.

A	Hydraulic cylinder, 3HAC 11731-1
B	Distance, 3HAC 023062-001
C	Press housing, 3HAC 023080-004
D	Support housing, 3HAC 023080-003
E	Screw M6x14, 2pcs (MC6S)
F	Flange lock nut, M16
G	Threaded bar, M16 L=435 mm
H	Nut M16

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. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

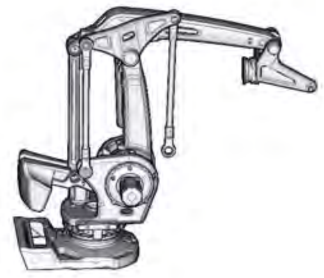
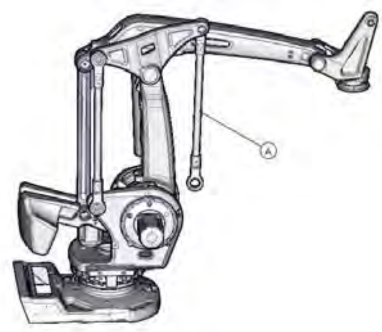
Removal, tilthouse

This procedure describes how to remove the tilthouse unit.

The item letters within parentheses refer to the figure *Cut away view of the assembly of the tilthouse unit on page 192*.

	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 tilthouse rests on a workbench, pallets or similar.	
3	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	

Continues on next page

	Action	Note
4	Secure the *tilthouse* with a roundsling in an overhead crane. This is done in order to prevent the tilthouse from falling down when the upper link is removed. **DANGER** If not secured the tilthouse will fall down when the upper link is removed. See figure!	 xx1000001067
5	Disassemble the *upper link* from the tilt house unit. **Note** It is not needed to remove the upper link from the link.	Detailed in section *Replacement of linkage - upper rod on page 213*  xx1000001065 Part: Upper link
6	Disconnect *motor cables* from motor axis 6. Place the motor cables in a way that it will not be damaged.	Detailed in section *Replacing the cable harness, upper end (incl. axis 6) on page 173*

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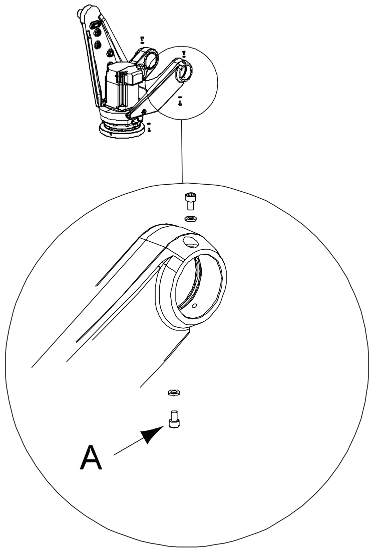
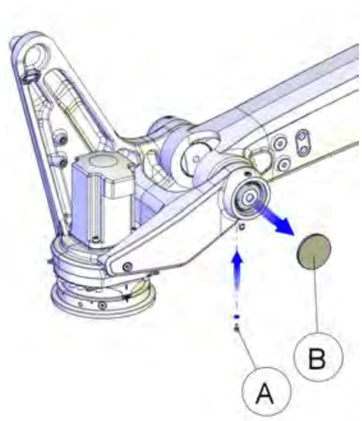
	Action	Note
7	Remove one of the *M6 screws* and *washer* at the cover for filling grease.	 xx0600002735 • A: Screw M6, grease filling hole
8	Be careful not to damage the ball plug! **Note** **Do not** remove the ball plug!	Shown in the figure *Location of tilt house on page 191*.
9	Remove one shaft at a time by following the steps below.	
10	Use compressed air in the M6 **hole for filling grease**, in order to remove the *VK cover*. **CAUTION** Only a very low air pressure is needed!	Put a hand with some paper over the VK cover in order to catch it.  xx1000001072 Parts: M6 screw in hole for filling grease VK cover

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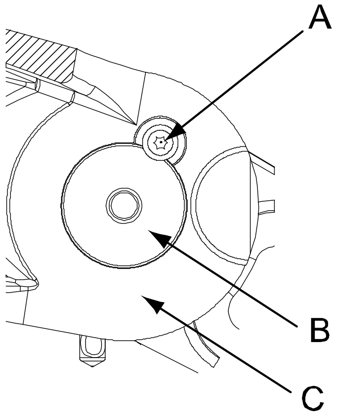
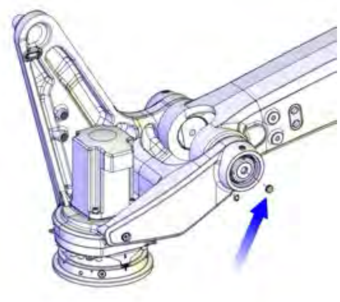
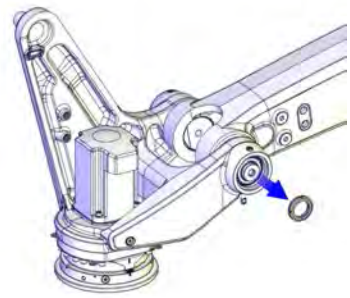
	Action	Note
11	Remove the screw that locks the shaft.	 xx0600002703 • A: Screw M6x16 • B: Shaft • C: Upper arm
12	Remove the *small VK cover* from the inside with the help of a punch.	 xx1000001073
13	Remove the *lock nut*.	 xx1000001074

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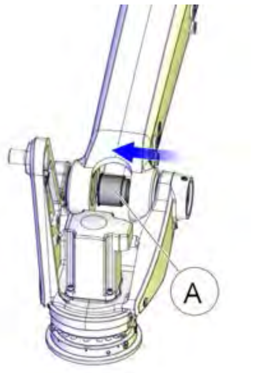
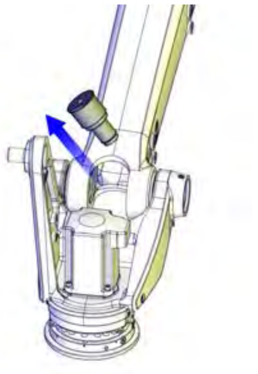
	Action	Note
14	Apply the press tool, mounting axis 6 in the following way: • Push the threaded bar M16 through the holes in the shafts. • Apply the washer and the nut on the right side of the right shaft. • Put the distance ring on the bar on the left side of the shaft • Apply the hydraulic pump on the bar • Secure the hydraulic pump with a nut. Remove the *shaft* with the *press tool, mounting axis 6*. **Note** A longer threaded bar M16 is needed when removing the shaft than the one specified when fitting.	Art.no. is specified in *Required equipment on page 193*.
15	Press out the *shaft*.	 xx1000001075 A Shaft
16	Remove the *press tool, mounting axis 6* and the *shaft*.	 xx1000001076

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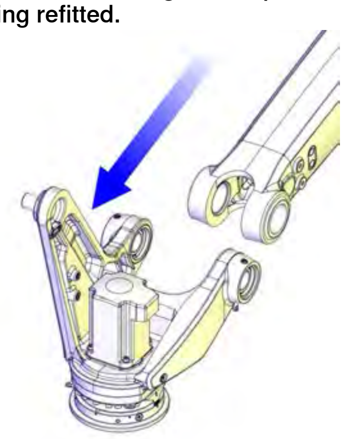
	Action	Note
17	Check that the tilthouse is secured in a over-head crane or similar before proceeding with the next shaft.	
18	Remove the other shaft in the same way.	Follow steps above.
19	Lift the tilthouse to a safe place.	Check that bearings are kept clean, if being refitted.  xx1000001077
20	Force away the sealing ring (N) with a screw-driver or similar.	The sealing must be replaced with a new one when refitting.
21	If needed change the bearings.	

Premounting tilthouse bearings and other parts, axis 2 side

The procedure below details how to fit the bearings and other parts in the tilthouse on the axis 2 side, before fitting the tilthouse to the upper arm.

This work is best done on a workbench or similair.

	Action	Note
1	Lift the tilthouse to a workbench (or similair) with a roundsling in an overhead crane.	
2	Apply some *grease* in the hole for the *bearings* (J) and (K).	Art.no. is specified in *Required equip-ment on page 193*. Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*.
3	Fit two *retaining rings for bores* (F).	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*.
4	Fit the outer race of the *bearing* (J) facing the outside of the tilthouse. Use a plastic hammer or similair.	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*.

Continues on next page

	Action	Note
5	Thread the *radial seal with dustlip* (N) and the *inner bearing complete* (K) on the *presswasher* (F) of the *pressing tool, premounting bearings*.	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*. Shown in the figure *Press tool premounting bearing on page 194*. Art.no. is specified in *Required equipment on page 193*.
6	Thread the race of the outer *bearing* (J) on the *bushing* (C) of the *pressing tool, premounting bearings*.	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*. Shown in the figure *Press tool premounting bearing on page 194*. Art.no. is specified in *Required equipment on page 193*.
7	Fit the pressing tool and press the parts together.	

Premounting tilthouse bearings and other parts, axis 3 side

The procedure below details how to fit the bearings and other parts in the tilthouse on the axis 3 side, before fitting the tilthouse to the upper arm.

This work is best done on a workbench or similair.

	Action	Note
1	Apply some *grease* in the hole for the *bearings* (J) and (K).	Art.no. is specified in *Required equipment on page 193*. Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*.
2	Fit the outer race of the *bearing* (J) facing the outside of the tilthouse. Use a plastic hammer or similiar.	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*.
3	Thread the *radial seal with dustlip* (N), the *inner bearing complete* (K) and the *ring* (L) on the *press washer* (F) of the *pressing tool, premounting bearings*.	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*. Shown in the figure *Press tool premounting bearing on page 194*. Art.no. specified in *Required equipment on page 193*.
4	Thread the race of the outer *bearing* (J) on the *bushing* (C) of the *pressing tool, premounting bearings*.	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*. Shown in the figure *Press tool premounting bearing on page 194*. Art.no. is specified in *Required equipment on page 193*.
5	Fit the pressing tool and press the parts together.	

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Refitting, tilt house

The procedure below details how to refit the tilthouse unit.

Before starting this procedure, prepare the tilthouse as detailed in the procedures *Premounting tilthouse bearings and other parts, axis 2 side on page 201* and *Premounting tilthouse bearings and other parts, axis 3 side on page 202*.

	Action	Note
1	Secure the tilthouse with a roundsling in an overhead crane and lift it to its mounting position on the upper arm.	
2	Apply *Dinitrol 490* (G) on the surfaces where the tilthouse faces the upper arm for rust protection.	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*.
3	Apply some *grease* in the holes for the *shafts* (M) in the upper arm.	Art. no. is specified in *Required equipment on page 193*. Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*.
4	*Note*! Fit the axis 2 side first.	Shown in the figure *Location of axes 2 and 3 sides of the robot on page 192*.
5	Push the axis 2 **shaft** (M) into its hole, from the inside.	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*.
6	Thread the race of the *bearing* (J) facing the outside of the tilthouse, on the *press housing* (C) of the *press tool, mounting axis 6* and fit it on the *shaft* (M).	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*. Shown in the figure *Press tool mounting axis 6 on page 195*. Art. no. is specified in *Required equipment on page 193*.
7	Fit the rest of the *press tool, mounting axis 6* from the outside of the tilthouse.Secure the parts with the *flange locknut* (F).	Art. no. is specified in *Required equipment on page 193*. Shown in the figure *Press tool mounting axis 6 on page 195*.

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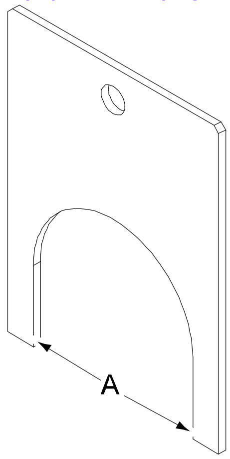
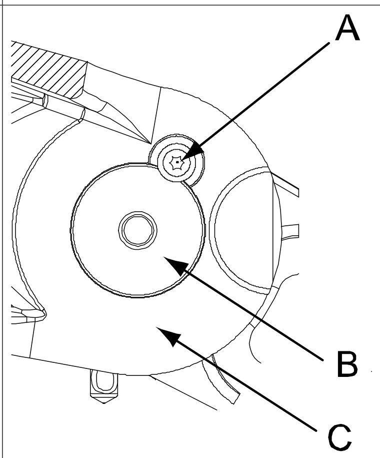
	Action	Note
8	Insert the *shims* in the space between the tilthouse and the upper arm on the axis 2 side.	Art. no. is specified in *Required equipment on page 193*.  xx0600002748 • Shims, width = 3 mm • A: 68 mm
9	Press the parts together.	
10	Fit the axis 3 side in the same way, by following steps 4 through 6.	
11	Insert the *shims* in the space between the tilthouse and the upper arm on the axis 3 side.	
12	Press the parts together.	
13	Apply locking liquid on the lock nut, KM7 axis 2 side and fit it with the flat surface facing inside.	Loctite 243. Tightening torque: 90 Nm
14	Apply locking liquid on the lock nut, KM7 axis 3 side and fit it with the flat surface facing inside.	Loctite 243. Tightening torque: 90 Nm
15	Apply locking liquid in the holes for the screws locking the shafts and fit screws and washers on both sides, locking the shafts.	 xx0600002703 • A: Screw M6x16 • B: Shaft • C: Upper arm

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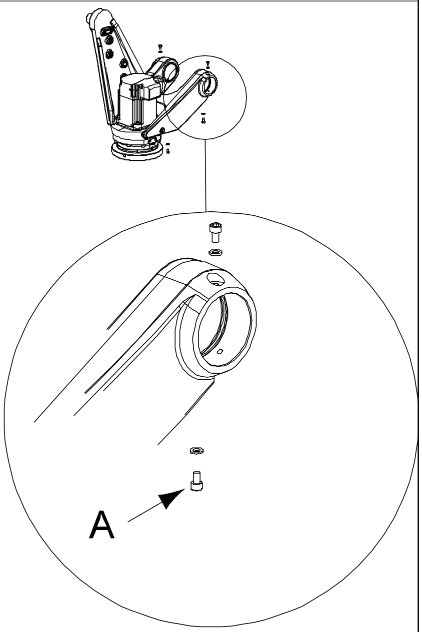
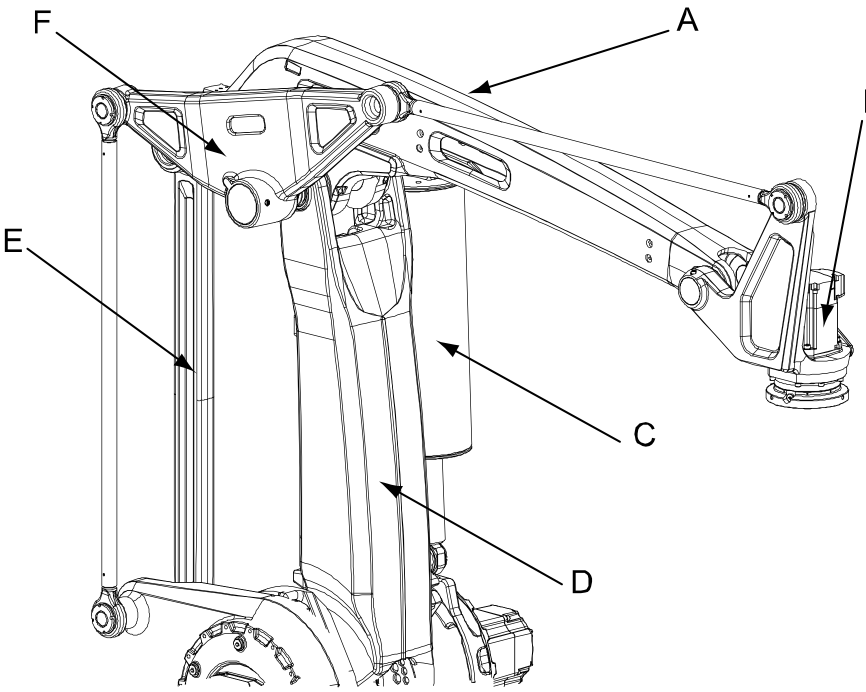
	Action	Note
16	Fit the inner *VK cover* (C) on both axes.	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*.
17	Fit the outer *VK cover* (D) on both axes.	Shown in the figure *Cut away view of the assembly of the tilthouse unit on page 192*.
18	Fill bearings with grease.	Specified in *Required equipment on page 193*.
19	Refit the motor cable, axis 6.	Detailed in section *Replacing the cable harness, upper end (incl. axis 6) on page 173*
20	Refit the M6 screw and washer at the cover for filling grease.	 xx0600002735 • A: Screw M6, grease filling hole
21	Refit the upper rod.	Detailed in section *Replacement of linkage - upper rod on page 213*
22	Recalibrate the robot.	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.
23	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.4.3 Replacement of upper arm

Location of upper arm

The upper arm is located as shown below.



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A	Upper arm
B	Motor axis 6
C	Balancing device
D	Lower arm
E	Parallel rod
F	Linkage

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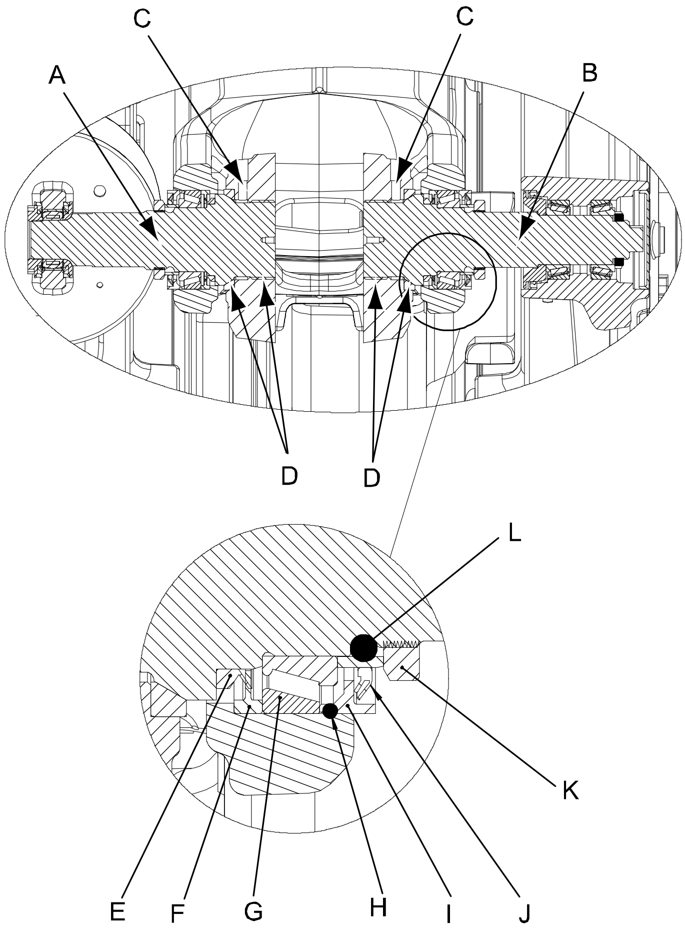
View of the assembly of the upper arm components

Shown below is a cut away view of how the upper arm is fitted to the lower arm (seen from above). The letters are being referred to in the following step by step procedures.



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A	Shaft, axis 2
B	Shaft, axis 3
C	Set screw, cup point (M10 x 20)
D	Lubricant paste (Molycote 1000)
E	Sealing ring (V-ring)
F	Sealing ring
G	Taper roller bearing
H	O-ring
I	Sealing ring
J	Sealing assembly
K	Lock nut (KM12)
L	O-ring (Di = 54.2 mm, t = 5.7 mm)

Continues on next page

Required equipment

Equipment, etc.	Art.no.	Note
Upper arm, axis 4	For spare part part number, see *Spare part lists on page 365*.	
Adapter	3HAC023916-001	
Grease filling tool	-	
Rust preventive	3HAC034903-001	Mercasol 3110 Waxcoat
Pressing tool, upper arm	3HAC023084-001	
KM12 socket	3HAC5347-1	
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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 *Circuit diagrams on page 367*.

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. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	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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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 the turning disk.	
3	Move the upper arm to a horizontal position.	
4	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
5	Secure the *upper arm* with roundslings in an overhead crane.	
6	Remove the *cable harness* in the upper arm.	Detailed in section
7	**CAUTION** The complete upper arm with weighs 170 kg (without any additional equipment fitted). Use a suitable lifting accessory to avoid injury to personnel!	
8	Raise the lifting equipment to take the weight of the upper arm.	
9	Remove the *balancing device*.	Detailed in section *Replacing the balancing device on page 249*
10	Remove the *linkage*.	Detailed in section *Replacement of linkage - upper rod on page 213* Detailed in section *Replacing the linkage - lower rod on page 217* Detailed in section *Replacement of linkage - link on page 221*
11	Remove the *parallel rod.*	Detailed in section *Replacing the parallel rod on page 228*
12	Remove the *lock nut* (K) on the *shaft, axis 3* (B).	Shown in the figure *View of the assembly of the upper arm components on page 207*.
13	Remove the *set screw* (C) holding the *shaft*.	Shown in the figure *View of the assembly of the upper arm components on page 207*.
14	Put the *adapter* on the *shaft*.	Art.no. is specified in *Required equipment on page 208*

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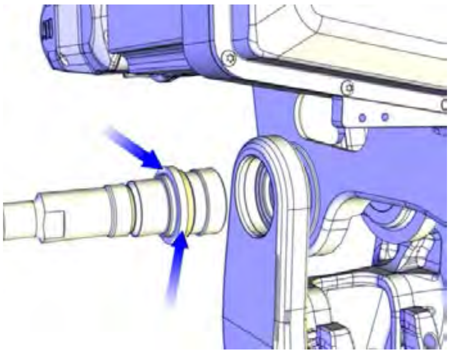
	Action	Note
15	Remove the *shaft axis 3* (B).	Shown in the figure *View of the assembly of the upper arm components on page 207*. Perform the removal with care. Threads can otherwise be damaged!
16	Then remove the *shaft, axis 2* (A) in the same order: 1 Remove the *lock nut* (K) 2 Remove the *set screw* (C) holding the shaft 3 Remove the *shaft axis 2*.	Shown in the figure *View of the assembly of the upper arm components on page 207*. **Note** The adapter is not needed on this shaft!
17	Put the *shafts* in a clean and safe place.	
18	Remove the *upper arm*.	

Preparations before refitting, upper arm

The procedure below details the preparations which must be done before refitting the upper arm.

	Action	Note
1	Put the *shafts* (A & B) on a workbench and fit the *sealing rings* (E).	Shown in the figure *View of the assembly of the upper arm components on page 207*.
2	Apply some grease on the *shafts* and *sealing rings*.	**Note** Don´t apply grease on the threads and cones of the shafts!
3	Fill the *bearings* (G) with bearing grease. Use grease filling tool.	Art. no. is specified *Required equipment on page 208* Shown in the figure *View of the assembly of the upper arm components on page 207*.
4	Apply *lubricant paste* (D) on the threads and cones of the *shafts*.	Molycote 1000. Shown in the figure *View of the assembly of the upper arm components on page 207*
5	*Foundry Plus:* Apply rust preventive on the surfaces on the shaft, according to illustration. **Note** Apply rust preventive to the shafts on both sides of the robot.	 xx1400001124

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Refitting, upper arm

The procedure below details how to refit the upper arm.

	Action	Note
1	Secure the *upper arm* with roundslings in an overhead crane.	
2	**CAUTION** The complete upper arm with weighs 170 kg (without any additional equipment fitted). Use a suitable lifting accessory to avoid injury to personnel!	
3	Lift the *upper arm* with an overhead crane and move it to its mounting position. Make sure that the *upper arm* is placed in a horizontal position.	
4	**Note** Refit the axis 3 side first!	
5	Carefully refit the *shaft, axis 3* (B) by hand only. Do not use force since the threads can be damaged if fitting is not done in the correct way.	Shown in the figure *View of the assembly of the upper arm components on page 207*.
6	Put the *adapter* on the *shaft* and fit it. Secure the shaft. Tightening torque: 400 Nm.	Art.no. is specified in *Required equipment on page 208* The adapter is used in order to be able to use the same tool on both axis 2 and 3 *shaft* when refitting. The adapter is only used on the *shaft axis 3*.
7	Refit the *sealing ring* (F) on the *shaft*.	Shown in the figure *View of the assembly of the upper arm components on page 207*.
8	Refit the *bearing* (G) on the *shaft* with the pressing tool, upper arm.	Shown in the figure *View of the assembly of the upper arm components on page 207*.
9	Fit an *o-ring* (H) on the *sealing ring* (I) and fit it on the *shaft*. **Note** The o-ring shall be faced against the *bearing*.	Shown in the figure *View of the assembly of the upper arm components on page 207*.
10	Fit the *o-ring* (L) on the *sealing assembly* (J) and refit the *sealing assembly* on the *shaft*.	Shown in the figure *View of the assembly of the upper arm components on page 207*.
11	Apply locking liquid on the *lock nut* (K) and refit it.	Shown in the figure *View of the assembly of the upper arm components on page 207*. Loctite 243. Tightening torque 90 Nm.

Continues on next page

	Action	Note
12	The refit the axis 2 side in the same order with the exception of the *lock nut* (K).	Follow the steps for refitting shaft axis 3 above. Shown in the figure *View of the assembly of the upper arm components on page 207*.
13	Apply locking liquid on the *lock nut* (K) and refit it. **Note** The order of the tightening torques is very important! **Note** The fitting of the lock nut on axis 2 is performed in three steps: 1 Fit the *lock nut* with a tightening torque of 300 Nm. 2 Unscrew the *lock nut*. 3 Fit the *lock nut* once again. This time with a tightening torque of 90 Nm.	Shown in the figure *View of the assembly of the upper arm components on page 207*. Loctite 243. Tightening torque the *first* time: 300 Nm Tightening torque the *second* time: 90 Nm
14	Apply locking liquid in the holes for the *set screws* (C) and fit the screws.	Shown in the figure *View of the assembly of the upper arm components on page 207* Loctite 243. Tightening torque: 35 Nm.
15	Wipe residual grease from the *shafts*.	
16	Refit the **parallel rod**.	Detailed in section *Replacing the parallel rod on page 228*
17	Refit the *cable harness, upper end*.	Detailed in section
18	Refit the *linkage*.	Detailed in section *Replacement of linkage - upper rod on page 213* Detailed in section *Replacing the linkage - lower rod on page 217* Detailed in section *Replacement of linkage - link on page 221*
19	Refit the *balancing device*.	Detailed in section *Replacing the balancing device on page 249*
20	Recalibrate the robot.	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.
21	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

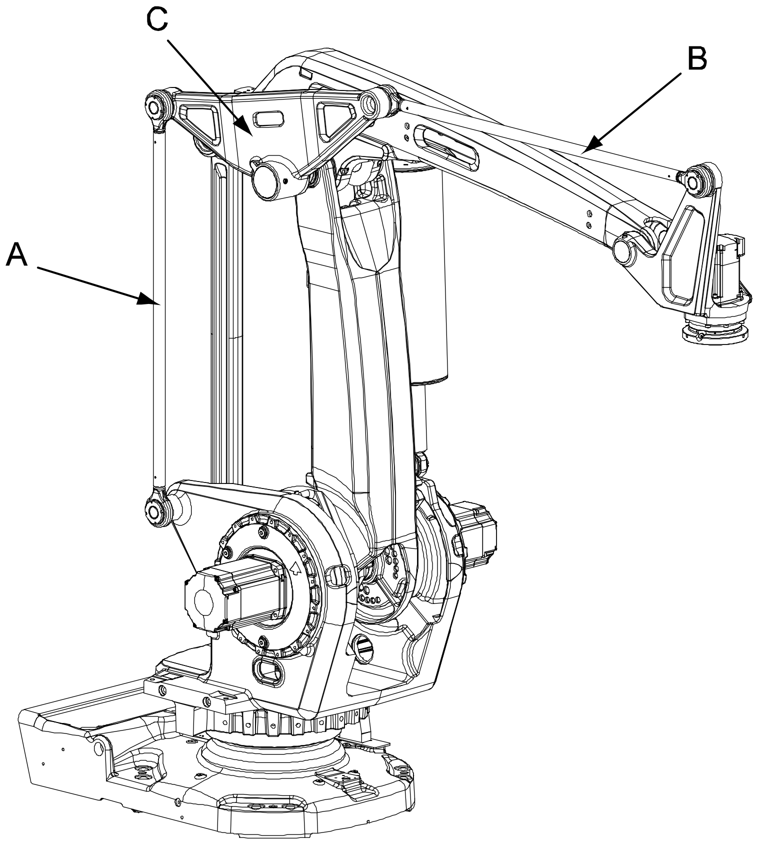
4.4.4 Replacement of linkage - upper rod

Overview

The link system consists of three basic parts - upper rod, lower rod and link. These procedures describes how to remove and refit the upper rod.

Location of upper rod

The upper rod is located as shown in the figure below.



xx0600002592

A	Lower rod
B	Upper rod
C	Link

Required equipment

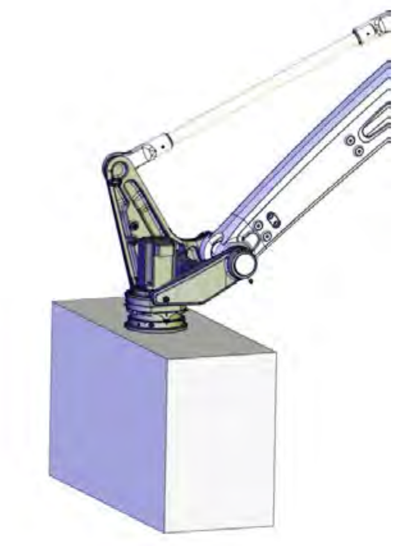
Equipment	Spare part no.	Art no.	Note
Upper rod	3HAC023744-003		White RAL 9003
Needle bearing	3HAC3311-1		Replace if damaged.
Bearing grease		3HAB3537-1	Used to lubricate the bear-ings.
Locking liquid		3HAB7116-1	Loctite 243

Continues on next page

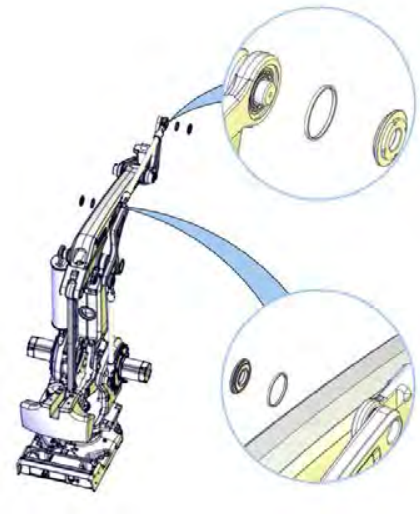
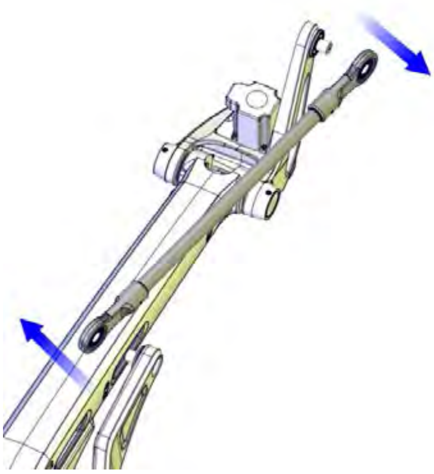
Equipment	Spare part no.	Art no.	Note
Standard toolkit		-	Content is defined in section *Standard tools on page 359*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

Removal, upper rod

The procedure below details how to remove the upper rod of the linkage.

	Action	Note
1	Put the robot in a position where it is possible to reach all parts that shall be removed.	Check especially that it is possible to remove the lock nut at the link.
2	Let the *tilthouse* rest on a workbench, on some pallets or similar. This is done in order to prevent the tilthouse from falling downwards when the upper rod is removed.	 xx1000001132
3	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	

Continues on next page

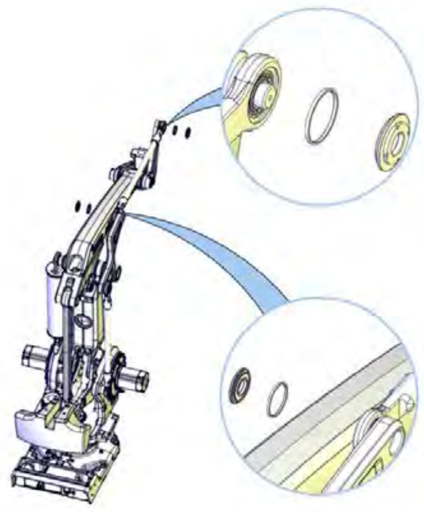
	Action	Note
4	Remove the *lock nuts* and *support washers* holding the upper rod at each end.	 xx1000001080
5	Remove the upper rod as shown in the figure. **Note** The support washers on the inside of the rod can stick to the grease of the bearings when the rod is being removed. Remove them from the link arm!	 xx1000001081
6	Remove the *support washers* and the *sealing rings*.	
7	Remove residual grease.	

Refitting, upper rod

The procedure below details how to refit the upper rod of the linkage.

	Action	Note
1	If needed, replace the *bearings* in the rod. **Note** The bearings are sensitive for pushes. Make sure they are not damaged!	Spare part no. is specified in *Required equipment on page 213*.

Continues on next page

	Action	Note
2	Lubricate the bearings properly with *bearing grease*.	Specified in *Required equipment on page 213*.
3	Refit the *sealing rings* on the shaft ends of the link and tilthouse.	
4	Refit the *support washers* on the shaft ends.	
5	Refit the upper rod to its place on the shafts.	Check that the rod is pushed in completely.
6	Refit the *support washers* on the outside of the upper rod on the shaft ends.	 xx1000001080 Lock nut (2 pcs) Support washer (2 pcs)
7	Apply *locking liquid* on the threads for the lock nuts.	
8	Refit the *lock nuts* on the link and tilthouse, using *locking liquid*.	Tightening torque: 120 Nm.
9	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.4.5 Replacing the linkage - lower rod

Overview

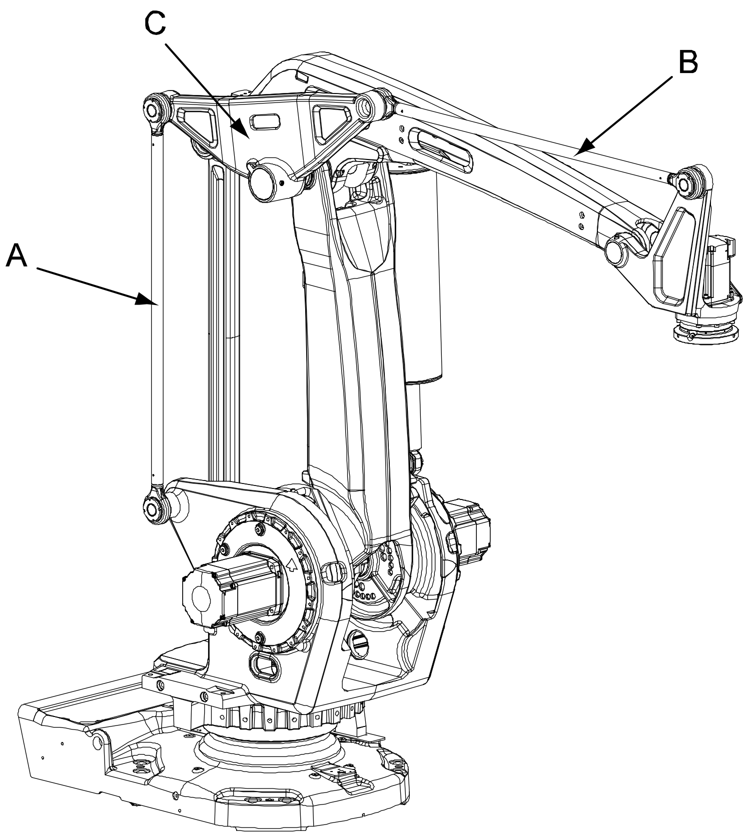
The linkage consists of three basic parts - upper rod, lower rod and link. The procedures below details how to remove and refit the lower rod.

How to replace the upper rod and link, see:

- *Replacement of linkage - upper rod on page 213*.
- *Replacement of linkage - link on page 221*

Location of lower rod

The lower rod is located as shown in the figure below.



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A	Lower rod
B	Upper rod
C	Link

Required equipment

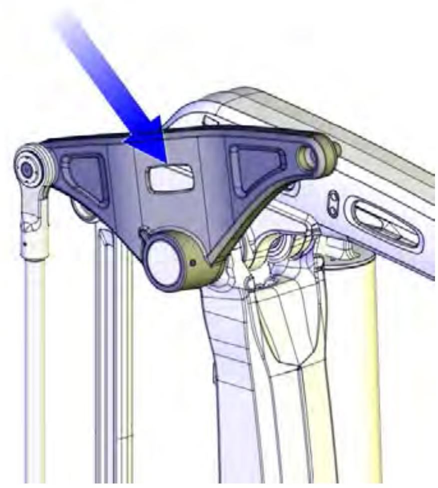
Equipment	Art no.	Note
Lower rod	For spare part no. see: • *Spare part lists on page 365*	

Continues on next page

Equipment	Art no.	Note
Needle bearing	For spare part no. see: • *Spare part lists on page 365*	Replace if damaged.
Bearing grease	3HAB3537-1	
Locking liquid	3HAB7116-1	Loctite 243
KM10 socket	-	Standard
Standard toolkit		Content is defined in section *Standard tools on page 359*.
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, lower rod

Use this procedure to remove the lower rod of the linkage.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
2	If the upper rod is removed, secure the link with a roundsling in a crane. Use the hole in the middle of the link.	 xx1000001252 This is done in order to prevent the link from moving if both the upper rod and lower rod are removed.

Continues on next page

	Action	Note
3	Remove the *lock nuts* and *support washers* that hold the lower rod at each end. **Note** The support washers can stick to the grease and can easily be forgotten and lost when removing the lock nuts.	
4	**CAUTION** The link weighs . All lifting accessories used must be sized accordingly!	
5	Remove the lower rod by lifting it straight out. **Note** The support washers on the inside of the rod can stick to the grease of the bearings when the rod is being removed. Remove them from the rod!	
6	Remove the inner *support washers* and the *sealing/spacer rings*.	
7	Remove residual grease.	

Refitting, lower rod

Use this procedure to refit the lower rod of the linkage.

	Action	Note
1	If needed, replace the *bearings*. **Note** The bearings are sensitive for pushes. Make sure they are not damaged!	Spare part no. is specified in *Required equipment on page 217*.
2	Lubricate the bearings properly with *bearing grease*.	Specified in *Required equipment on page 217*.
3	Refit the sealing/spacer rings to the shaft ends on the link and frame.	
4	Refit the *support washers* on the sealing/spacer rings.	Replace if damaged. **Tip** Putting some grease on the support washers will keep them in position.
5	Check that the bearings in the lower rod are fitted correctly, that is in the center of the hole. (The same distance from bearing to the edge of the lower rod on both sides.)	

Continues on next page

	Action	Note
6	**CAUTION** The link weighs . All lifting accessories used must be sized accordingly!	
7	Place the lower rod on the shaft ends of the link and frame. **Note** Check that the lower rod is pushed completely in.	
8	Refit the support washers on the outside of the lower rod, on the link and frame shafts.	
9	Apply *locking liquid* on the threads of the lock nuts.	Specified in *Required equipment on page 217*.
10	Refit the lock nuts on the shaft ends. Use a KM10 socket.	Tightening torque: 120 Nm.
11	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.4.6 Replacement of linkage - link

Overview

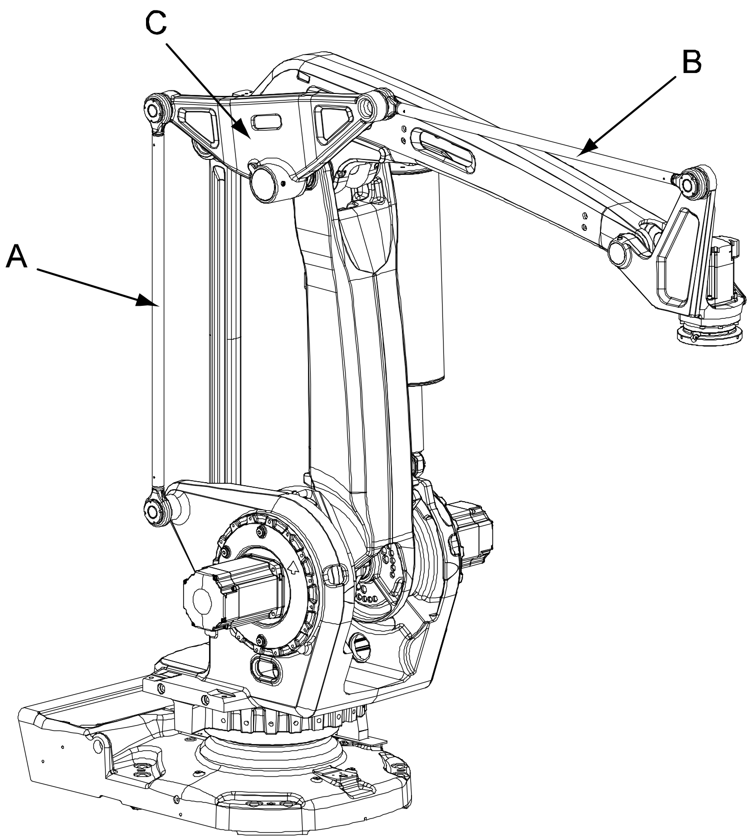
The linkage consists of three basic parts - upper rod, lower rod and link. The procedures below details how to remove and refit the link.

How to replace the upper rod and lower rod, see:

- *Replacement of linkage - upper rod on page 213*.
- *Replacing the linkage - lower rod on page 217*.

Location of link

The link is located as shown in the figure.



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A	Lower rod
B	Upper rod
C	Link

Cut away view of the assembly of the link

The figure shows a cut view of how the link is fitted.

Continues on next page

Required equipment

Equipment, etc.	Art. no.	Note
Link	For spare part no. see: • *Spare part lists on page 365*	
Auxiliary shaft	3HAC023081-004	Used for bearings.
Pressing tool, link	3HAC023081-001	Used to press the link on the shaft
Pressing tool, link	3HAC023079-001	Used to press the outer rings of the bearings in the link
Lubrication tool	3HAC5222-2	
Sealing compound	-	Permatex No. 3
Locking liquid	3HAB7116-1	Loctite 243
Grease	3HAB3537-1	
Standard toolkit		Content is defined in section *Standard tools on page 359*.
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

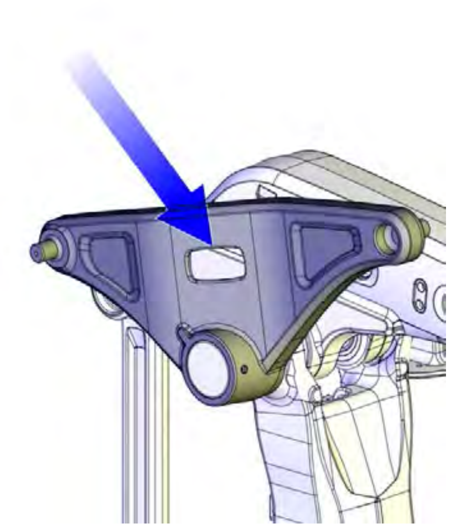
Decide which calibration routine to be used, based on the information in the table. Depending on which routine is chosen, action might be required prior to beginning the repair work of the robot, see the table.

	Action	Note
1	Decide which calibration routine to use for calibrating the robot. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

Continues on next page

Removal, link

Use this procedure to remove the link of the linkage.

	Action	Note
1	Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2	 **DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Secure the link with a roundsling in a crane. Use the hole in the middle of the link. This is done to prevent the link from moving when the upper rod and lower rod are removed.	 xx1000001265
4	Remove the upper rod and lower rod.	Detailed in section *Replacement of linkage - upper rod on page 213* Detailed in section *Replacing the linkage - lower rod on page 217*
5	Fit the auxiliary shaft on the shaft.	Art.no. is specified in *Required equipment on page 222*

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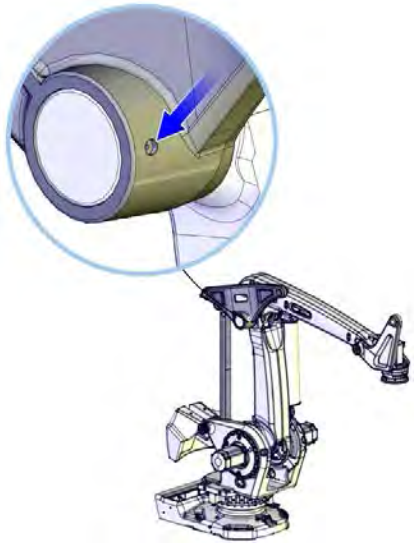
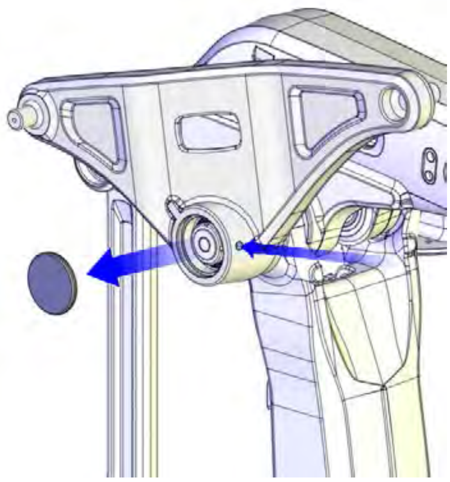
	Action	Note
6	Remove *screw and washer* in the hole for filling grease.	 xx1000001266
7	Use compressed air to remove the *VK cover*. Blow with a very low air pressure into the hole for filling grease. **CAUTION** Only a very low air pressure is needed!	 xx1000001267 Put one hand with some paper on top of the VK cover in order to catch it when released.

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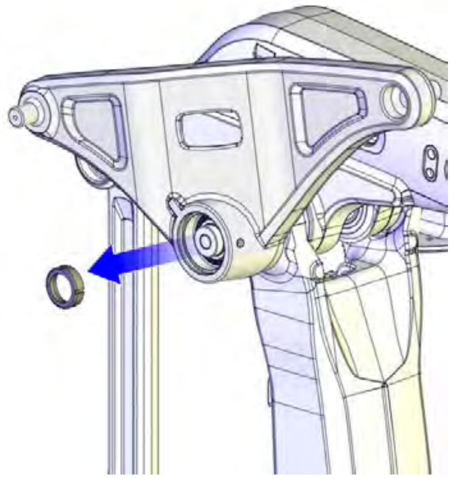
	Action	Note
8	Remove the *lock nut (KM8)*.	 xx1000001268
9	**CAUTION** The link weighs . All lifting accessories used must be sized accordingly!	
10	Put the end of the link facing the upper rod, downwards in order to find room to knock on it from the inside as close to its center as possible.	Normally a not too hard knock is needed to loosen the link. **Note**! Loosen the roundsling some before knocking! Otherwise the link may be locked by the lifting power.
11	Use a pair of levers, to bend the link loose.	
12	Remove the link.	
13	Remove the *support ring* with the *radial seal*.	
14	Wipe off residual grease.	
15	If needed, replace the bearings and radial seal.	

Preparations - fitting outer races of the bearing and sealing in the link

Use this procedure to fit the outer races of the bearings in the link.

	Action	Note
1	Put the link on a workbench.	
2	Place the outer rings of the bearings in the link.	
3	Use the *pressing tool* and fit the outer rings .	Art.no. is specified in *Required equipment on page 222*

Continues on next page

Refitting, link

Use this procedure to refit the link of the linkage.

	Action	Note
1	**CAUTION** The link weighs . All lifting accessories used must be sized accordingly!	
2	Secure the link with a roundsling in an overhead crane and lift it to the mounting position.	
3	Fit the *auxiliary shaft* on the shaft.	Art.no. is specified in *Required equipment on page 222*
4	Apply sealing compound on the support ring.	Permatex No. 3
5	Fit the support ring, with the radial seal fitted, on the shaft.	Replace the radial seal if needed!
6	Lubricate and place the bearings and link on the shaft, in the following order: • bearing • link • bearing	
7	Apply the *pressing tool* and secure the link.	Art.no. is specified in *Required equipment on page 222*
8	Apply *locking liquid* on the lock nut.	Loctite 243
9	Secure the lock nut in these three steps: 1 Tighten with a torque of 300 Nm. 2 Unscrew the lock nut. 3 Tighten the lock nut finally with a tightening torque of 90 Nm. **Note** The recommended order of tightening the lock nut is important to follow to avoid future problems with the shaft.	
10	Refit the VK cover.	

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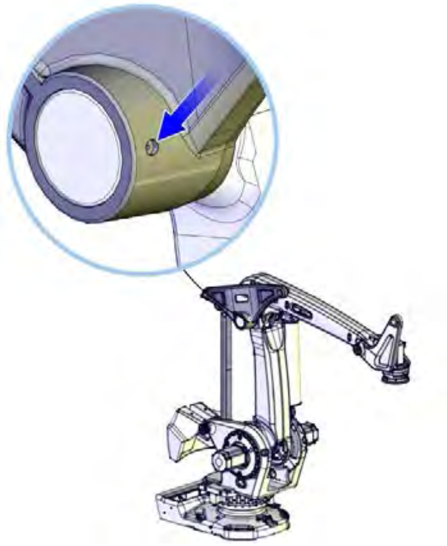
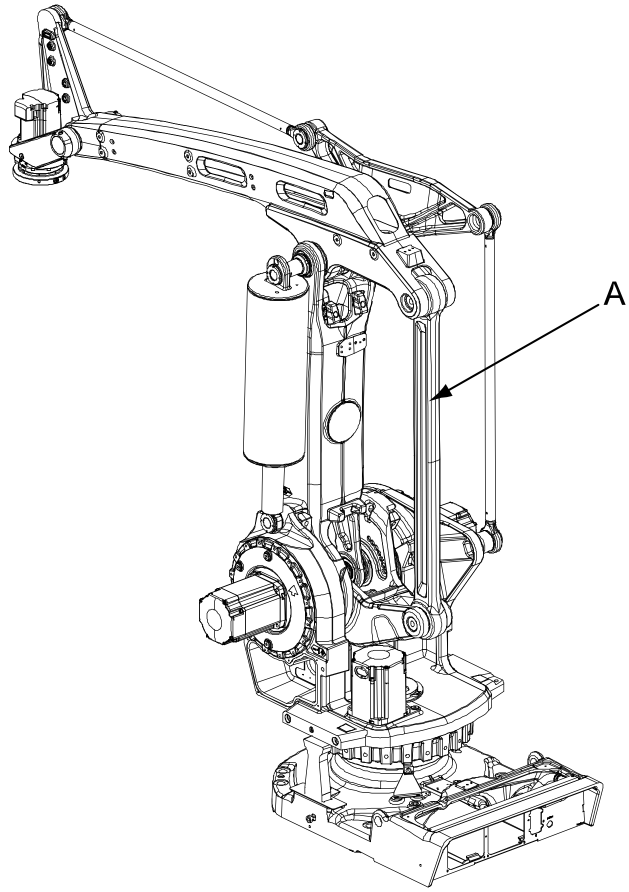
	Action	Note
11	Fill the link with *grease*. Use lubrication tool.	Art.no. is specified in *Required equipment on page 222*  xx1000001266
12	Refit the screw and washer in the hole for filling grease.	
13	Refit the upper rod to the link.	Detailed in section *Replacement of linkage - upper rod on page 213*
14	Refit the upper rod to the link.	Detailed in section *Replacing the linkage - lower rod on page 217*
15	Recalibrate the robot!	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.
16	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.4.7 Replacing the parallel rod

Location of parallel rod

The parallel rod is located as shown in the figure.



xx0600002610

A	Parallel rod

Required equipment

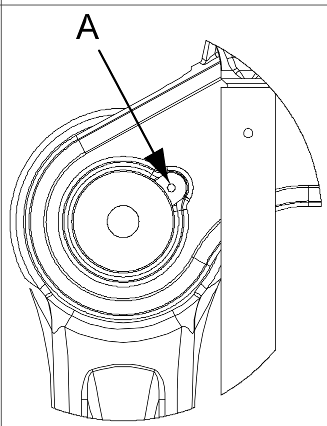
Equipment, etc.	Art.no.	Note
Parallel rod	For spare part no. see: • *Spare part lists on page 365*.	
Mounting/Demounting tool	3HAC5021-1	
Locking liquid	3HAB7116-1	Loctite 243
Rust preventive	3HAC034903-001	Mercasol 3110 Waxcoat
Protection plug	3HAC4836-2	F21 28x22, 4x12x9
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.

Continues on next page

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.

Removing, parallel rod

Use this procedure to remove the parallel rod. The procedure is the same in both ends of the parallel rod.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
2	**CAUTION** Secure the upper arm with a roundsling in an overhead crane or similar, in order to avoid accidents.	
3	*Foundry Plus:* Remove the protection plugs	
4	Remove the upper *lock screw* and *washer*, that secure the parallel rod in position.	 xx0600002741 • A: Lock screw M6x16

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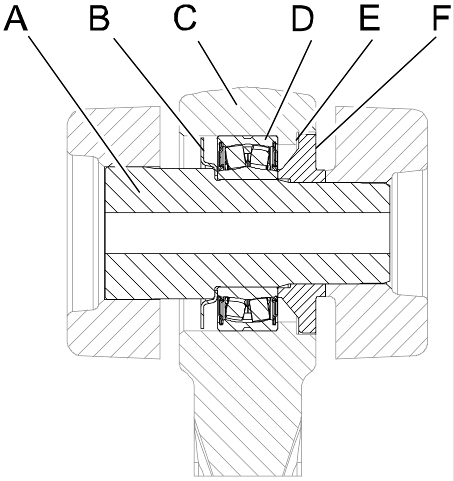
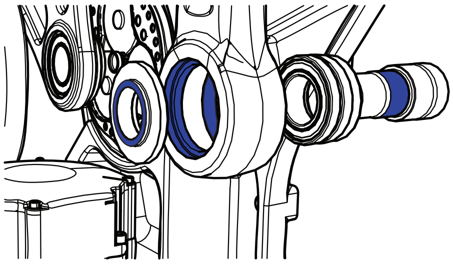
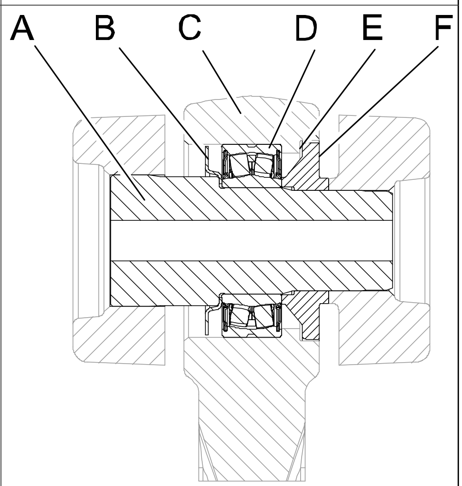
	Action	Note
5	Remove the upper *shaft* (A) and *cover washer* (B), using the *fitting/removing tool*.	Art. no. is specified in *Required equipment on page 228*.  xx0700000065 Parts: A Shaft B Cover washer C Parallel rod D Sealed spherical bearing E Bearing grease F Thrust washer
6	Remove the *thrust washer* (F).	See figure above!
7	**CAUTION** The parallel rod weighs . All lifting accessories used must be sized accordingly!	
8	Move the *parallel rod* backwards from its upper connection point and let it rest against the frame and base.	See figure above and *Location of parallel rod on page 228*!
9	Secure the parallel rod with a roundsling in an overhead crane or similar.	
10	Remove the lower end of the parallel rod in the same way as the upper end: 1 Remove the lower *lock screw* and washer. 2 Remove the lower *shaft* (A)and *cover washer* (B). 3 Remove the *thrust washer* (F).	See figure above!
11	Remove the parallel rod from the robot.	
12	Replace the *bearings* (D), if necessary.	See figure above!

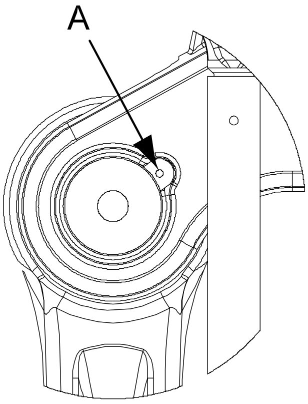
Continues on next page

Refitting, parallel rod

Use this procedure to refit the parallel rod. The procedure is the same in both ends of the parallel rod.

	Action	Note
1	Start by refitting the lower end.	
2	Verify that the bearings are in correct position in the parallel rod.	
3	**CAUTION** The parallel rod weighs . All lifting accessories used must be sized accordingly!	
4	Lift the parallel rod to the mounting position of the lower end, and let it rest on the the frame and base.	
5	*Foundry Plus:* Apply rust preventive on the highlighted areas. **Note** Rust preventive should be applied in both ends of the parallel rod.	 xx1400001126
6	Put the *thrust washer* (F) on the axis 2 side of the *parallel rod* (C).	 xx0700000065 Parts: A Shaft B Cover washer C Parallel rod D Sealed spherical bearing E Bearing grease F Thrust washer
7	Put the *cover washer* (B) on the axis 3 side of the parallel rod.	See figure above!

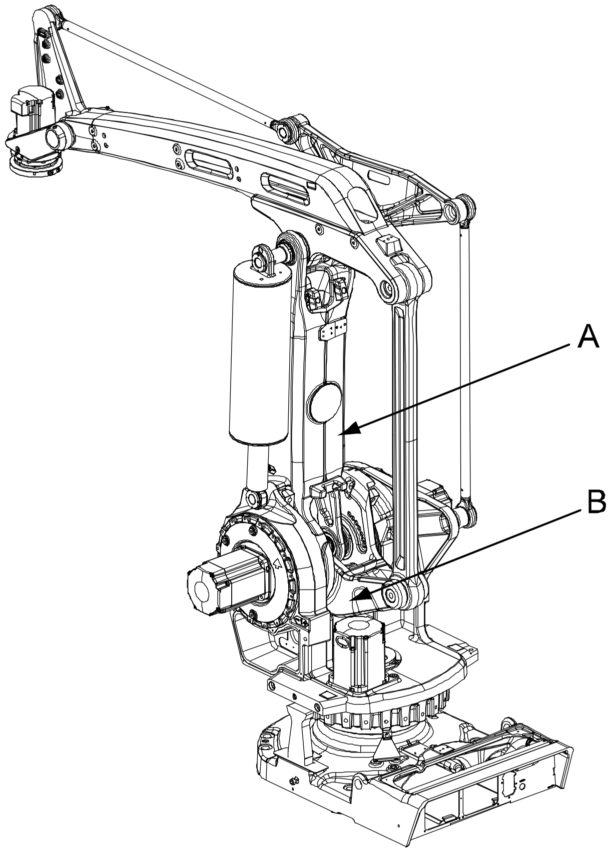
Continues on next page

	Action	Note
8	Refit the *shaft* (A) by pressing it through the parallel bar with the *fitting/removing tool*.	Art. no. is specified in *Required equipment on page 228*. See figure above!
9	Apply *locking liquid* in the hole of the lock screw.	Loctite 243
10	Refit the *lock screw* and plain washer.	 xx0600002741 • A: Lock screw M6x16
11	Lift the parallel rod up into position for fitting the upper end.	
12	Refit the upper end of the parallel rod in the same way as the lower end.	
13	*Foundry Plus:* Refit the protection plugs.	
14	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.4.8 Replacing the complete lower arm

Location of lower arm

The complete lower arm is located as shown in the figure below.



xx0600002611

A	Lower arm
B	Parallel arm

Required equipment

Equipment, etc.	Art.no.	Note
Lower arm	For spare part no. see: • *Spare part lists on page 365*.	
Sealing, axes 2/3		Always change the sealing.
Guide sleeves	3HAC14446-1	Used to keep the axes 2/3 sealing in place during refitting of lower arm.
Crank	3HAC023132-001	
Lock screw	-	M16x90
Lifting tool, lower arm complete	3HAC8446-1	

Continues on next page

Equipment, etc.	Art.no.	Note
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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 *Circuit diagrams on page 367*.

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.

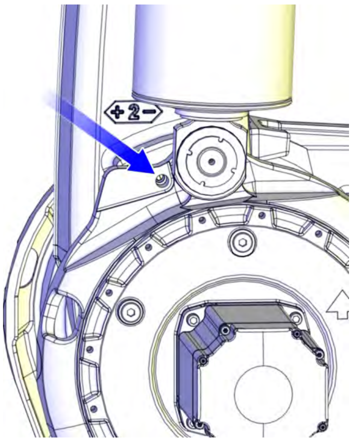
	Action	Note
1	Decide which calibration routine to use for calibrating the robot. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	If the robot is 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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

Removal, lower arm

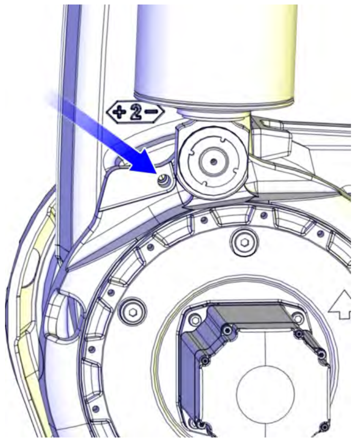
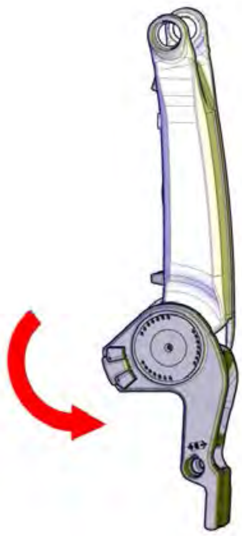
The procedure below details how to remove the lower arm.

	Action	Note
1	Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	

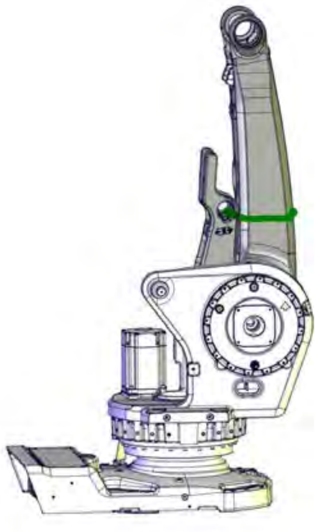
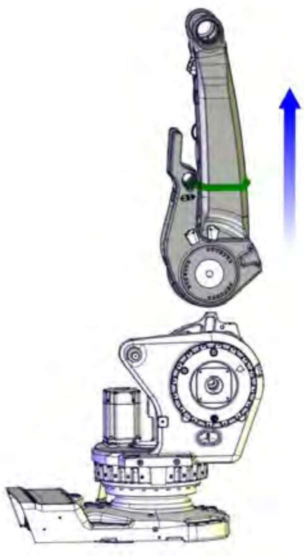
Continues on next page

	Action	Note
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Secure the lower arm with a *lock screw* in the hole as shown in the figure to the right. **CAUTION** Tighten by hand!	 xx1000001101
4	Remove the linkage.	See *Replacement of linkage - upper rod on page 213* See *Replacing the linkage - lower rod on page 217* See *Replacement of linkage - link on page 221*
5	Remove the balancing device.	See *Replacing the balancing device on page 249*
6	Remove the parallel rod.	See *Replacing the parallel rod on page 228*.
7	Remove the cable harness in the upper and lower arm. Secure the cable harness in a way that it is protected from oil spill and damage.	See *Replacing the cable harness, upper end (incl. axis 6) on page 173*.
8	Remove the complete upper arm.	See *Replacement of upper arm on page 206*.
9	Remove the axes 2 and 3 motors.	See *Replacing motors, axes 2 and 3 on page 271*.
10	Remove the axes 2 and 3 gearboxes.	See *Replacing the gearbox, axes 2-3 on page 301*.
11	**CAUTION** The robot lower arm weighs 65 kg. All lifting accessories used must be sized accordingly!	

Continues on next page

	Action	Note
12	Secure the complete lower arm system (including the parallel arm) with a *lifting tool, lower arm complete* in an overhead crane or similar.	Specified in *Required equipment on page 233*.
13	Remove the *lock screw* that secures the lower arm system.	 xx1000001101
14	Remove all M12 and M16 screws that hold the lower arm, on both sides. **Note** The axis 3 side has no M16 screws!	
15	**DANGER** Secure the parallel arm to the lower arm before lifting the lower arm system. If not secured, the parallel arm can fall down and cause a serious accident!	 xx1000001359
16	**CAUTION** The parallel arm system weighs 118 kg. All lifting accessories used must be sized accordingly!	

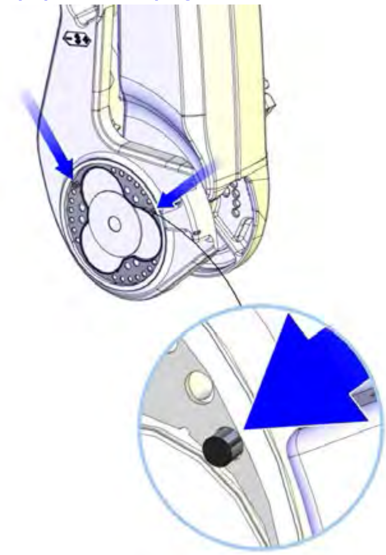
Continues on next page

	Action	Note
17	Move the parallel arm and secure it to the lower arm as shown in the figure, to prevent it from falling down.	 xx1000001357
18	The space between the gearboxes is cramp. Push therefor the lower and parallel arm together with help of an iron bar or similar before removing them.	**Note** If the parts are not pushed together, it will be difficult to remove the complete lower arm.
19	**CAUTION** The robot lower arm weighs 65 kg. All lifting accessories used must be sized accordingly!	
20	Remove the complete lower arm (including the parallel arm).	 xx1000001358
21	How to replace the parallel arm is detailed in section *Replacement of parallel arm on page 242*.	

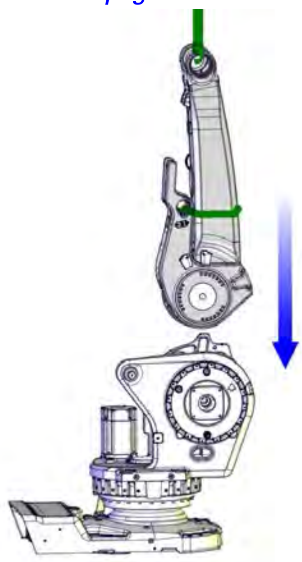
Continues on next page

Refitting, lower arm

Use this procedure to refit the lower arm system.

	Action	Note
1	Fit the parallel arm to the lower arm.	See *Replacement of parallel arm on page 242*.
2	**CAUTION** The robot lower arm weighs 65 kg. All lifting accessories used must be sized accordingly!	
3	Fit a *lifting tool, lower arm complete*, to the lower arm system and lift it up. **DANGER** Secure the parallel arm to the lower arm before lifting the lower arm system. If not secured, the parallel arm can fall down and cause a serious accident!	Specified in *Required equipment on page 233*.
4	Fit two *guide sleeves* for the axes 2/3 sealings to the lower arm and put the sealings on them. See figure.	Art. no. is specified in *Required equipment on page 233*.  xx1000001368

Continues on next page

	Action	Note
5	Put the lower arm in its mounting position. If the hole pattern needs to be adjusted, use a *crank* to move the gears in order to find the correct hole pattern.	Art. no. is specified in *Required equipment on page 233*.  xx1000001370
6	**Note** Refit the axis 2 side first!	
7	Verify that the sealings are still in place.	
8	Refit all screws (both M12 and M16) and washers, that are possible to fit at this stage, on the axis 2 side.	Tightening torque M16: 300 Nm Tightening torque M12: 120 Nm
9	Push the parallel arm against the axis 3 side with the help of an iron bar or similar.	
10	Refit all screws and washers, that are possible to fit, on the axis 3 side. **Note** The axis 3 side has no M16 screws!	Tightening torque M12: 120 Nm
11	Remove the guide sleeves and secure two screws more.	
12	Change the position of the lower arm in order to reach the remaining attachment holes, and fit the remaining screws.	

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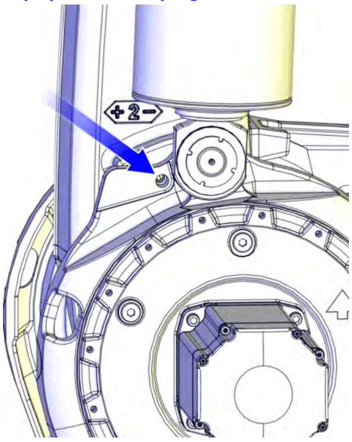
	Action	Note
13	Secure the lower arm by fitting a *lock screw*. **CAUTION** Tighten by hand!	Dimension is specified in *Required equipment on page 233*.  xx1000001101
14	Refit the axes 2 and 3 gearboxes.	See *Replacing the gearbox, axes 2-3 on page 301*.
15	Refit the axes 2 and 3 motors.	See *Replacing motors, axes 2 and 3 on page 271*.
16	Refit the complete upper arm.	See *Replacement of upper arm on page 206*.
17	Refit the cable harness.	See *Replacing the cable harness, upper end (incl. axis 6) on page 173*.
18	Refit the parallel rod.	See *Replacing the parallel rod on page 228*
19	Refit the balancing device.	See *Replacing the balancing device on page 249*.
20	Refit the linkage.	See *Replacement of linkage - upper rod on page 213* See *Replacing the linkage - lower rod on page 217* See *Replacement of linkage - link on page 221*
21	Remove the lock screw.	
22	Recalibrate the robot.	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.

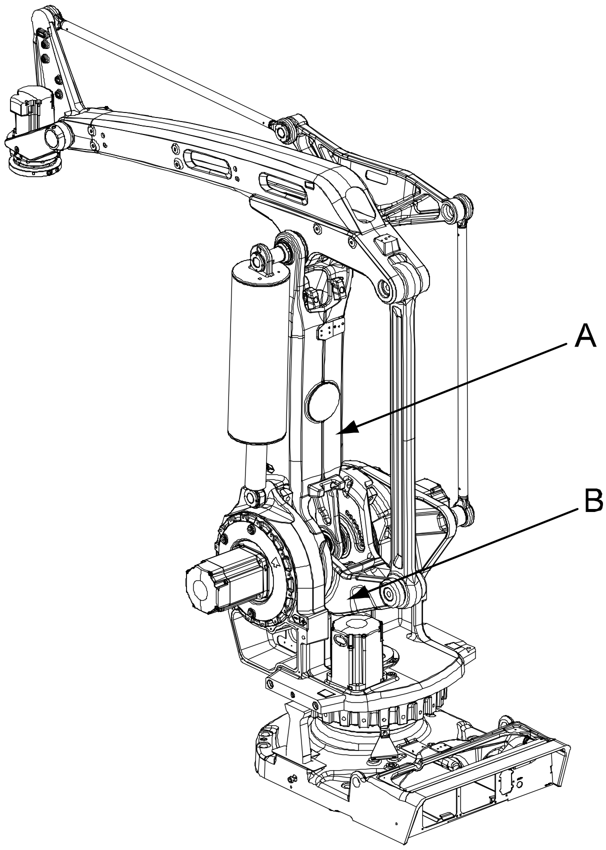
Continues on next page

	Action	Note
23	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.4.9 Replacement of parallel arm

Location of parallel arm

The parallel arm is located as shown in the figure below.



xx0600002611

A	Lower arm
B	Parallel arm

Required equipment

Equipment, etc.	Art.no.	Note
Parallel arm	For spare part no. see: • *Spare part lists on page 365*.	
VK cover		
VK cover		
Bearing grease	3HAB3537-1	
Rust preventive	3HAC034903-001	Mercasol 3110 Waxcoat
Pressing tool, lower arm	3HAC023092-001	
Lifting accessory, parallel arm	3HAC023098-001	

Continues on next page

Equipment, etc.	Art.no.	Note
Lifting accessory, lower arm complete	3HAC8446-1	
Level	-	
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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.

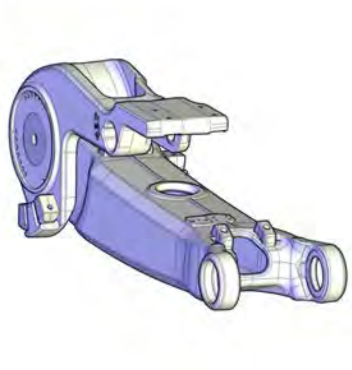
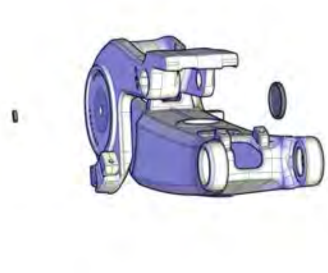
	Action	Note
1	Decide which calibration routine to use for calibrating the robot. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	If the robot is 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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

Removal, parallel arm

Use this procedure to remove the parallel arm.

	Action	Note
1	Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	

Continues on next page

	Action	Note
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Remove the complete lower arm.	See *Replacing the complete lower arm on page 233*.
4	Put the complete lower arm on a workbench as shown in the figure. **Tip** Removal of the parallel arm is best performed on a workbench.	 xx1000001024
5	Remove the two VK covers.	 xx1000001371

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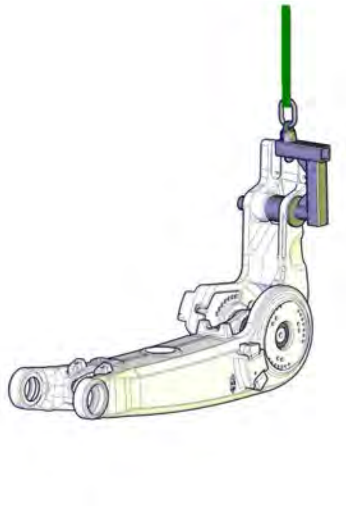
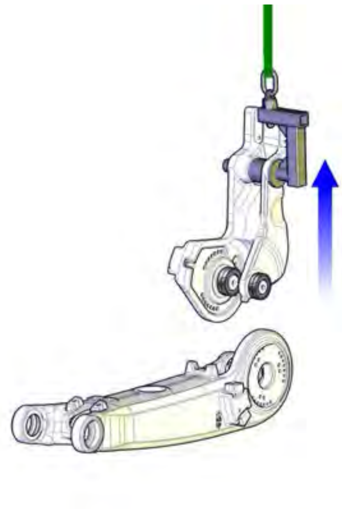
	Action	Note
6	Fit the *lifting accessory, parallel arm* on the parallel arm. Lift the parallel arm to the position shown in the figure.	Art. no. is specified in *Required equipment on page 242*.  xx1000001375
7	Disassemble the parallel arm from the lower arm by using the *pressing tool, lower arm*.	Art. no. is specified in *Required equipment on page 242*.
8	**CAUTION** The parallel arm system weighs 118 kg. All lifting accessories used must be sized accordingly!	
9	Remove the parallel arm.	 xx1000001018
10	If needed, change the bearings.	

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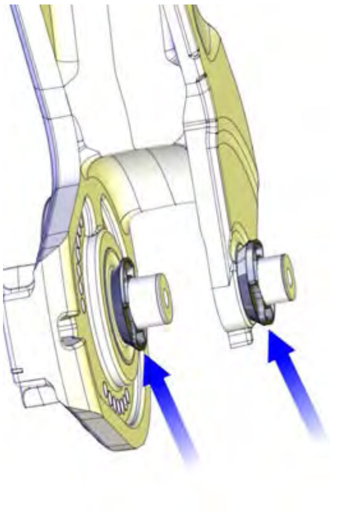
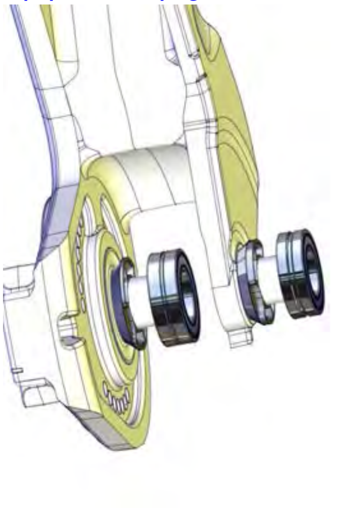
Refitting, parallel arm

Use this procedure to refit the parallel arm.

	Action	Note
1	Refitting of the parallel arm is best performed on a workbench.	
2	Apply some *grease* on the shafts on the parallel arm.	Specified in *Required equipment on page 242*
3	Refit a *spacing sleeve* on each shaft.	 xx1000001376
4	Refit a bearing on each shaft with *pressing tool, lower arm*.	Art. no. is specified in *Required equipment on page 242*  xx1000001377

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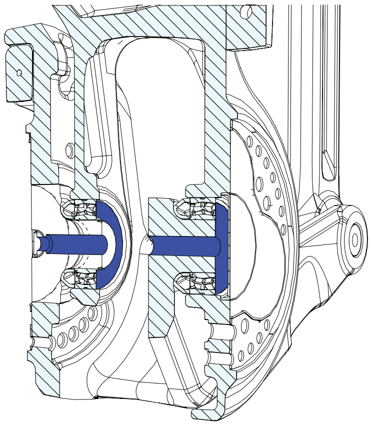
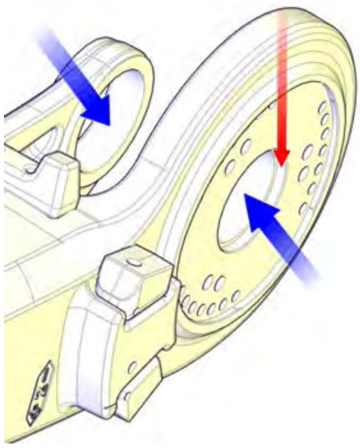
	Action	Note
5	*Foundry Plus:* Apply rust preventive on the highlighted areas.	 xx1400001127
6	Refit the protection washer on the inner shaft.	
7	Refit the lock ring on the inner shaft.	
8	**CAUTION** The parallel arm system weighs 118 kg. All lifting accessories used must be sized accordingly!	
9	Fit the *lifting accessory, parallel arm*.	Art. no. is specified in *Required equipment on page 242*.
10	Lift the parallel arm onto the workbench where the lower arm is placed.	Art. no. is specified in *Required equipment on page 242*
11	Adjust the lower arm in a way that both holes are parallel. Use a *level*.	
12	Apply some *grease* in the holes in the lower arm (thick blue arrows). **Note** Do not put grease on the surfaces for the VK covers (thin red arrow)!	 xx1000001380

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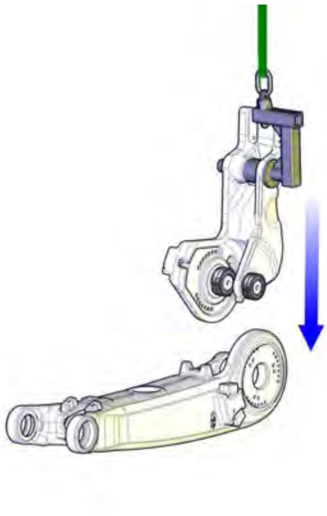
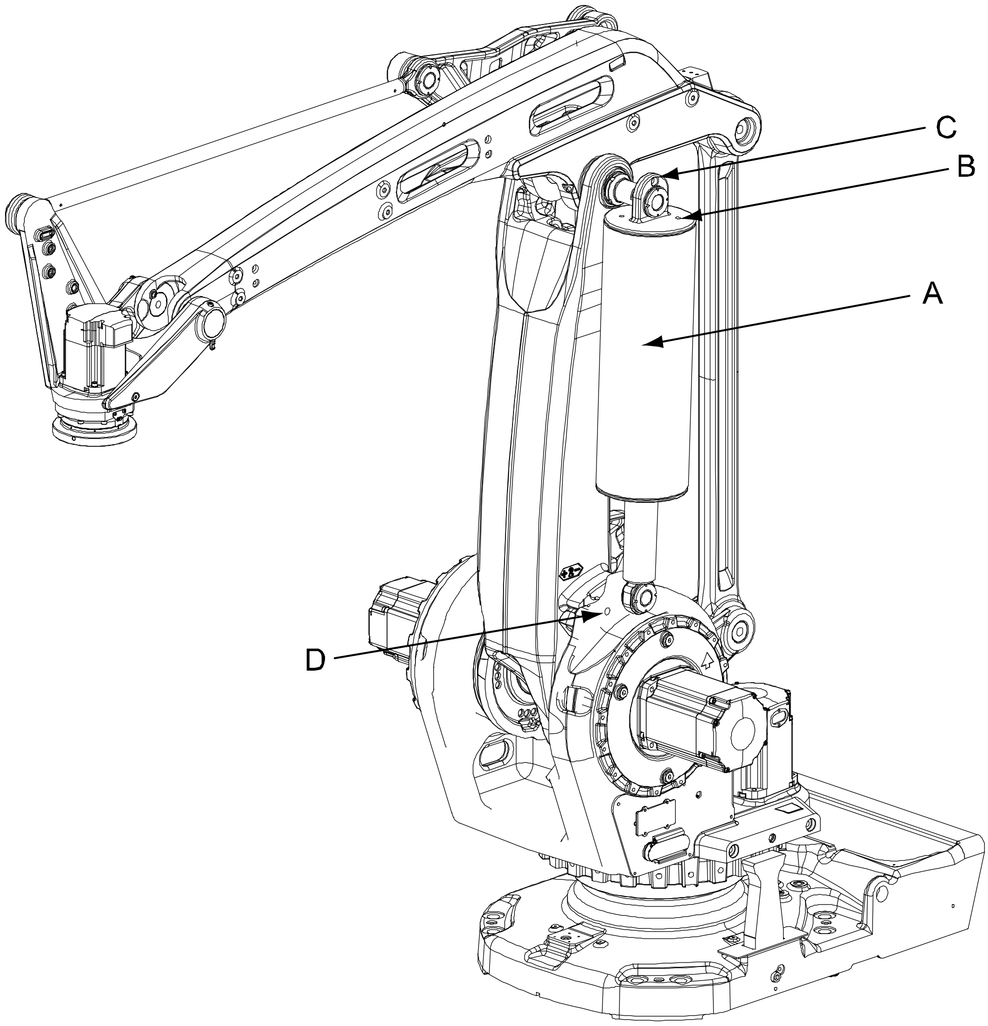
	Action	Note
13	Lift the parallel arm, lower it and put it in mounting position with the lower arm.	 xx1000001379
14	Carefully press the parallel arm onto the lower arm using the *pressing tool, lower arm*.	Art. no. is specified in *Required equipment on page 242*.
15	Fit the big and small VK cover.	
16	Refit the complete lower arm.	Detailed in section *Replacing the complete lower arm on page 233*.
17	Recalibrate the robot.	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.
18	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.5 Frame and base

4.5.1 Replacing the balancing device

Location, balancing device

The balancing device is located as shown in the figure.



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A	Balancing device
B	Hole to neutralize the spring force. (M12)
C	Hole on lifting ear
D	Hole for lock screw

Required equipment

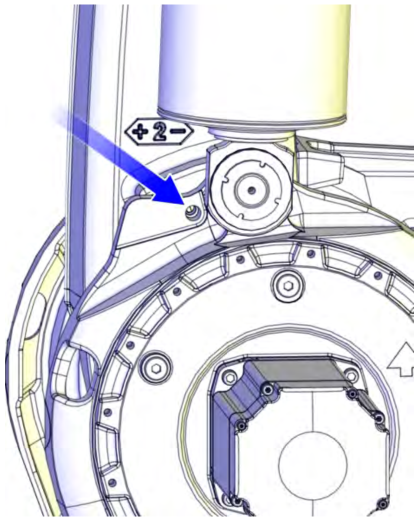
Equipment, etc.	Art.no.	Note
Balancing device	For spare part number, see *Spare part lists on page 365*.	

Continues on next page

Equipment, etc.	Art.no.	Note
Auxiliary shaft	3HAC5281-1	For fitting the inner rings of the bearings
Auxiliary shaft, long	3HAC5275-1	
Auxiliary shaft, short	3HAC5276-1	
Lock screw	-	M16 x 90 For securing the lower arm.
Screw		2 pcs, M12 x 50 For neutralizing the spring force of the balancing cylinder.
Lubrication tool	3HAC5222-2	
Lifting accessories	-	
Locking liquid	3HAB7116-1	Loctite 243
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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.

Removing, balancing device

Use this procedure to remove the balancing device.

	Action	Note
1	Move the robot to a position close enough to its calibration position, to allow the lock screw to be inserted into the hole for the lock screw.	The balancing device must be placed in a 90° angle from the floor, in order the be lifted in the most secure way. See the figure in *Location, balancing device on page 249*.
2	Lock the lower arm by inserting the *lock screw* into the *hole*. **CAUTION** Tighten by hand!	 xx1000001101

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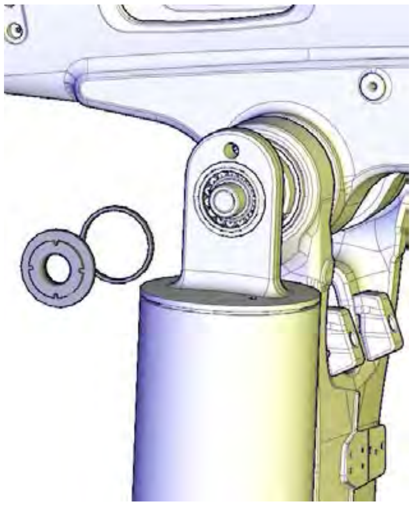
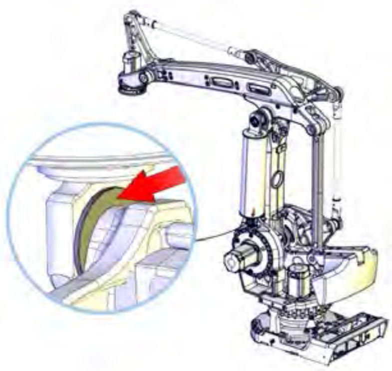
	Action	Note
3	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
4	Remove the *protection hood* in the upper end of the balancing device.	
5	Insert two *screws, M12x50* in the holes to neutralize the spring force. Screw in the screws until they have proper contact with the cylinder inside. The length of the cylinder is now locked and the balancing device is unloaded. It should now be possible to easily rotate the balancing device.	
6	Attach a *lifting accessories* to the balancing device. Use the *hole* in the lifting ear.	 xx1000001112

Continues on next page

	Action	Note
7	Remove the upper and lower *lock nuts* and *support washers* (2+2 pcs). **Note** Make sure that the shaft between the upper and lower arm does not rotate when unscrewing the lock nuts! The lock nut is locked with Loctite 243.	 xx1000001113
8	Fit the *auxiliary shafts* on the upper and lower pivot shaft. Fit the short auxiliary shaft on the upper shaft and the longer on the lower shaft.	Art.no. is specified in *Required equipment on page 249*
9	Stretch the *roundsling*.	
10	Apply a *ball bearing puller* behind the lower ear of the balancing device. **Note** The ball bearing puller must be applied around the *spacer ring*. See figure!	 xx1000001115
11	**CAUTION** The balancing device weighs 70 kg. All lifting accessories used must be sized accordingly!	

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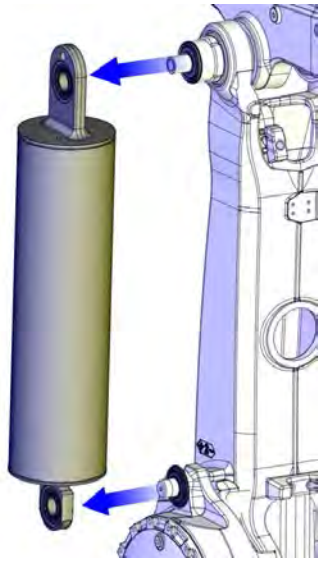
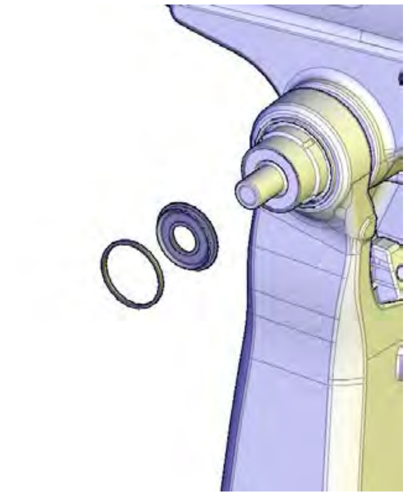
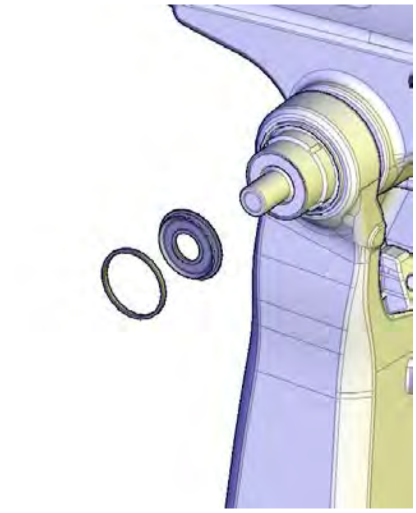
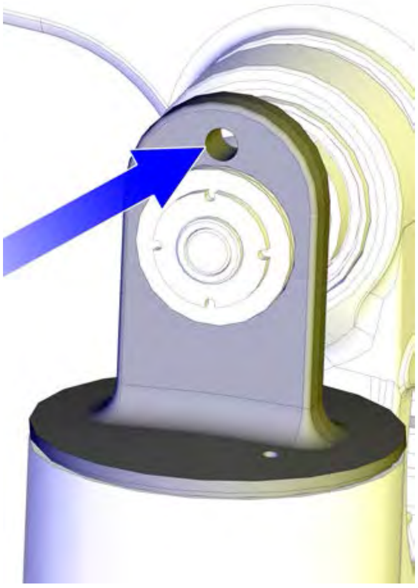
	Action	Note
12	With the help of the ball bearing puller carefully remove the *balancing device* from its upper and lower attachments.	 xx1000001114
13	Remove the balancing device and put it in a safe place.	
14	Remove the inner rings of the bearings.	
15	Remove upper and lower *spacer rings* and *support washers* (2+2 pcs).	 xx1000001116
16	Remove residual grease.	

Refitting, balancing device

use this procedure to refit the balancing device.

	Action	Note
1	Check the bearings. Replace if needed.	

Continues on next page

	Action	Note
2	Refit the inner *sealing rings* and *support washers* in both ends.	 xx1000001116
3	Refit the inner ring of the bearings on the upper and lower pivot shaft with the auxialiary shaft.	
4	Fit the auxiliary shafts on the upper and lower shafts. Fit the short auxiliary shaft on the upper shaft and the longer on the lower shaft.	Art.no. is specified in section *Required equipment on page 249*
5	**CAUTION** The balancing device weighs 70 kg. All lifting accessories used must be sized accordingly!	
6	Attach lifting accessory to the balancing device and lift it on to the auxiliary shafts.	 xx1000001112

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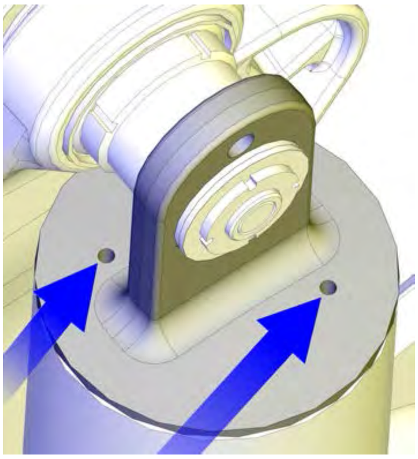
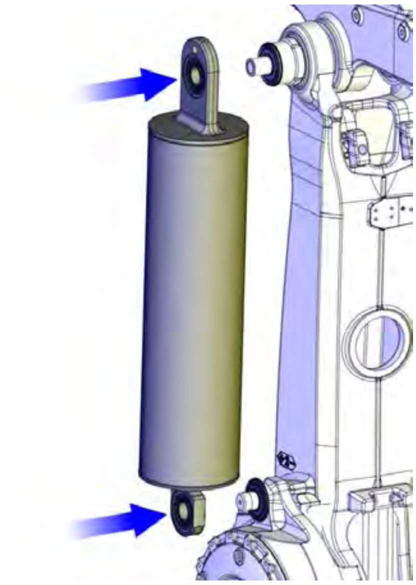
	Action	Note
7	Adjust the length between the upper and lower bearings by means of the M12 screws, used to neutralize the spring force. This length should preferably be 0.5 mm too short than 0.1 mm too long. If the distance is too long the bearings may be damaged when erecting the balancing device.	 xx1000001111
8	Carefully refit the balancing device on the upper and lower shafts.	 xx1000001271
9	Fit the *lubricating tool*. The tool should be tightened to the bottom position by hand power only.	Art. no. is specified in section *Required equipment on page 249*.
10	Fill the bearings with grease through the nipple. Continue until grease excudes behind the inner sealing.	
11	Remove the lubricating tool and wipe off protruding grease.	
12	Remove the auxiliary shafts.	
13	Apply *locking liquid* on the threads of the lock nuts.	Specified in section *Required equipment on page 249*.

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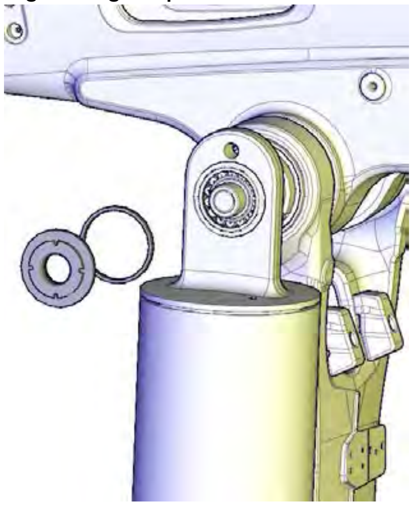
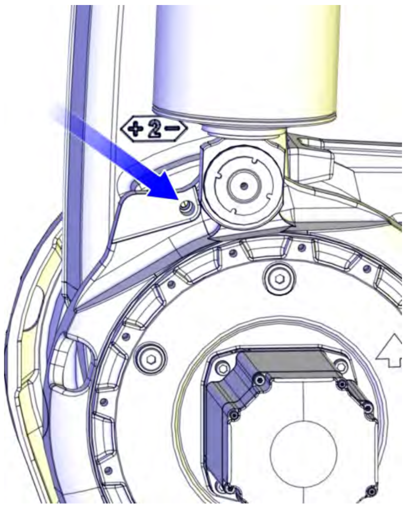
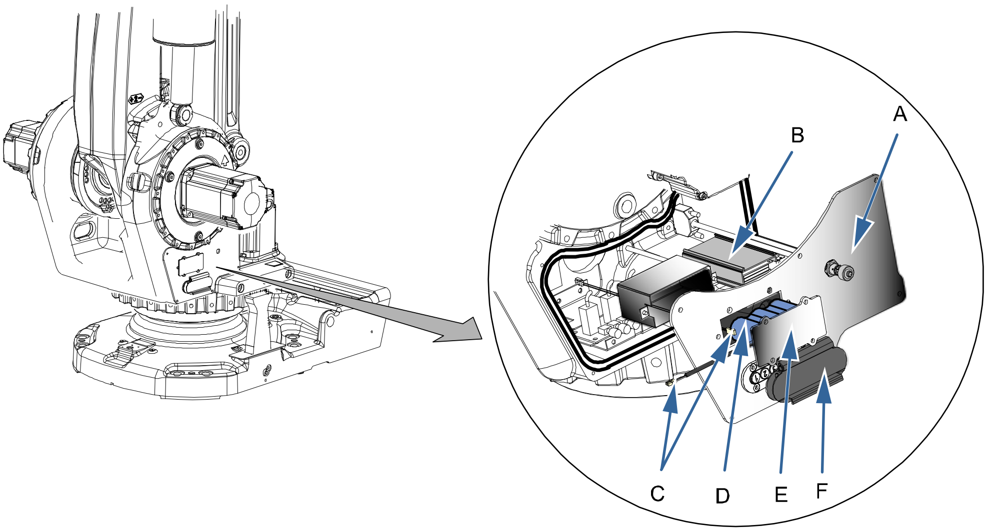
	Action	Note
14	Refit the lock nuts and support washers.	Tightening torque: 120 Nm  xx1000001113
15	Check play (min. 0.1 mm) between support washers and bearing seat at both bearings.	
16	Remove the M12x50 screws from the balancing device to restore the springforce.	
17	Remove the *lock screw*.	 xx1000001101
18	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.5.2 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.



xx0600002621

A	SMB cover
B	SMB unit
C	Battery cable
D	SMB battery
E	SMB battery, cover

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: *Spare part lists on page 365*.	
Battery pack	For spare part number, see: *Spare part lists on page 365*.	
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.

Continues on next page

Equipment, etc.	Art. no.	Note
Circuit diagram	-	See chapter *Circuit diagrams on page 367*.

Removing, SMB unit

Use this procedure to remove the SMB unit.

	Action	Note
1	Move the robot to the calibration position.	
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	 xx0200000023 **WARNING!** The unit is sensitive to ESD. Before handling the unit please read the safety information in the section *WARNING - The unit is sensitive to ESD! on page 54*	
4	Remove the *SMB cover* by unscrewing its attachment screws.	Shown in the figure *Location of SMB unit on page 257*.
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 *guide pins* that secure the board.	Shown in the figure *Location of SMB unit on page 257*.
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 *battery cable* from the SMB unit.	Shown in the figure *Location of SMB unit on page 257*.

Refitting, SMB unit

Use this procedure to refit the SMB unit.

	Action	Note
1	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	

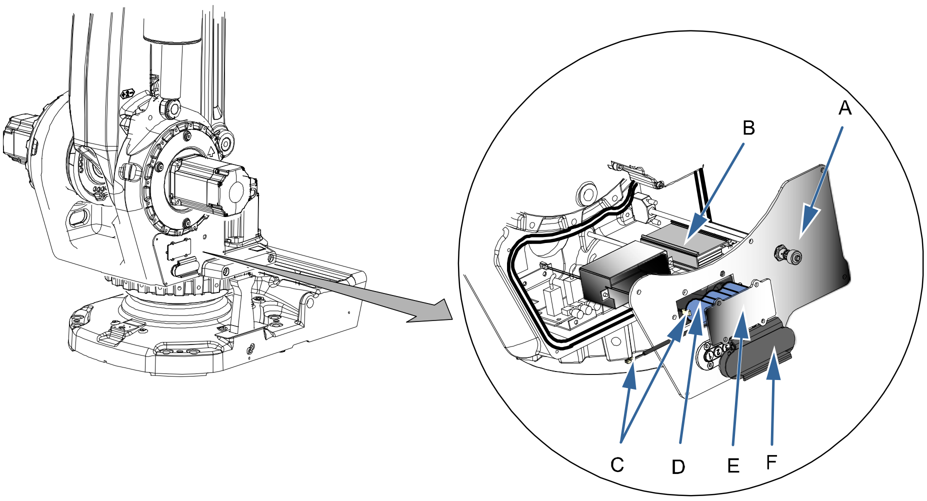
Continues on next page

	Action	Note
2	 xx0200000023 **WARNING!** The unit is sensitive to ESD. Before handling the unit please read the safety information in the section *WARNING - The unit is sensitive to ESD! on page 54*	
3	Connect the *battery cable* to the SMB unit.	Shown in the figure *Location of SMB unit on page 257*.
4	Connect all connectors to the SMB board: R1.SMB1-3, R1.SMB6 and R2.SMB	Art. no. is specified in *Required equipment on page 257*. Shown in the figure *Location of SMB unit on page 257*.
5	Fit the *SMB unit* onto the *guide pins*.	
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 *SMB cover* 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 *Location of SMB unit on page 257*.
9	Update the revolution counter!	See *Updating revolution counters on page 326*.
10	 **DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.5.3 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.



xx0600002621

A	SMB cover
B	SMB unit
C	Battery cable
D	SMB battery
E	SMB battery, cover

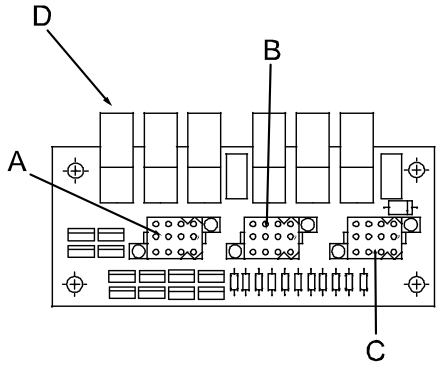
Required equipment

Equipment, etc.	Art. no.	Note
Brake release board with buttons	For spare part no. see: • *Spare part lists on page 365*	
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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

Removing, brake release board

Use this procedure to remove the brake release board.

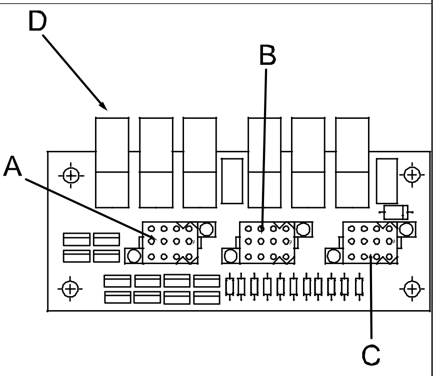
	Action	Note
1	 **DANGER** Turn off all: • electric power supply to the robot • hydraulic pressure supply to the robot • air pressure supply to the robot Before entering the robot working area.	
2	 **ELECTROSTATIC DISCHARGE (ESD)** The unit is sensitive to ESD. Before handling the unit read the safety information in section *WARNING - The unit is sensitive to ESD! on page 54*	
3	Remove the *push button guard* from the SMB cover.	Shown in the figure *Location of brake release board on page 260*. The guard must be removed to ensure a correct refitting of the brake release board.
4	Open the *SMB cover* by unscrewing the attachment screws. Let the battery stay connected, to avoid the need of synchronization of the robot!	Shown in the figure *Location of brake release board on page 260*.
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 *brake release board.*	 xx0200000129 • A: Connector X8 • B: Connector X9 • C: Connector X10 • D: Push buttons Location of the brake release unit is shown in the figure *Location of brake release board on page 260*.

Continues on next page

	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 *WARNING - The unit is sensitive to ESD! on page 54*	
2	Fasten the *brake release board* 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 *Location of brake release board on page 260*. Art. no. is specified in *Required equipment on page 260*.
3	Connect the connectors X8, X9 and X10 to the brake release board.	 xx0200000129 • A: Connector X8 • B: Connector X9 • C: Connector X10 • D: Push buttons
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 *SMB cover* 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 *Location of brake release board on page 260*.
6	**WARNING** Before continuing any service work, please observe the safety information in section *WARNING - The brake release buttons may be jammed after service work on page 52*!	

Continues on next page

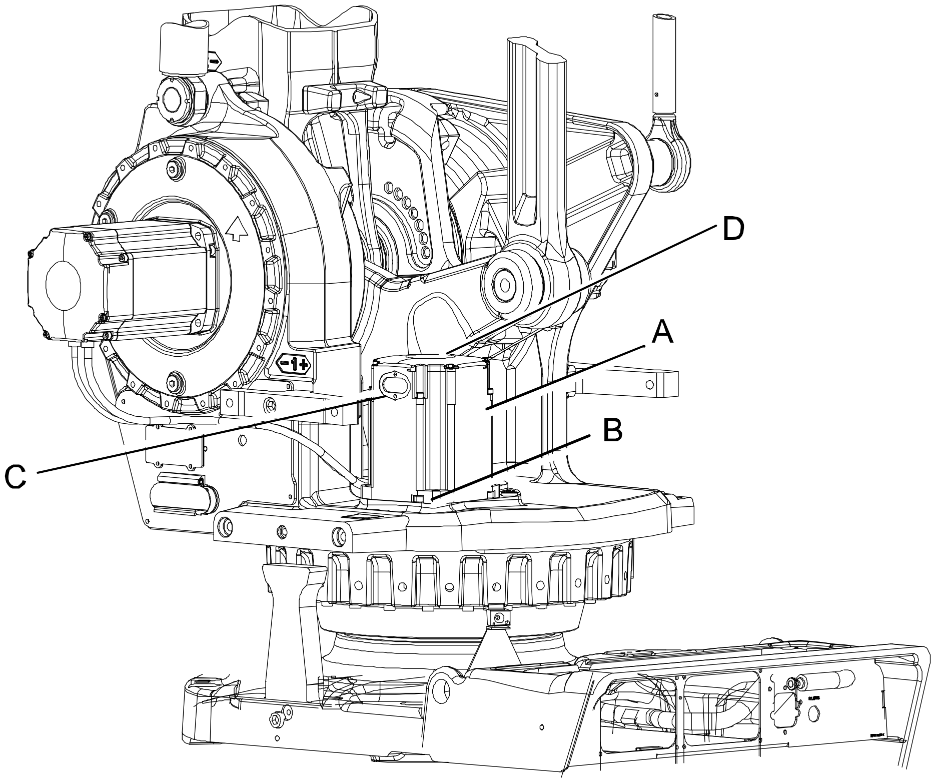
	Action	Note
7	Refit the *push button guard* to the SMB cover.	Shown in the figure *Location of brake release board on page 260*.
8	If the battery has been disconnected the revolution counter must be updated.	Detailed in the Calibration chapter - section *Updating revolution counters on page 326*.
9	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.6 Motors

4.6.1 Replacing motor, axis 1

Location of motor axis 1

The motor axis 1 is located on the left hand side of the robot as shown in the figure.



xx0600002598

A	Motor axis 1
B	Motor attachment screws and washers
C	Cable gland cover (located on the left hand side of the motor)
D	Motor cover

Required equipment

Equipment, etc	Art.no.	Note
Motor axis 1	For spare part number, see: • *Spare part lists on page 365*	Includes: • motor • pinion • o-ring (The old o-ring must be replaced when replacing the motor)
Grease	3HAB3537-1	Used to lubricate the o-ring
Bits extension	3HAC023760-001	Used to reach the attachment screws for the motor.

Continues on next page

Equipment, etc	Art.no.	Note
Power supply	-	24 VDC, max. 1,5 A For releasing the brakes.
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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 *Circuit diagrams on page 367*.

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.

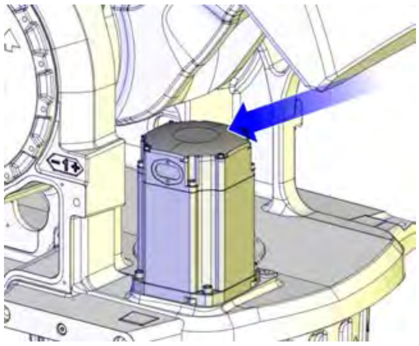
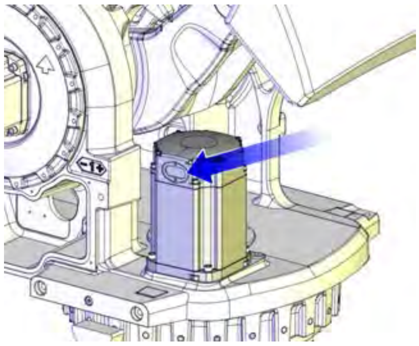
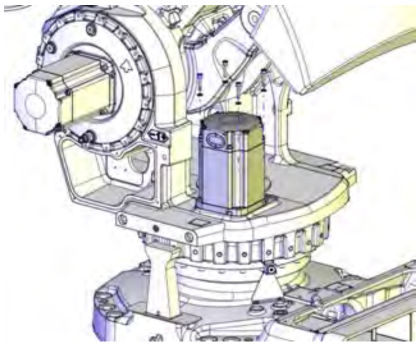
	Action	Note
1	Decide which calibration routine to use for calibrating the robot. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	If the robot is 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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

Removing motor axis 1

Use this procedure to remove motor axis 1.

	Action	Note
1	Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	

Continues on next page

	Action	Note
2	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
3	Remove the *motor cover* to get access to the connectors on top of the motor.	 xx1000001092
4	Remove the *cable gland cover* at the cable exit of the motor. **Note** Make sure the gasket is undamaged! Replace if damaged.	 xx1000001094
5	Disconnect all connectors beneath the motor cover.	
6	In order to release the brake, connect the 24 VDC power supply.	Connect to connector R2.MP1 • + : pin 2 • -: pin 5
7	Remove the *attachment screws* of the motor. Use the bits extension.	 xx1000001090

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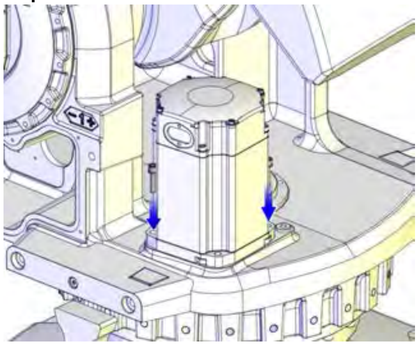
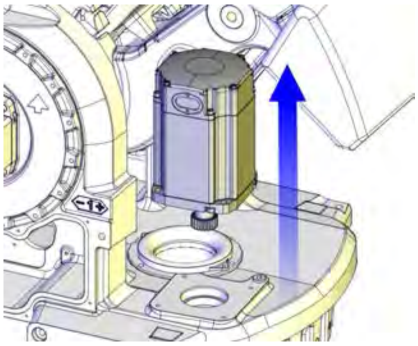
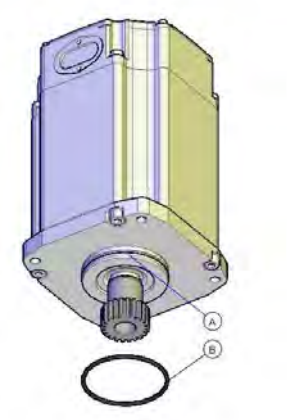
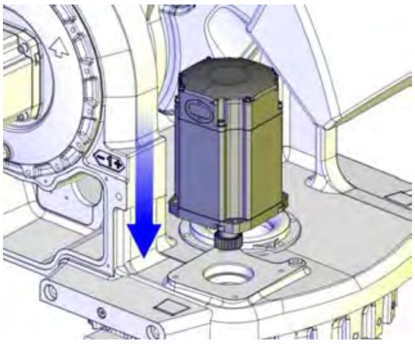
	Action	Note
8	If required, press the motor out of position by fitting two screws in the holes on the motor for pressing out the motor.	Always use removal screws and tools in pairs!  xx1000001207
9	**CAUTION** The motor weighs 29 kg. All lifting accessories used must be sized accordingly!	
10	Remove the motor by carefully lifting it straight up to get the pinion away from gear. **CAUTION** Be careful not to damage the pinion in the process!	 xx1000001021
11	Disconnect the brake release voltage.	
12	Check the pinion. If there is any damage, the pinion must be replaced.	

Continues on next page

Refitting motor axis 1

Use this procedure to refit motor axis 1.

	Action	Note
1	Make sure the *o-ring* on the *circumference* of the motor is seated properly. Lightly lubricate the o-ring with *grease*.	 xx1000001096 Parts: A Circumference of motor B O-ring **Note** The o-ring must be replaced when replacing the motor.
2	**CAUTION** The motor weighs 29 kg. All lifting accessories used must be sized accordingly!	
3	In order to release the brake, connect the 24 VDC power supply.	Connect to connector R2.MP1 • + : pin 2 • -: pin 5
4	Gently lower the *motor* into the gear, making sure the *pinion* is properly mated to the gearbox of axis 1. **Note** Make sure the motor is turned the right way. See figure. **Note** Make sure the motor pinion does not get damaged!	 xx1000001269

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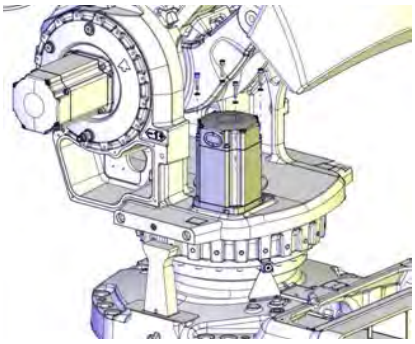
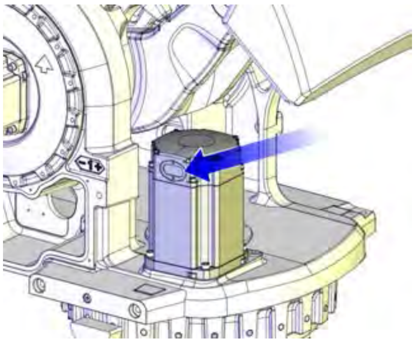
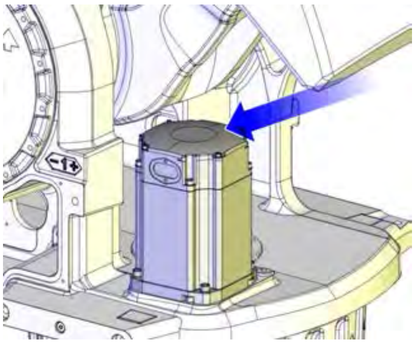
	Action	Note
5	Secure the motor with its four *attachment screws* and plain *washers*. Use the bits extension.	 xx1000001090 **Attachment screws**: • M10x40 quality 12.9 Gleitmo **Tightening torque**: • 50 Nm
6	Disconnect the brake release voltage.	
7	Reconnect all connectors beneath the motor cover.	
8	Refit the *cable gland cover* at the cable exit with its attachment screws. **Note** Make sure the cover is tightly sealed! Replace gasket if damaged.	 xx1000001094
9	Refit the *motor cover* with its attachment screws. **Note** Make sure the cover is tightly sealed!	 xx1000001092
10	Recalibrate the robot!	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.

Continues on next page

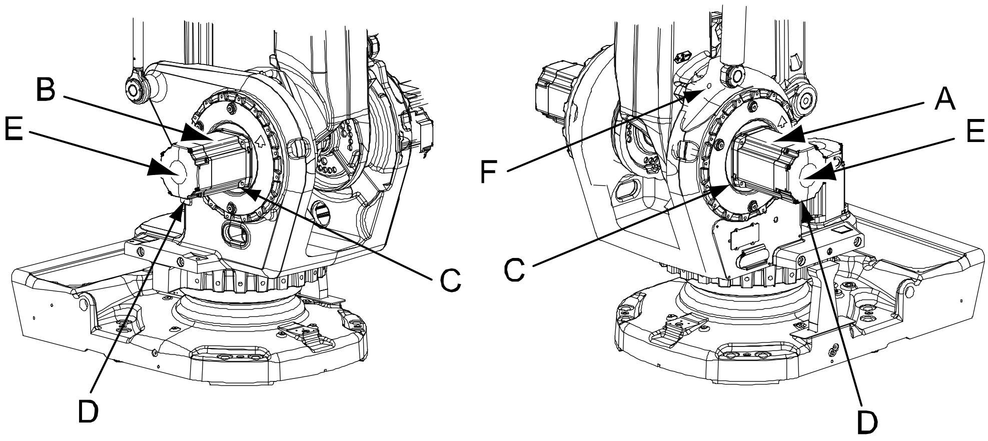
	Action	Note
11	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.6.2 Replacing motors, axes 2 and 3

Location of motors, axes 2 and 3

The motors axes 2 and 3 are located on either side of the robot as shown in the figure.

The procedure is the same for both motors.



xx0600002599

A	Motor, axis 2
B	Motor, axis 3
C	Motor attachment screws and washers
D	Cable gland cover (located on the lower side of the motor)
E	Motor cover
F	Hole for lock screw

Required equipment

Equipment, etc.	Art. no.	Note
Motor axes 2-3	For spare part no. see: • *Spare part lists on page 365 chapter*	Includes • motor • pinion • o-ring (the o-ring must be replaced when the motor is replaced)
Grease	3HAB3537-1	For lubricating the o-ring.
Guide pins	3HAC13120-2	M10x150 For guiding the motor. Guide pins are to be used in pairs!
Lifting accessory, motor axes 2-3	3HAC14586-1	
Lock screw	-	M16x90 For securing the lower arm.
Bits extension	3HAC023760-001	Used to reach the attachment screws for the motor.

Continues on next page

Equipment, etc.	Art. no.	Note
Power supply	-	24 VDC, 1.5 A For releasing the brakes.
Rotation tool		Used to rotate the motor pinion when mating it to the gear, when brakes are released with 24 VDC power supply.
Standard toolkit		Content is defined in section *Standard tools on page 359*.
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 *Circuit diagrams on page 367*.

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.

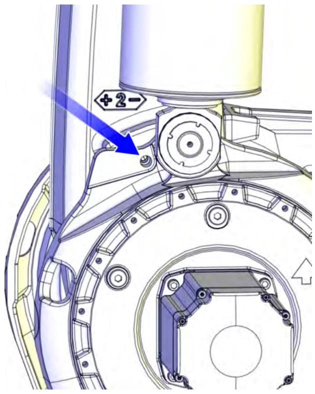
	Action	Note
1	Decide which calibration routine to use for calibrating the robot. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	If the robot is 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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

Continues on next page

Removing motors axes 2 and 3

Use this procedure to remove motors axes 2 and 3.

The procedure is the same for both motors.

	Action	Note
1	Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2	Run the robot to a position close enough to its calibration position, to allow the lock screw to be inserted into the *hole for lock screw*.	 xx1000001101
3	Lock the *lower arm* by inserting the *lock screw* into the hole of the frame. This is done in order to secure axis 2 from collapsing when the axis 2 motor is being removed. **CAUTION** Tighten by hand!	See figure above.
4	Run axis 3 to the end position so that it rests against the mechanical stop. Release the brake of axis 3 in order to set the weight of axis 3 against the mechanical stop. This is done in order to secure axis 3 from collapsing when the axis 3 motor is being removed.	
5	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
6	Drain the oil from *gearbox*.	See section • *Changing oil, gearbox axes 2 and 3 on page 143*.

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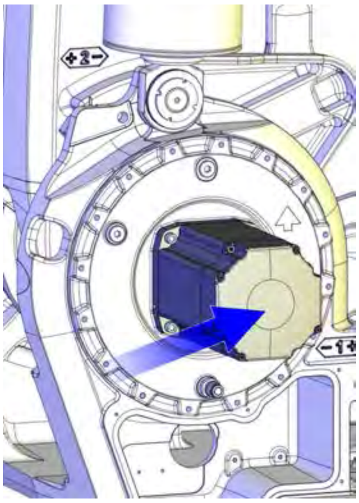
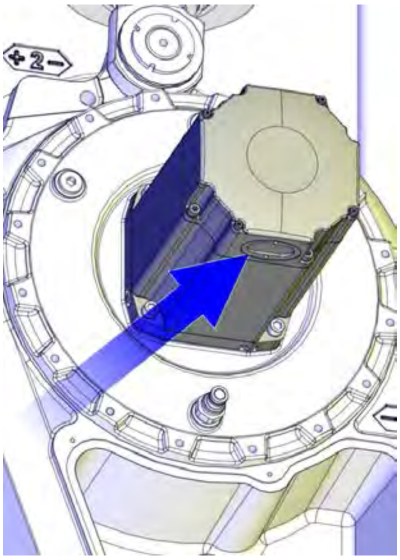
	Action	Note
7	Remove the *motor cover*.	 xx1000001102
8	Remove the *cable gland cover* at the cable exit . **Note** Make sure the gasket is not damaged! Replace if damaged.	 xx1000001103
9	Disconnect all connectors beneath the motor cover.	
10	In order to release the brake, connect the 24 VDC power supply.	Connect to connector R2.MP2 • + : pin 2 • -: pin 5

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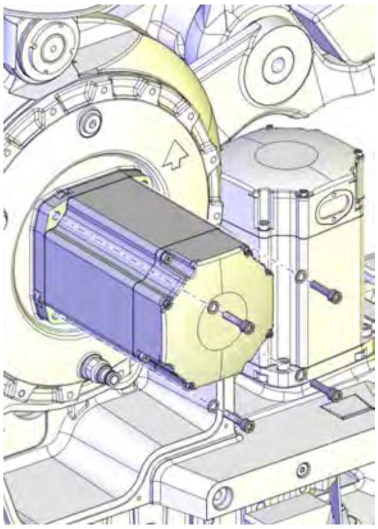
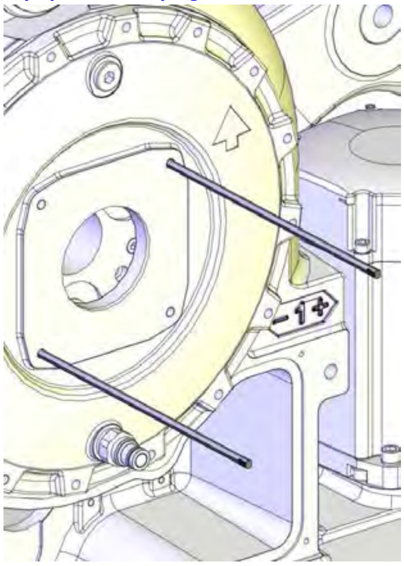
	Action	Note
11	Unscrew *attachment screws* and *washers* of the motor. Use the *bits extension*.	 xx1000001104
12	Fit two *guide pins* in two of the motors attachment holes.	Art. no. is specified in *Required equipment on page 271*.  xx1000001131

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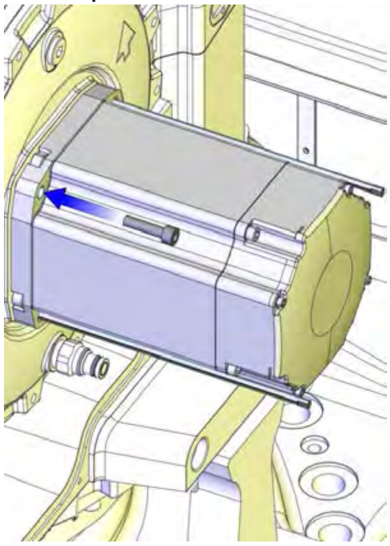
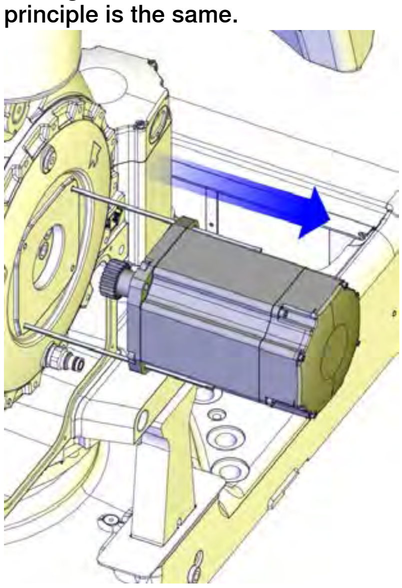
	Action	Note
13	If required, press the motor out of position by fitting two *screws* in the remaining attachment holes of the motor, diagonal to each other.	M12x70, fully threaded. Always use the removal screws and tools in pairs!  xx1000001184
14	Remove the two screws and fit the *lifting tool, motor axes 2-3* to the motor.	Art. no. is specified in *Required equipment on page 271*.
15	**CAUTION** The motor weighs 32 kg. All lifting accessories used must be sized accordingly!	
16	Pull out the *motor* on the guide pins to get the pinion away from the gear. Make sure the pinion does not get damaged!	The figure shows IRB 760 but the principle is the same.  xx1000001105
17	Remove the motor by gently lifting it straight out and place it on a secure surface.	

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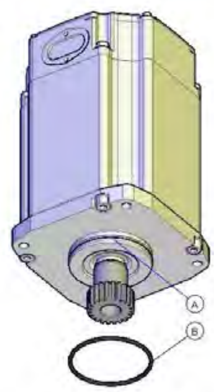
	Action	Note
18	Disconnect the brake release voltage!	
19	Check the pinion. If there is any damage, the motor pinion must be replaced.	

Refitting, motors axes 2 and 3

Use this procedure to refit motors axes 2 and 3.

The procedure is the same for both motors.

	Action	Note
1	Make sure the *o-ring* on the *circumference* of the motor is seated properly. Lightly lubricate the o-ring with grease.	 xx1000001096 Parts: A Circumference; B O-ring
2	In order to release the brake, connect the 24 VDC power supply.	Connect to connector R2.MP1 • + : pin 2 • -: pin 5
3	Fit the *lifting tool, motor axes 2-3* to the motor.	Art. no. is specified in *Required equipment on page 271*.

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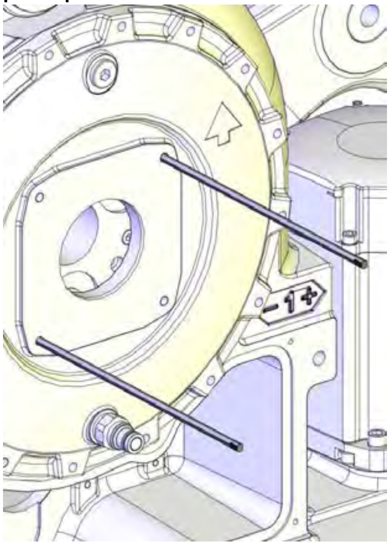
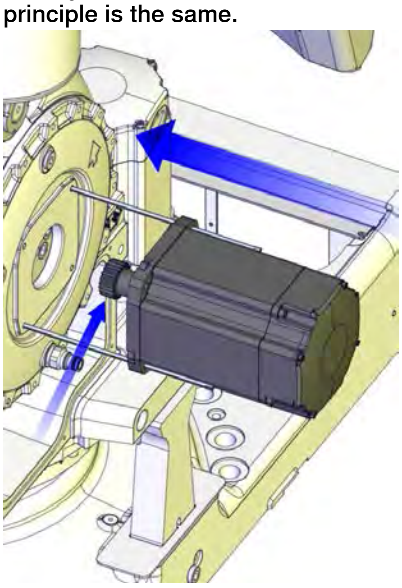
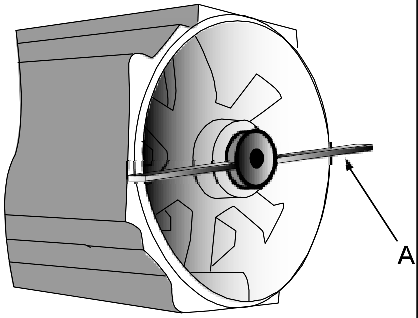
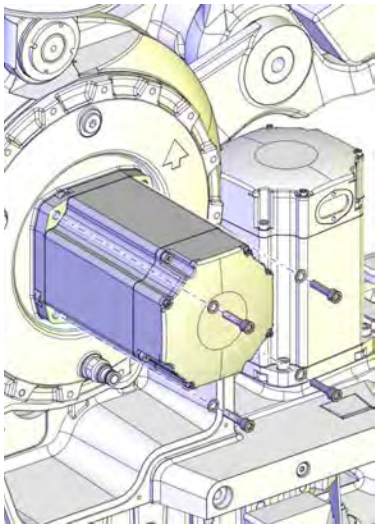
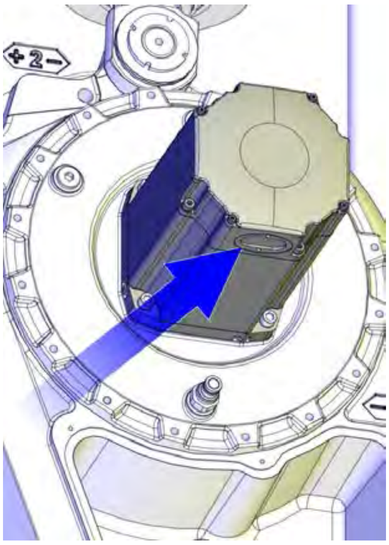
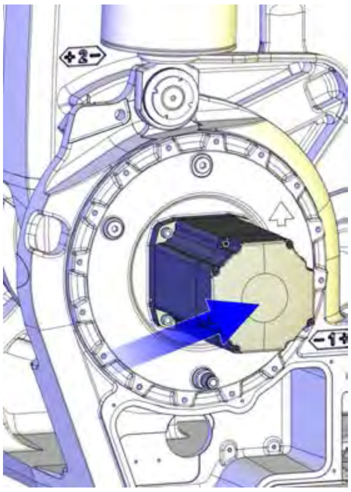
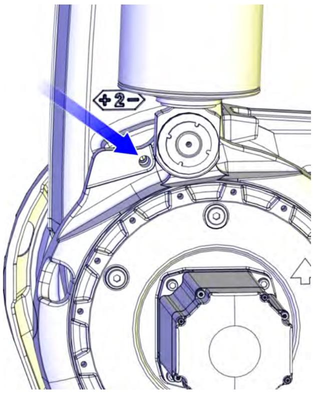
	Action	Note
4	Fit the two *guide pins* in the two lower motor attachment holes.	Art. no. is specified in *Required equipment on page 271*. The figure shows IRB 760 but the principle is the same.  xx1000001131
5	**CAUTION** The motor weighs 32 kg. All lifting accessories used must be sized accordingly!	
6	Lift the *motor* and guide it on to the *guide pins*, as close to the correct position as possible without pushing the motor *pinion* into the gear. **Note** Make sure the motor is turned the right way, that is connections for the cables facing downwards.	The figure shows IRB 760 but the principle is the same.  xx1000001185
7	Remove the lifting tool and allow the motor to rest on the guide pins.	

Continues on next page

	Action	Note
8	Use the *rotation tool* in order to rotate the motor pinion when mating it to the gear (see figure). Fit the motor, making sure the motor pinion is properly mated to the gear of gearbox axis 2-3 and that it doesn´t get damaged. **Note** The rotation tool is used beneath the motor cover, directly on the motor shaft as shown in figure above.	 xx0200000165 Part: Rotation tool
9	Remove the guide pins.	
10	Secure the motor with its four *attachment screws* and *plain washers*. Use the *bits extension*. Reused screws can be used, providing they are lubricated as detailed in section *Screw joints on page 355* before fitting.	 xx1000001104 **Attachment screws**: • M10 x 40 quality 12.9 Gleitmo **Tightening torque**: • 50 Nm
11	Disconnect the brake release voltage.	
12	Reconnect all connectors beneath the motor cover.	Connect in accordance with markings on connectors.

Continues on next page

	Action	Note
13	Refit the *cable gland cover* at the cable exit with its two attachment screws. **Note** Use a new gasket!	 xx1000001103
14	Refit the *motor cover* with its attachment screws and washers. **Note** Make sure the cover is tightly sealed!	 xx1000001102
15	Remove the *lock screw* from the *hole for lock screw*.	 xx1000001101
16	Perform a leak-down test of the axis 2 or 3 gearbox.	See section *Performing a leak-down test on page 160*.
17	Refill the gearbox with oil.	See section *Changing oil, gearbox axes 2 and 3 on page 143*.

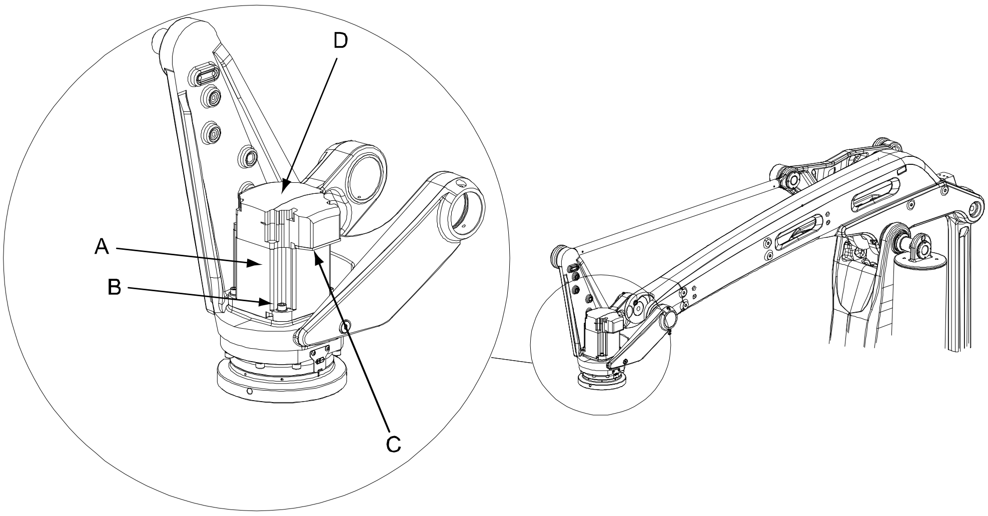
Continues on next page

	Action	Note
18	Recalibrate the robot!	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.
19	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.6.3 Replacing motor, axis 6

Location of motor axis 6

Motor axis 6 is located in the center of the tilthouse as shown in the figure.



xx0600002600

A	Motor, axis 6
B	Attachment screws and washers
C	Cable gland cover
D	Motor cover

Required equipment

Equipment, etc.	Art.no.	Note
Motor axis 6	For spare part no. see: • *Spare part lists on page 365*	Includes • motor • pinion • o-ring (the o-ring must be replaced when the motor is replaced)
Bits extension	3HAC023760-001	Used to reach attachment screws for motor.
Locking liquid	3HAB7116-1	Loctite 243
Power supply	-	24 VDC, 1.5 A For releasing the brakes.
Grease	3HAB3537-1	For lubricating the o-ring.
Standard toolkit	-	Content is defined in section *Standard tools on page 359*.
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

Equipment, etc.	Art.no.	Note
Circuit diagram		See chapter *Circuit diagrams on page 367*.

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.

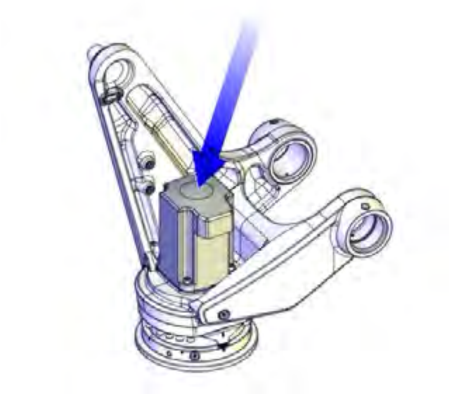
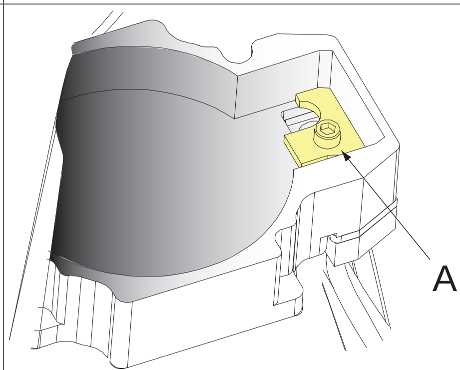
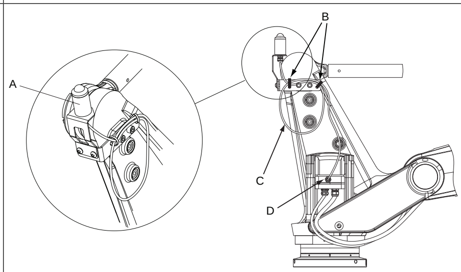
	Action	Note
1	Decide which calibration routine to use for calibrating the robot. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	If the robot is 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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

Removing, motor axis 6

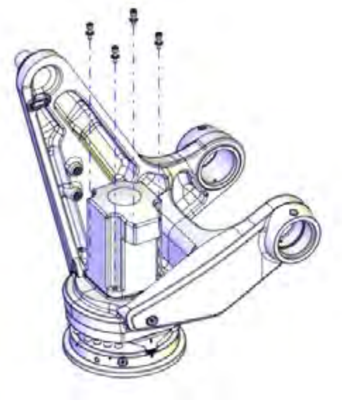
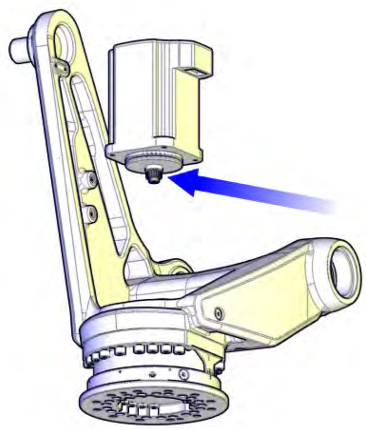
Use this procedure to remove motor, axis 6.

	Action	Information
1	Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	
2	Run the robot to a position where it is easiest to remove the motor axis 6 when standing in front of the robot. **Note** The motor axis 6 can be replaced without draining the gear oil.	

Continues on next page

	Action	Information
3	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
4	Remove *motor cover*.	 xx1000001106
5	Remove the *cable gland cover* at the cable exit by unscrewing its *attachment screw* (A) on the inside. **Note** Make sure the gasket is not damaged!	 xx0600002694
6	Disconnect all connectors beneath the cover. **Note** The connection to the *UL lamp*, must also be disconnected, if the robot is equipped with one.	 xx0500002466 A Signal lamp (UL lamp) B Cable straps, outdoor C Cable D Connection point to the cable gland

Continues on next page

	Action	Information
7	In order to release the brake, connect the 24 VDC power supply.	Connect to connector R2.MP6 • + : pin 2 • -: pin 5
8	Remove *attachment screws* and *washers*. Use the bits extension.	 xx1000001012
9	If required, press the motor out of position by fitting two screws in the motor attachment holes diagonal to each other	Always use the screws for removal in pairs!
10	Lift the motor carefully to get the *pinion* away from the gear. **Note** Make sure the *pinion* does not get damaged!	 xx1000001108
11	Disconnect the brake release voltage.	
12	Remove the motor by gently lifting it straight up and place it on a secure surface.	

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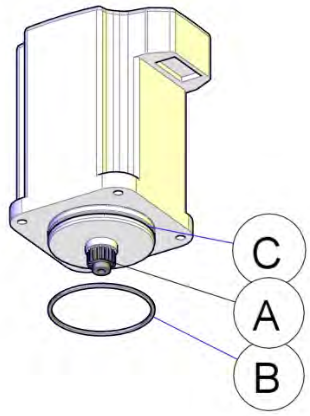
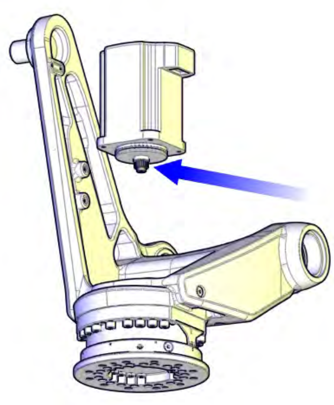
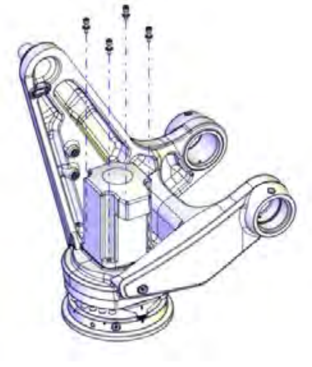
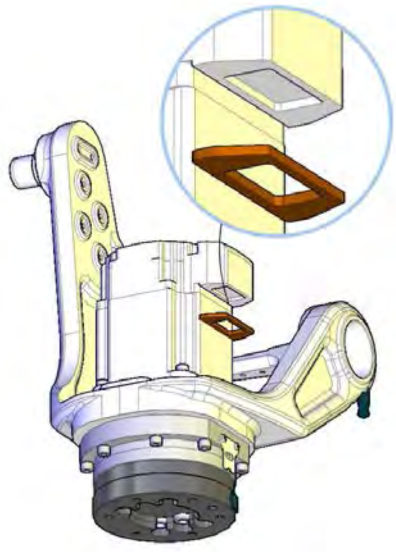
Refitting, motor axis 6

Use this procedure to refit motor axis 6.

	Action	Information
1	Make sure the *o-ring* on the *circumference* of the motor is seated properly. Lightly lubricate the o-ring with grease. **Note** The o-ring must be replaced when the motor is replaced.	 xx1000001109 Parts: • A: Pinion • B: O-ring • C: Circumference
2	In order to release the brake, connect the 24 VDC power supply.	Connect to connector R2.MP6 • + : pin 2 • -: pin 5
3	Fit the two *guide pins* in two of the motor attachment holes.	Art. no. is specified in *Required equipment on page 282*.
4	Lift the motor carefully in place. Make sure the motor *pinion* is properly mated to the gearbox, axis 6. **Note** Make sure the motor is turned the correct way. See figure!	 xx1000001108
5	Remove the guide pins.	
6	Apply *locking liquid (Loctite 243)* on the attachment screws.	

Continues on next page

	Action	Information
7	Secure the motor with its four *attachment screws* and *washers*. Reused screws may be used, providing they are lubricated as detailed in section *Screw joints on page 355* before fitting.	 xx1000001012 *Washers*: • 8.4x16x1.6 quality Steel-A2F *Attachment screws*: • M10 x 40 quality 8.8-A2F **Tightening torque**: • 50 Nm
8	Disconnect the brake release voltage.	
9	Perform a leak-down test of the axis 6 gearbox.	See section *Performing a leak-down test on page 160*.
10	Reconnect all connectors in motor axis 6.	Connect in accordance with markings on connectors.
11	Refit the connections to the UL lamp, if the robot is equipped with one.	
12	Check the *gasket*. If damaged, replace it.	 xx1000001224

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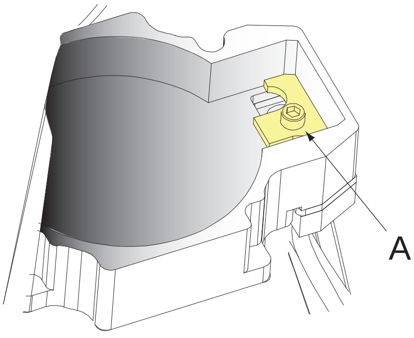
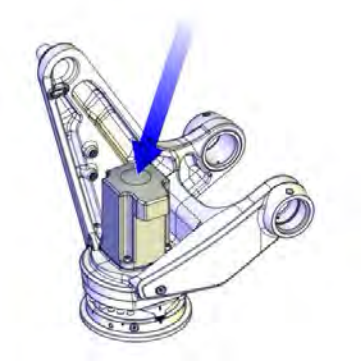
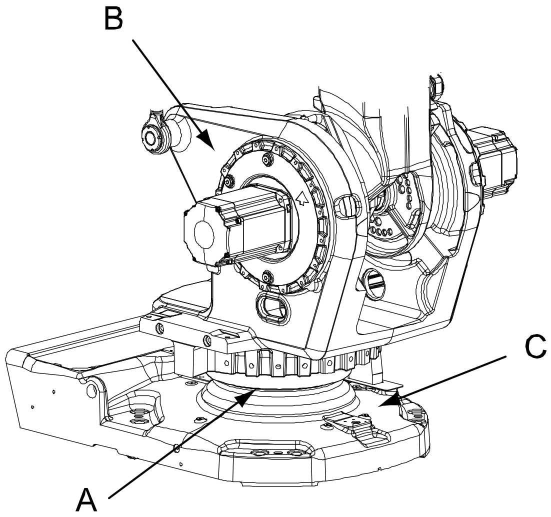
	Action	Information
13	Refit the cable gland with its attachment screw.	xx0600002694 • A: Screw holding the cable gland Make sure the gasket is not damaged! Replace if damaged.
14	Refit the cover, motor axis 6 with its *attachment screws* and *washers*. **Note** Make sure the cover is tightly sealed!	 xx1000001106
15	Recalibrate the robot!	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.
16	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

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.



xx0600002631

A	Gearbox, axis 1
B	Frame
C	Base

Required equipment

Equipment, etc.		Art. no.	Note
Gearbox		For spare part no. see: • *Spare part lists on page 365*.	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.
Support, base and gear 1		3HAC15535-1	
Lifting accessory, base		3HAC15560-1	
Lifting accessory (chain)		3HAC15556-1	

Continues on next page

Equipment, etc.		Art. no.	Note
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 *Standard tools on page 359*.
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. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.

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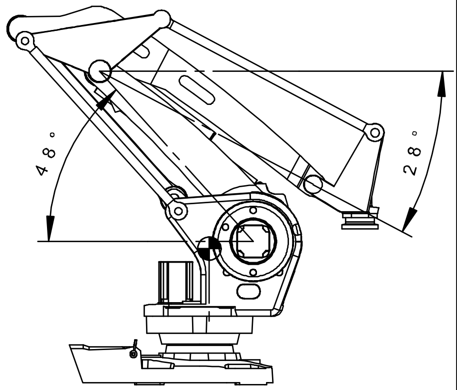
	Action	Note
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

Removal, 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.	 xx0500002275
3	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
4	Drain the axis 1 gearbox.	See *Changing oil, axis-1 gearbox on page 140*.
5	Remove the complete arm system.	See *Replacing the base, including axis 1 gearbox on page 179*.
6	Unfasten the robot base from the foundation by removing the base attachment screws.	

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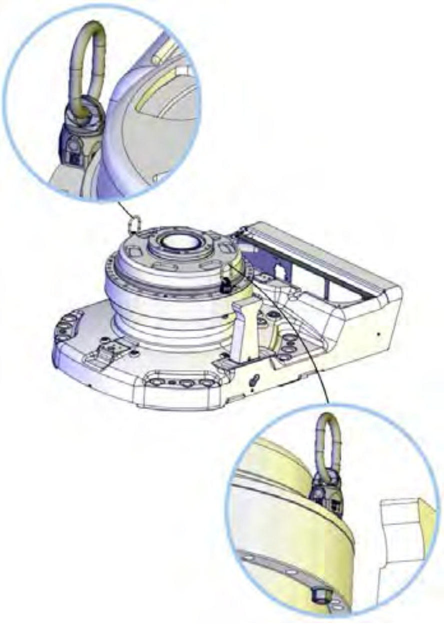
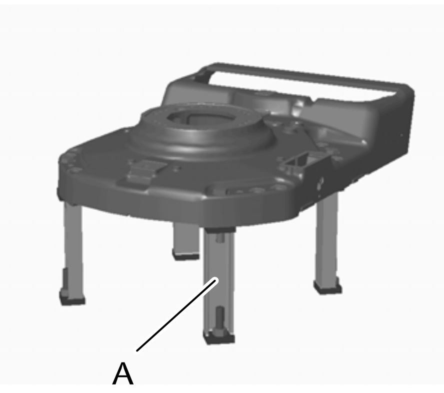
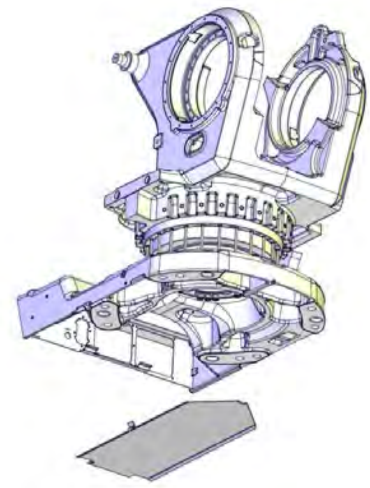
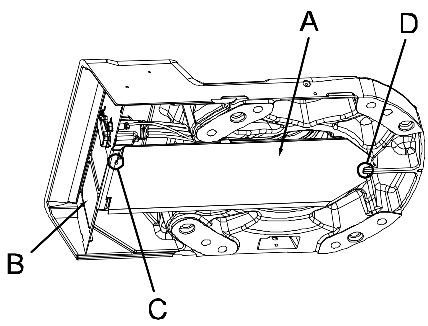
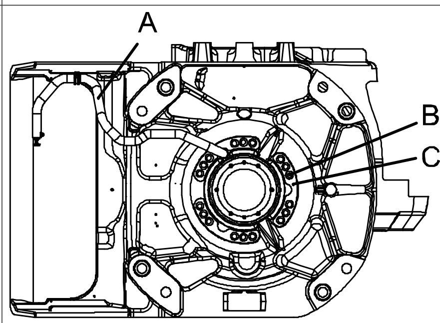
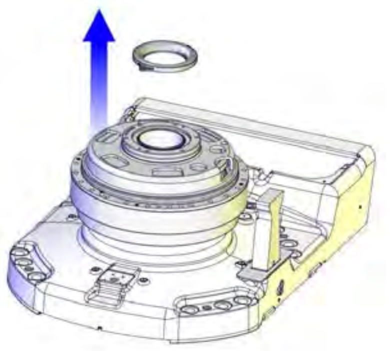
	Action	Note
7	Attach the *lifting accessory, base and gear 1* and the *lifting tool (chain)* to the gearbox and base.	 xx1000001395 Specified in *Required equipment on page 289*.
8	**CAUTION** The base and axis 1 gearbox weighs 130 kg + . All lifting accessories used must be sized accordingly!	
9	Lift the robot base including the axis 1 gearbox to allow the *base and gear 1 support* be fitted on each sides of the base.	Art. no. is specified in *Required equipment on page 289*.
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)

Continues on next page

	Action	Note
11	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.	 xx1000001385  xx0300000612 A Bottom plate B Rear connector plate C Attachment screw D Groove
12	Unscrew the attachment screws and remove the washers.	 xx0200000227 A view from below: • A: Oil drain hose • B: Attachment screws, gearbox axis 1, 18 pcs • C: Washers, 3 pcs

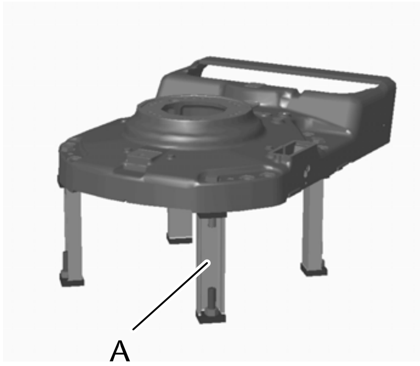
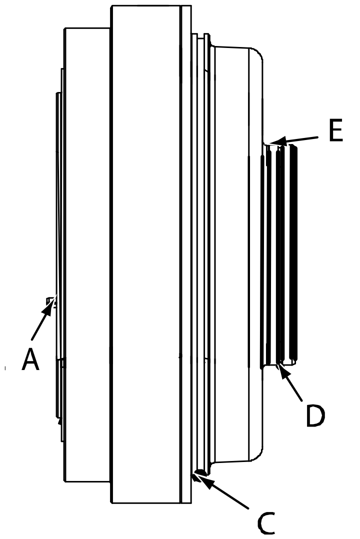
Continues on next page

	Action	Note
13	Remove the cable guide in the center of gearbox 1 by unscrewing its attachment screws.	 xx1000001387
14	**CAUTION** The gearbox weighs . 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. **Note** Move the protective pipe over to the new gearbox.	 xx1400000786

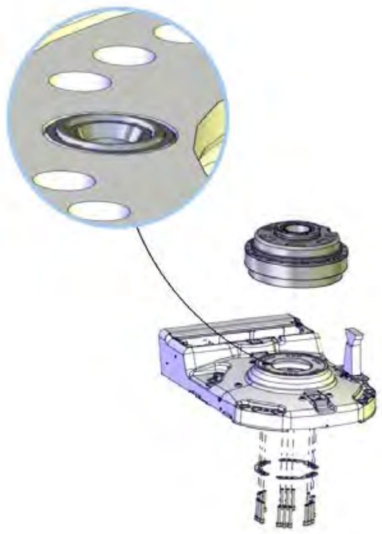
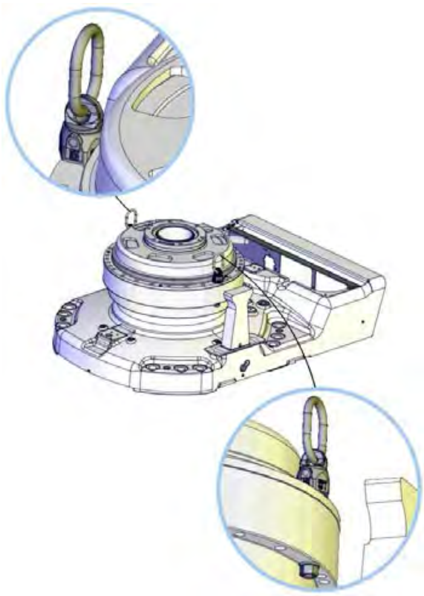
Continues on next page

Refitting, gearbox axis 1

Use this procedure to refit gearbox, axis 1.

	Action	Note
1	Fit the *support, base and gear 1* to the base.	Mounting of the support, base and gear 1 is detailed in section *Removal, gearbox axis 1 on page 291*.  xx1000000364 A Support base (4 pcs)
2	Make sure the two *o-rings* on the circumference of the gearbox are seated properly in their respective groove. Lubricate them with *grease*.	Art no. is specified in *Required equipment on page 289*.  xx0200000055 • A: Guide pin • C: O-ring 3HAB 3772-54 • D: O-ring 3HAB 3772-55 • E: Sealing ring 3HAC 11581-4

Continues on next page

	Action	Note
3	Make sure the small o-ring around the oil hole is fitted properly!	 xx1000001392
4	Attach the *lifting accessory, base and gear 1* and the *lifting tool (chain)* to the gearbox.	Specified in *Required equipment on page 289*.  xx1000001395
5	Fit two *guide pins* in two of the attachment holes in the gearbox, parallel to each other.	Specified in *Required equipment on page 289*.
6	**CAUTION** The gearbox weighs . All lifting accessories used must be sized accordingly!	

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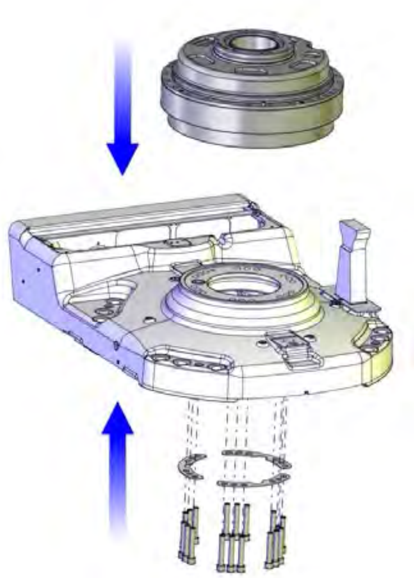
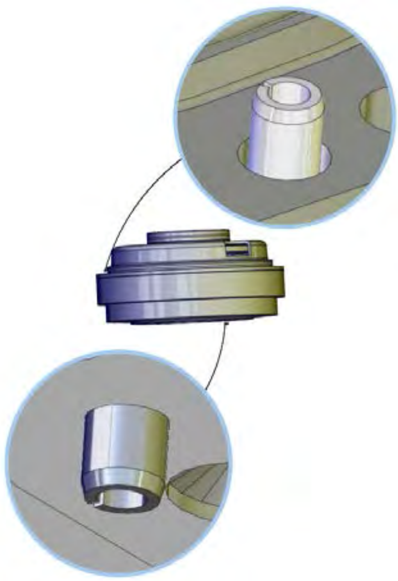
	Action	Note
7	Lift the gearbox. Make sure the guide pin in the bottom face of the gearbox is properly aligned with the base.	 xx1000001389  xx1000001391
8	Lift gearbox axis 1 onto the guide pins and lower it carefully to its mounting position.	Always use guide pins in pairs!

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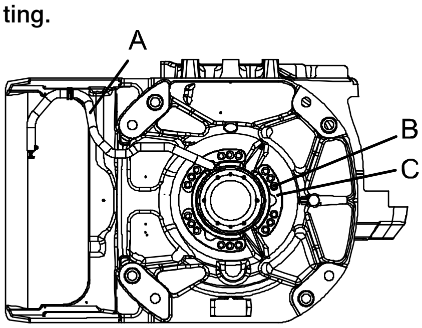
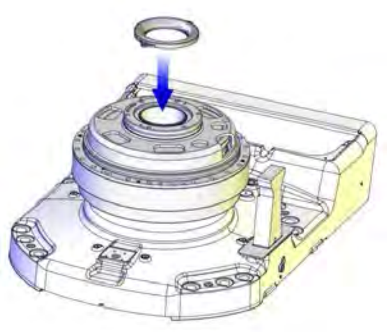
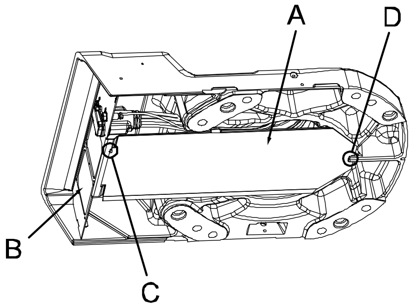
	Action	Note
9	Secure the gearbox with its *attachment screws* and washers.	18 pcs, M16 x 70, 12.9 quality UNBRAKO. Tightening torque: 300 Nm Reused screws may be used, providing they are lubricated as detailed in section *Screw joints on page 355* before fitting.  xx0200000227 A view from below: • A: Oil drain hose • B: Attachment screws, gearbox axis 1, 18 pcs • C: Washers, 3 pcs
10	Refit the cable guide in the center of gearbox 1 with its attachment screws.	 xx1000001393

Continues on next page

	Action	Note
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. **Note** Direct the bends on the bottom plate downwards!	1 screw: M6 x 8.  xx0300000612 • A: Bottom plate • B: Rear connector plate • C: Attachment screw • D: Groove
12	**CAUTION** The base and axis 1 gearbox weighs 130 kg + . All lifting accessories used must be sized accordingly!	
13	Lift the robot base and gearbox 1 and remove the base and gear support.	
14	Secure the base to the mounting site.	See *Orienting and securing the robot on page 85*.
15	Refit the complete arm system. **CAUTION** This is a complex task to be performed with utmost care in order to avoid injury or damage!	See *Replacing the base, including axis 1 gearbox on page 179*.
16	Perform a leak-down test.	See section *Performing a leak-down test on page 160*.
17	Refill the gearbox with oil.	See *Changing oil, axis-1 gearbox on page 140*.
18	Recalibrate the robot.	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.

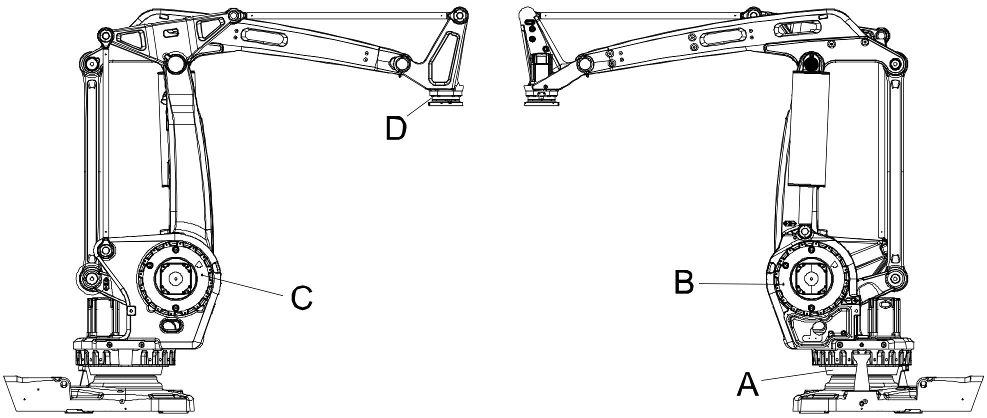
Continues on next page

	Action	Note
19	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.7.2 Replacing the gearbox, axes 2- 3

Location of gearbox, axes 2-3

The axis-2 and axis-3 gearboxes are located on either side of the frame as shown in the figure.



xx0500002467

A	Gearbox, axis 1
B	Gearbox, axis 2
C	Gearbox, axis 3
D	Gearbox, axis 6

Required equipment

Equipment, etc.	Art.no	Note
Gearbox, axes 2-3	For spare part no. see: • *Spare part lists on page 365*.	
Sealing axes 2-3	3HAC022379-001	Always replace.
Lock screw M16x55	-	Use to lock the lower arm.
Screw M12x50	-	2 pcs. Use to unload the balancing device.
Screw M12x100	-	2 pcs, must have full thread. Use to press the gearbox free from the frame.
Guide pins M12	-	Use guide pins in pairs.
Lifting accessory	-	Roundsling and a rotating lifting point. Lifting capacity: 100 kg. Used to lift the gearbox.
Guide sleeves	3HAC14628-1/2	Use to keep the sealing in place.
Grease		Use to lubricate surfaces on the gearbox for easier assembly.
Bearing grease	3HAB3537-1	Shell Alvania W R2 Option Foundry Plus

Continues on next page

Equipment, etc.	Art.no	Note
Rust preventive	3HAC034903-001	Mercasol 3110 Waxcoat
Standard toolkit		Content is defined in section *Standard tools on page 359*.
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. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

Removal, axis-2 / axis-3 gearbox

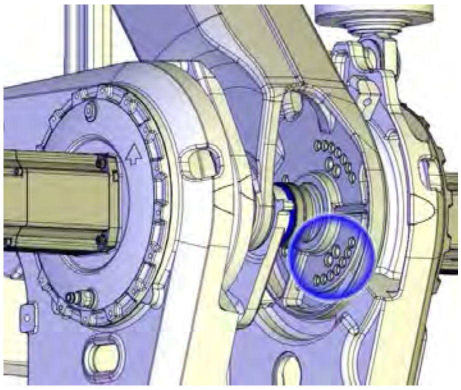
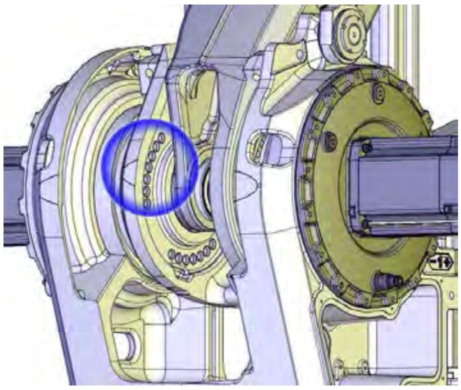
Use this procedure to remove the axis-2 or axis-3 gearbox.

Note

Do not replace both gearboxes at the same time, unless the complete arm system is already removed!

	Action	Note
1	Decide which calibration routine to use, and take actions accordingly prior to beginning the repair procedure.	

Continues on next page

	Action	Note
2	**When removing axis 2 gearbox:** Run the axis 2 to -42° and all other axes to 0° (calibration position). **When removing axis 3 gearbox:** Run the axis 2 to -40°, axis 3 to +15° and all other axes to 0°.	
3	**When removing axis 2 gearbox:** Remove all screws in the lower screw area on the inside of the lower arm (7 pcs M12, 2 pcs M16). See figure. **When removing axis 3 gearbox:** Remove all screws in the upper front screw area and three screws in the upper back area.	**Axis 2:**  xx1100000623 **Axis 3:**  xx1100000624
4	Run axis 2 to 0°.	

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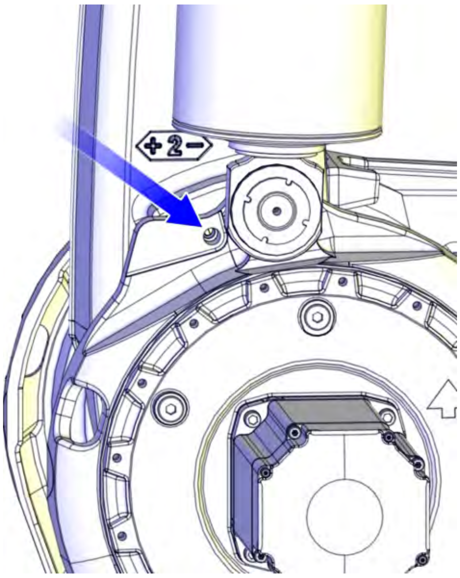
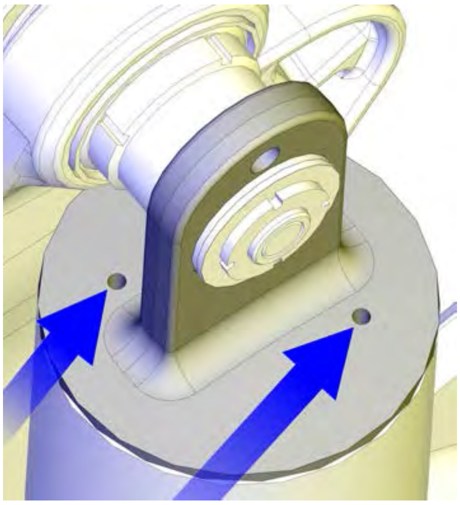
	Action	Note
5	Fit the *lock screw* in the lower arm to secure axis 2. **CAUTION** Tighten by hand!	 xx1000001101
6	Secure the weight of the upper arm with roundslings in an overhead crane.	
7	Raise the lifting equipment to take the weight of the upper arm.	
8	Release the brakes of axis 2 to rest the weight of the axis against the lock screw.	
9	Release the brakes of axis 3 to rest the weight of the axis by the roundslings and overhead crane.	
10	Remove the two plastic screws in the upper end of the balancing device. **Note** Keep the plastic screws. They will be refitted later.	 xx1000001111

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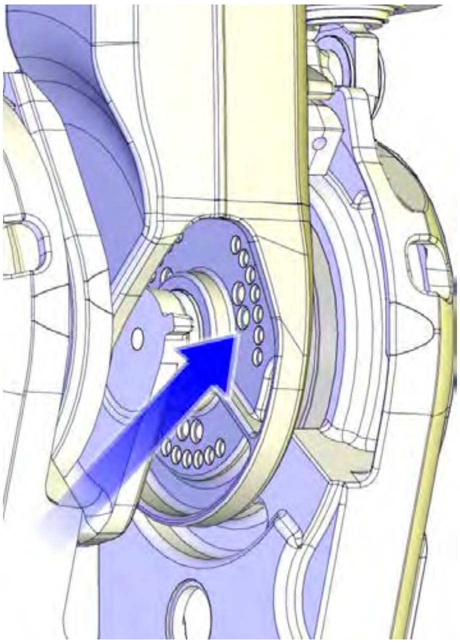
	Action	Note
11	Insert two *screws, M12x50* in the holes to neutralize the spring force. Screw in the screws until they have proper contact with the cylinder inside. The length of the cylinder is now locked and the balancing device is unloaded. It should now be possible to easily rotate the balancing device.	See the previous figure!
12	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
13	Drain the gearbox.	Detailed in section *Draining, axes 2 and 3 on page 145*. **Note** Time-consuming activity!
14	Remove the motor cables of axis-2 or axis-3 motor, depending on which gearbox is being removed. Protect the cables from getting damaged and from oil spill.	
15	Remove one gearbox at a time!	
16	Remove the axis-2 or axis-3 motor, depending on which gearbox is being removed.	Detailed in section *Replacing motors, axes 2 and 3 on page 271*
17	Remove all remaining *attachment screws* that secure the gearbox to the lower arm system. Axis 2: M16 and M12. Axis 3: M12.	 xx1000001405

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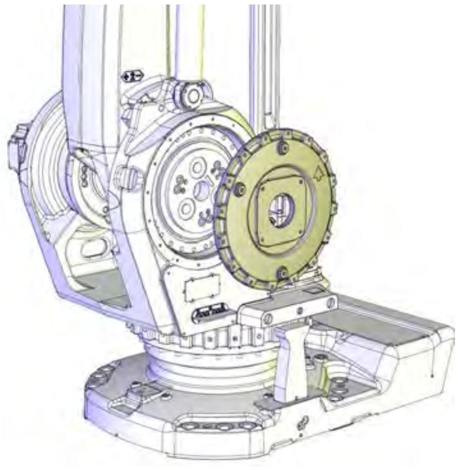
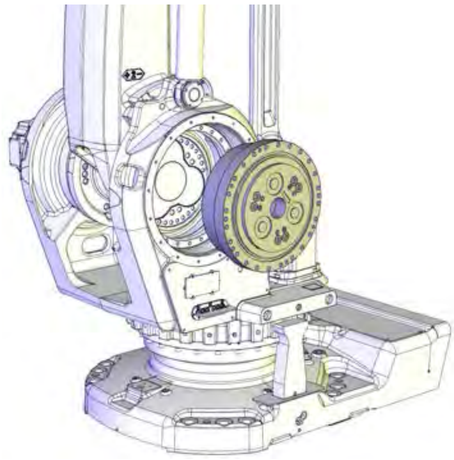
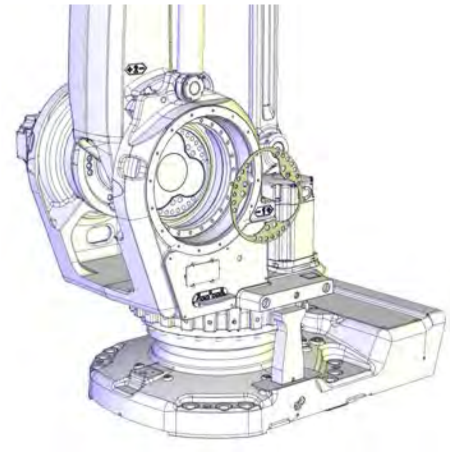
	Action	Note
18	Remove the gearbox cover by removing its attachment screws.	 xx1200000628
19	Remove two opposite screws of the attachment screws that hold the gearbox and replace them with two guide pins.	**Note** Always use guide pins in pairs!
20	Remove the remaining attachment screws.	
21	Fit the *lifting accessory* to the gearbox.	Art. no. is specified in *Required equipment on page 301*.
22	**CAUTION** The gearbox weighs 69 kg. All lifting accessories used must be sized accordingly!	
23	If required, apply two *screws, M12x100* to the holes in the gearbox, in order to press it free. (The screws need to have a full thread.)	
24	**CAUTION** When the gearbox comes free from the frame and comes off the guide pins it will tilt and there is a risk of damage to the gearbox surfaces! Be aware of this and remove the gearbox carefully!	

Continues on next page

	Action	Note
25	Remove the gearbox axis 2-3 using an overhead crane or similar, with guidance from the fitted guide pins.	 xx1200000629
26	Remove the sealing from the lower arm and clean it. **Note** The sealing can hang onto the gearbox, sticking to the oil.	 xx1200000630

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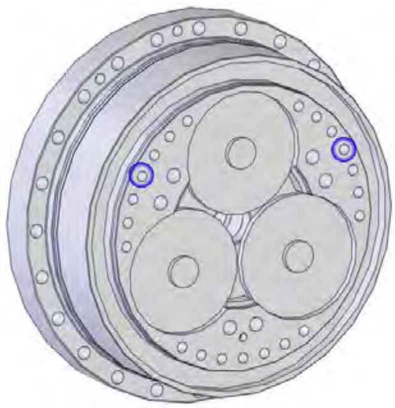
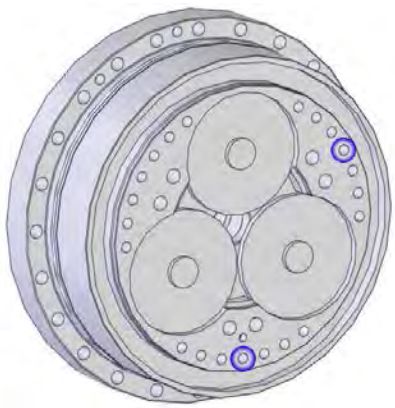
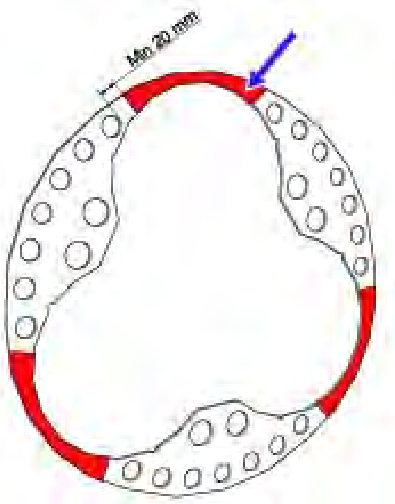
Refitting, axis-2 / axis-3 gearbox

Use this procedure to refit the axes-2 or axis-3 gearbox.

	Action	Note
1	Make sure that the o-ring is fitted to the gearbox. Lightly lubricate it with *grease*.	 xx1000001404 Specified in *Required equipment on page 301*.
2	Fit two *guide pins* in the frame. Use two of the attachment holes for the screws that hold the gearbox.	
3	**CAUTION** The gearbox weighs 69 kg! All lifting equipment used must be sized accordingly!	
4	Fit the *lifting accessory* to the gearbox and lift it with an overhead crane.	Specified in *Required equipment on page 301*.

Continues on next page

	Action	Note
5	Fit a new *sealing* to the gearbox and secure it to the gearbox by using two *guide sleeves*. **When refitting axis 2 gearbox:**Insert the guide sleeves in the two middle holes of the upper screw areas. **When refitting axis 3 gearbox:** Insert one guide sleeve in the middle screw hole in the upper back area and one guide sleeve in the middle screw hole in the the lower area.	Art. no. is specified in *Required equipment on page 301*. **Axis 2:**  xx1100000621 **Axis 3:**  xx1100000622
6	*Foundry Plus:* Apply bearing grease on the highlighted areas on both sides of the sealing. **Note** Do not apply grease closer than 20 mm from the edge of the holes in the sealing.	 xx1400000993

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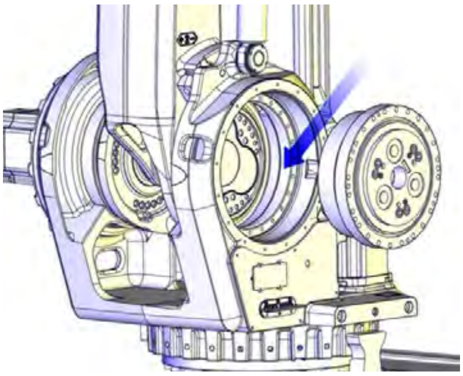
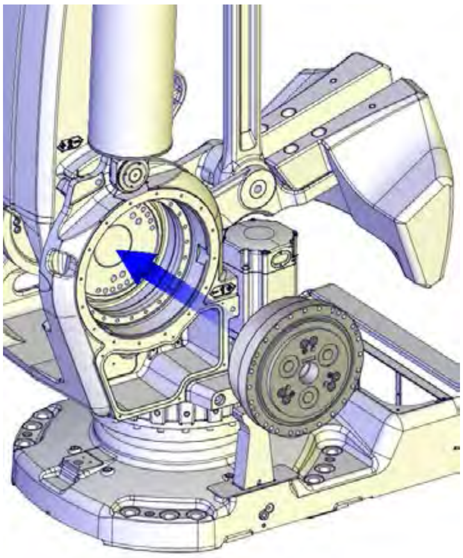
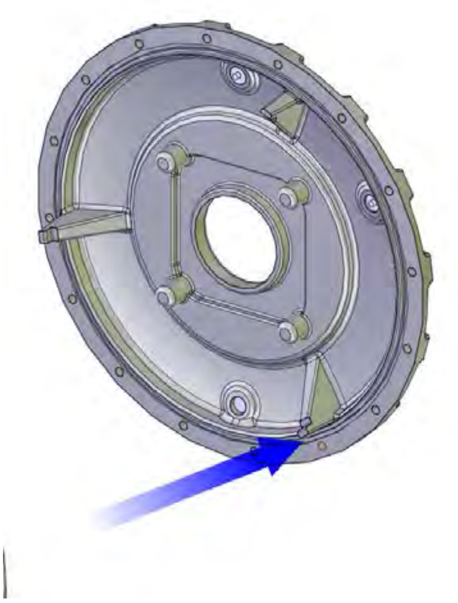
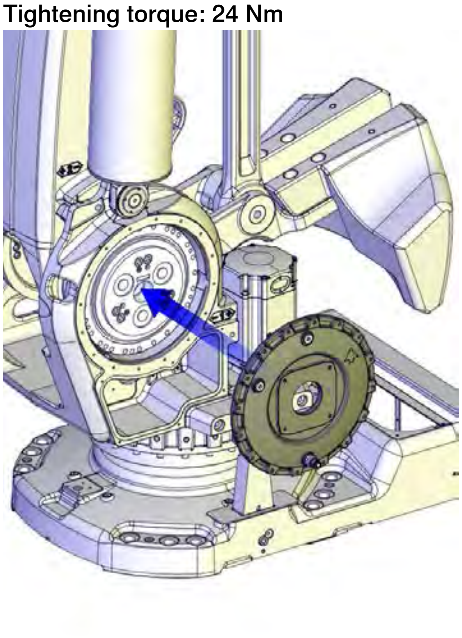
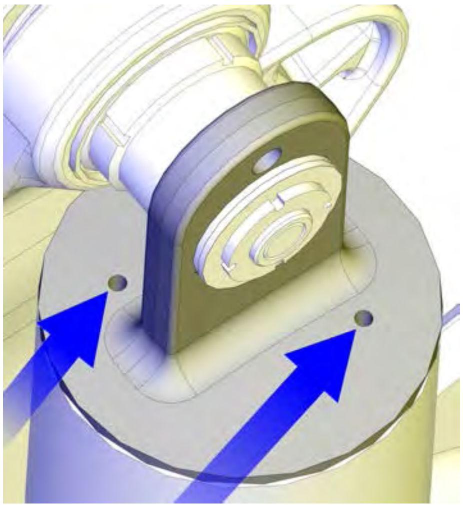
	Action	Note
	Foundry Plus: Apply rust preventive on the highlighted area.	 xx1400001132
7	Lubricate necessary surfaces of the gearbox with *grease* in order to make it easier to insert the gearbox into the frame.	Specified in *Required equipment on page 301*.
8	Put the gearbox onto the guide pins and slide it carefully into place in the frame. **Note** Check that the sealing is in place during the procedure.	 xx1000001406
9	Use a crank to move the gears in order to find the holes for the attachment screws.	
10	Secure the gearbox to the lower arm with the *attachment screws* and *washers* in two of the screw areas (the third is not reachable at this point). Do not remove the guide sleeves yet.	**Axis 2** M12x60 quality 12.9 Gleitmo (6+6 pcs) • Tightening torque: 120 Nm. M16x90 quality 12.9 Gleitmo (2+2 pcs) • Tightening torque: 300 Nm. **Axis 3** M12x60 quality 12.9 Gleitmo • Tightening torque: 120 Nm.
11	Remove the two guide sleeves and replace them with the two remaining M12 screws.	M12x60 quality 12.9 Gleitmo (1+1 pc) • Tightening torque: 120 Nm.
12	Secure the gearbox to the frame.	M12, quality 8.8-A2F Tightening torque: 120 Nm.

Continues on next page

	Action	Note
13	Clean the gearbox of residual grease.	
14	Apply locking liquid in the attachment holes for the gearbox cover.	Loctite 243.
15	Fit the *o-ring* in the cover.	 xx1000001407
16	Refit the cover with its attachment screws and washers. **Note** Fit the cover so that the arrow on the cover points upwards!	M8x35 quality 8.8-A2F (12 pcs) Tightening torque: 24 Nm  xx1000001408
17	Refit the *motors axes 2-3*.	See *Replacing motors, axes 2 and 3 on page 271*
18	Perform a leakdown test.	See *Performing a leak-down test on page 160*.

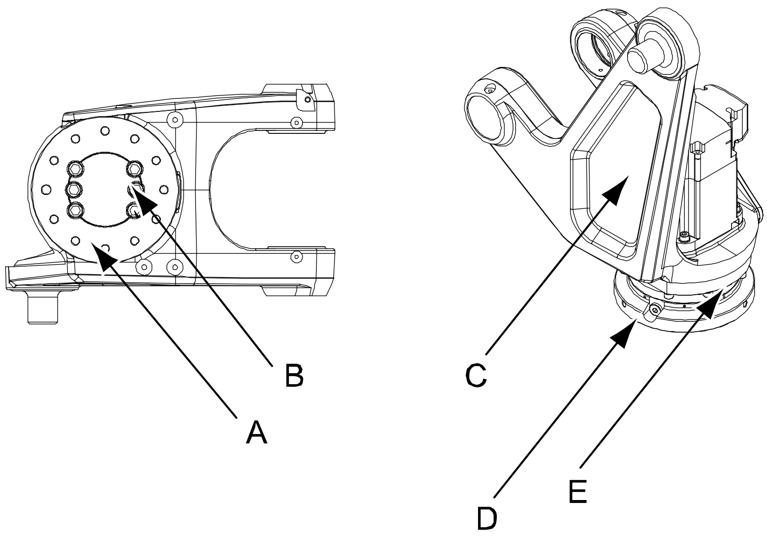
Continues on next page

	Action	Note
19	Refill the gearbox axes 2-3 with oil.	See *Filling, axes 2 and 3 on page 145*
20	Remove the screws that unload the balancing device and put back the plastic screws.	 xx1000001111
21	Remove the lock screw from the lower arm.	
22	Run the axes 2 and 3 to a position where the remaining screws in the lower arm can be fitted.	**Axis 2** M12x60 quality 12.9 Gleitmo (6 pcs) • Tightening torque: 120 Nm. M16x90 quality 12.9 Gleitmo (2 pcs) • Tightening torque: 300 Nm. **Axis 3** M12x60 quality 12.9 Gleitmo • Tightening torque: 120 Nm.
23	Recalibrate the robot.	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.
24	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

4.7.3 Replacing gearbox axis 6

Location of gearbox axis 6

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



xx0600002627

A	Turning disk
B	Attachment screws (6 pcs) turning disk
C	Tilthouse unit
D	Gearbox, axis 6
E	Attachment screws and washers, gearbox axis 6

Required equipment

Equipment	Art. no.	Note
Gearbox axis 6	For spare part no. see: • *Spare part lists on page 365*.	Includes o-ring
Turning disk	For spare part no. see: • *Spare part lists on page 365*.	
Washers	3HAA1001-172	Not included in gearbox. Replace only if damaged!
O-ring (type 2) 164.7x3.53	3HAB3772-57	Must be replaced when reassembling gearbox.
O-ring (type 2) 150.0x2.0	3HAB3772-64	Must be replaced when reassembling gearbox.
O-ring (type 2) 12 pcs 13.1x1.6	3HAB3772-61	Must be replaced when reassembling gearbox.
Grease	3HAB3537-1	For lubricating o-ring
Guide pins	-	Always use guide pins in pairs!

Continues on next page

Equipment	Art. no.	Note
Standard toolkit		The content is defined in the section *Standard tools on page 359*.
Other tools and propcedures may be rquired. 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.

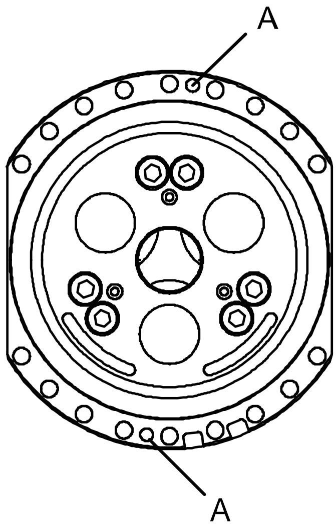
	Action	Note
1	Decide which calibration routine to use for calibrating the robot. • Reference calibration. External cable packages (DressPack) and tools can stay fitted on the robot. • Fine calibration. All external cable packages (DressPack) and tools must be removed from the robot.	
	If the robot is 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 *Reference calibration routine on page 331*. Read more about reference calibration for Pendulum Calibration in *Operating manual - Calibration Pendulum*.
	If the robot is to be calibrated with fine calibration: Remove all external cable packages (DressPack) and tools from the robot.	

Removing gearbox axis 6

Use this procedure 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	Jog the robot to a position where the tilthouse unit is placed in an appropriate service position.	

Continues on next page

	Action	Note
3	**DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	
4	Drain the *oil* from the gearbox.	See section • *Changing oil, gearbox axis 6 on page 147*
5	Remove the *turning disk*.	See section • *Replacing the turning disk on page 187*
6	Remove the gearbox by unscrewing the *attachment screws* and *washers* that secure it.	
7	If required apply two M8 screws in the holes shown in the figure, and press out the gearbox.	 xx0200000220 A: M8 holes for pressing out the gearbox

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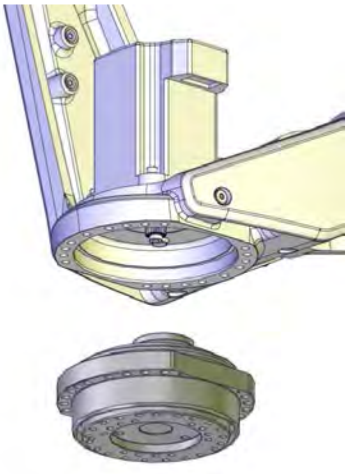
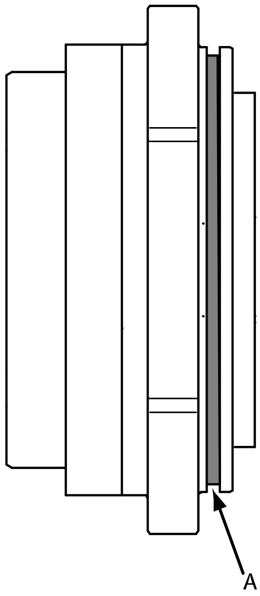
	Action	Note
8	Remove *gearbox axis 6* carefully without damaging pinion or gear.	 xx1000001412
9	Check the pinion. A damaged pinion must be replaced!	

Refitting gearbox axis 6

Use this procedure to refit gearbox axis 6.

	Action	Note
1	 **DANGER** Turn off all: • electric power supply • hydraulic pressure supply • air pressure supply to the robot, before entering the robot working area.	

Continues on next page

	Action	Note
2	Make sure the *o-ring* is undamaged and fitted to the gearbox. If the o-ring is damaged, replace! Lubricate the o-ring with grease.	For art. no. see: *Required equipment on page 313*.  xx0200000221
3	Release the brakes of the axis 6 motor manually.	See section • *Manually releasing the brakes on page 77*
4	Check that the *pinion* is undamaged on the axis 6 motor.	
5	Carefully insert the *axis 6 gearbox* into the tilthouse, using guide pins. Make sure the gears of the gearbox mate with the pinion of the axis 6 motor. **CAUTION** Do not damage pinion or gears in the process!	
6	Secure the gearbox with its *attachment screws* and *washers*. Reused screws may be used, providing they are lubricated as detailed in section *Screw joints on page 355* before fitting.	8 pcs or 18 pcs (depending on wrist version): M8 x 40, 12.9 quality Gleitmo, Tightening torque: 30 Nm.
7	Refit the *turning disk*.	See section • *Replacing the turning disk on page 187*
8	Perform a *leak-down test*.	See section • See section *Performing a leak-down test on page 160*.
9	Refill the gearbox with *oil*.	See section • *Changing oil, gearbox axis 6 on page 147*

Continues on next page

	Action	Note
10	Recalibrate the robot.	Pendulum Calibration is described in *Operating manual - Calibration Pendulum*, enclosed with the calibration tools. Axis Calibration is described in *Calibrating with Axis Calibration method on page 330*. General calibration information is included in section *Calibration on page 319*.
11	**DANGER** Make sure all safety requirements are met when performing the first test run. These are further detailed in the section *DANGER - First test run may cause injury or damage! on page 51*.	

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 330*.

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.

5.1.2 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	The calibrated robot is positioned at calibration position. Standard calibration data is found on the SMB (serial measurement board) or EIB in the robot. 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.	Axis Calibration or Calibration Pendulum [i]
Absolute accuracy calibration (optional)	Based on standard calibration, and besides positioning the robot at synchronization position, the Absolute accuracy calibration also compensates for: • Mechanical tolerances in the robot structure • Deflection due to load Absolute accuracy calibration focuses on positioning accuracy in the Cartesian coordinate system for the robot. Absolute accuracy calibration data is found on the SMB (serial measurement board) in the robot. 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. A robot calibrated with absolute accuracy has a sticker next to the identification plate of the robot. To regain 100% absolute accuracy performance, the robot must be recalibrated for absolute accuracy!  xx0400001197	CalibWare

[i] 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

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 660 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 330*.

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.

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. 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 360*.

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 326*. 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.

5.2 Synchronization marks and axis movement directions

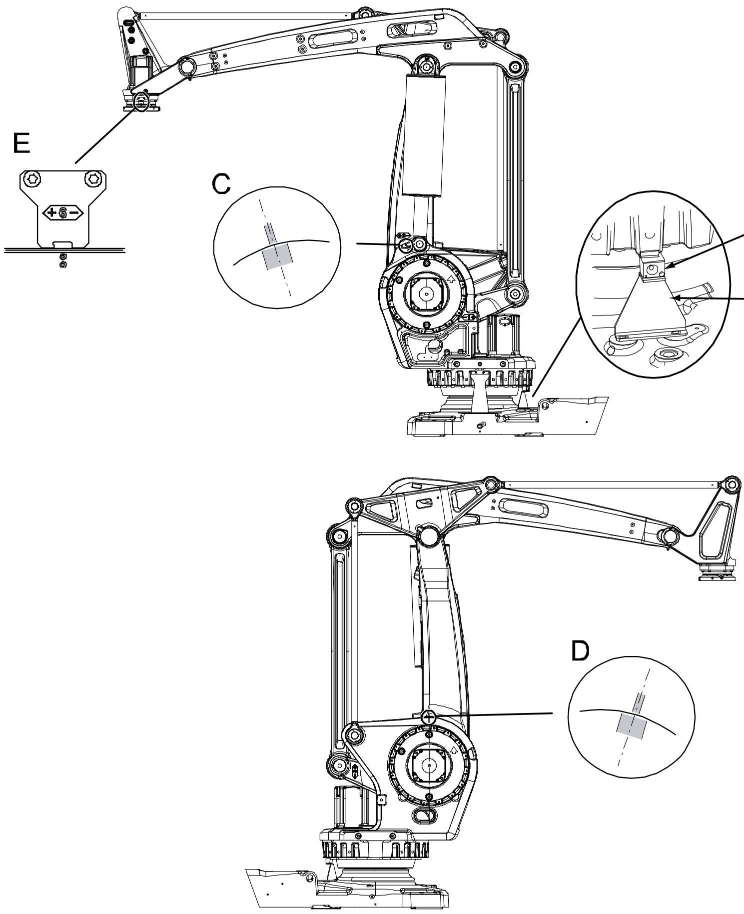
5.2.1 Synchronization marks and synchronization position for axes

Introduction

This section shows the position of the synchronization marks and the synchronization position for each axis.

Synchronization marks, IRB 660

This illustration shows the positions of the synchronization marks on the robot.



xx0500002487

A	Synchronization plate, axis 1
B	Synchronization tab on robot
C	Synchronization mark, axis 2
D	Synchronization mark, axis 3
E	Synchronization plate and mark, axis 6

Continues on next page

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.

5.2.2 Calibration movement directions for all axes

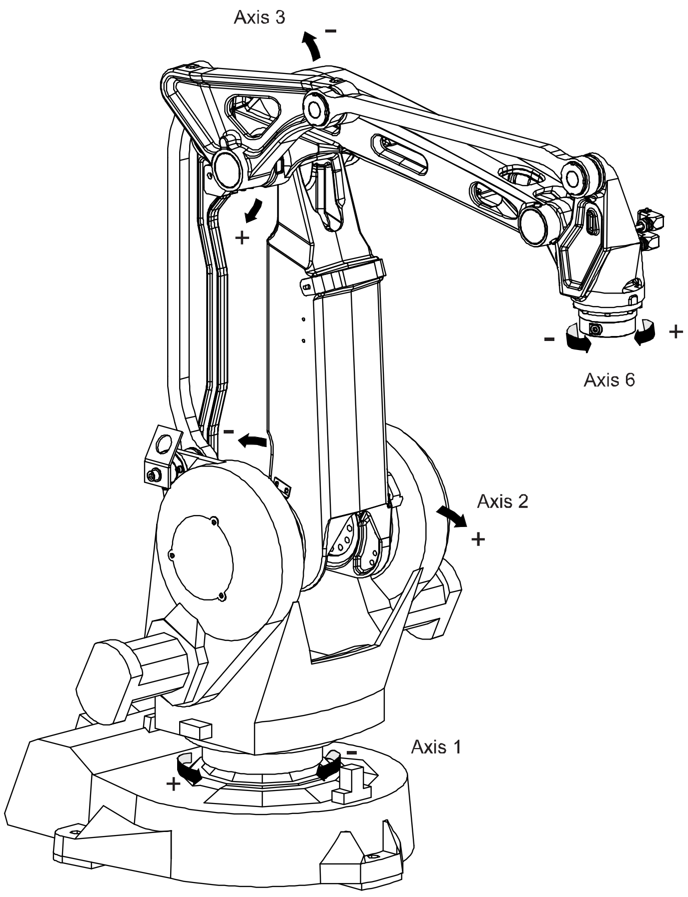
Overview

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, 4 axes

Note! The graphic shows an IRB 260. The positive direction is the same for all 4-axis robots



xx0500001927

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 *Synchronization marks and synchronization position for axes on page 323*.
3	When all axes are positioned, update the revolution counter.	*Step 2 - Updating the revolution counter with the FlexPendant on page 327*.

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:

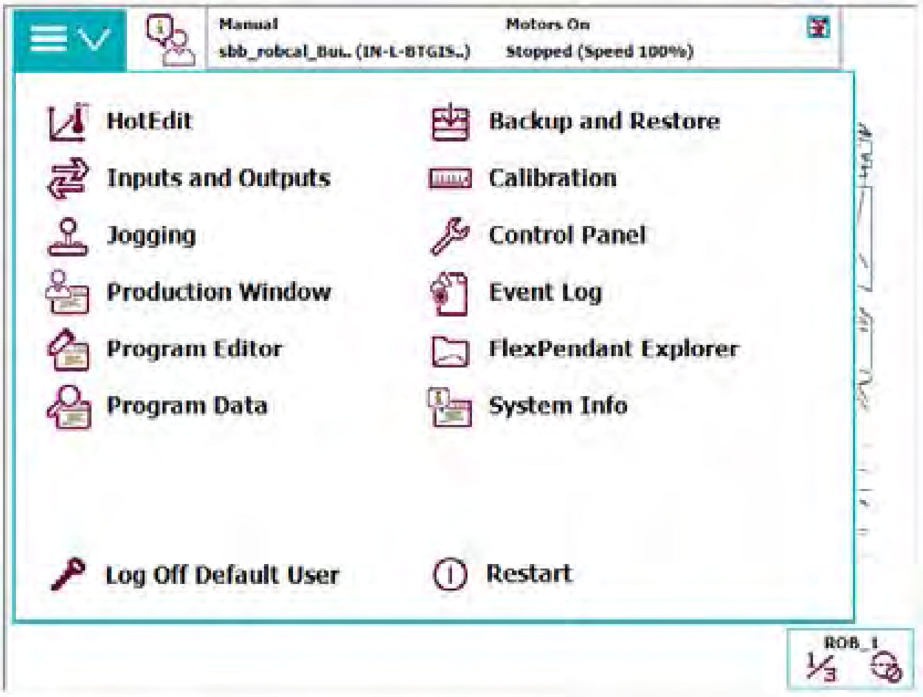
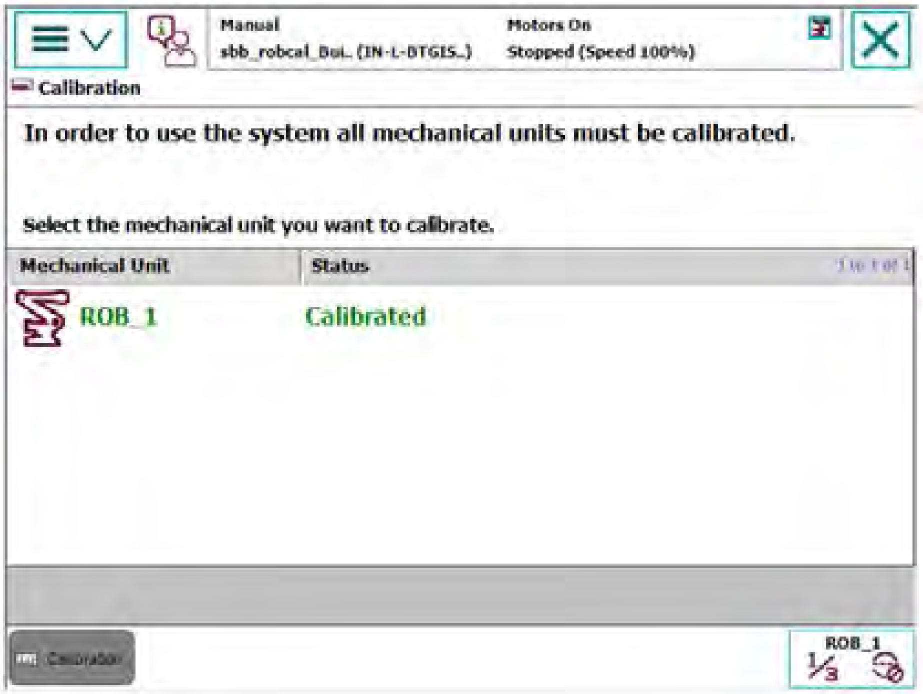
Manipulator variant	Axis 4	Axis 6
IRB 660	-	No

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).

Continues on next page

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**.  xx1500000942
2	All mechanical units connected to the system are shown with their calibration status. Tap the mechanical unit in question.  xx1500000943

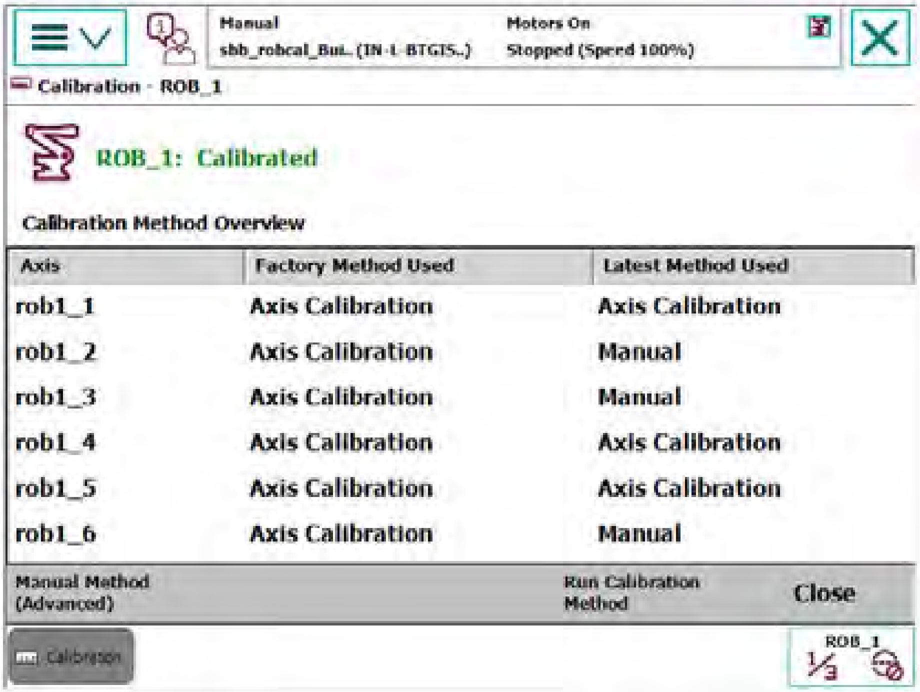
Continues on next page

<table>
<tr><th></th><th>Action</th></tr>
<tr><td>3</td><td>

This step is valid for RobotWare 6.02 and later.

Calibration method used at factory for each axis is shown, as well as calibration method used during last field calibration.

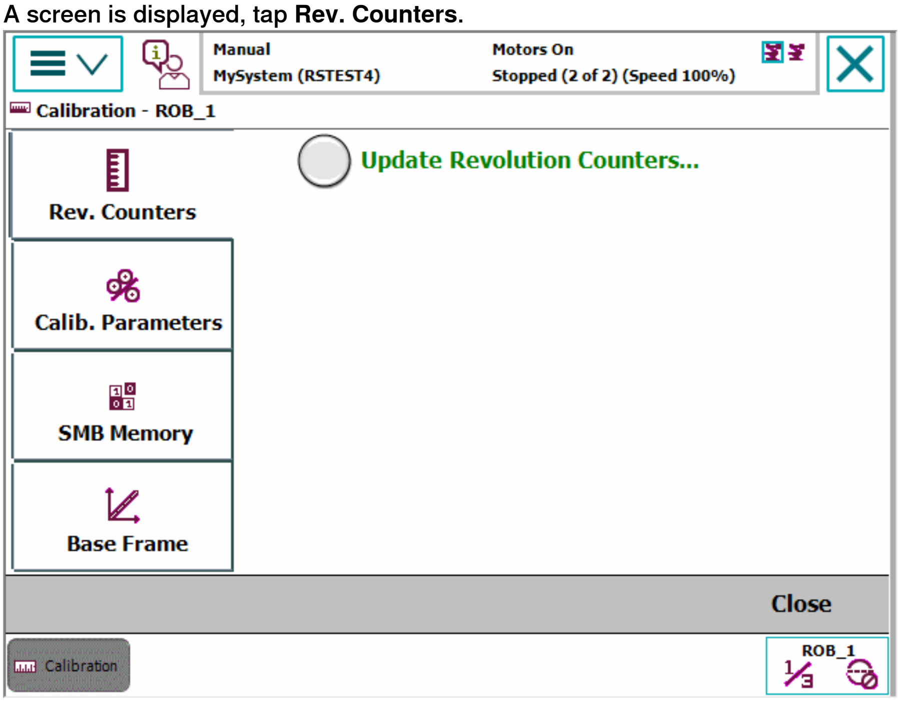
Tap **Manual Method (Advanced)**.



xx1500000944

</td></tr>
<tr><td>4</td><td>

A screen is displayed, tap **Rev. Counters**.



en0400000771

</td></tr>
</table>

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	Action
5	Tap **Update Revolution Counters...**. A dialog box is displayed, warning that updating the revolution counters may change programmed robot positions: • Tap **Yes** to update the revolution counters. • Tap **No** to cancel updating the revolution counters. Tapping **Yes** displays the axis selection window.
6	Select the axis to have its revolution counter updated by: • Ticking in the box to the left • Tapping **Select all** to update all axes. Then tap **Update**.
7	A dialog box is displayed, warning that the updating operation cannot be undone: • Tap **Update** to proceed with updating the revolution counters. • Tap **Cancel** to cancel updating the revolution counters. 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 *Checking the synchronization position on page 344*.

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.

Continues on next page

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.

Also choose this routine if the robot is wall mounted or suspended.

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.

5.4.2 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.

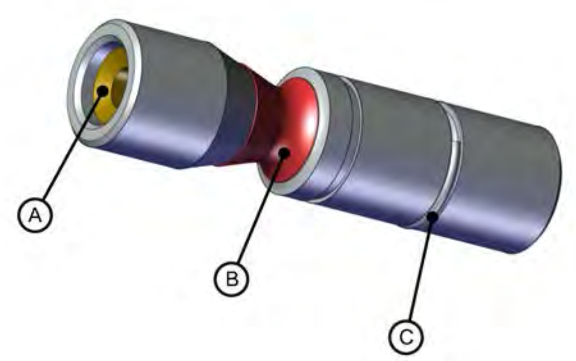
Examining the calibration tool

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).

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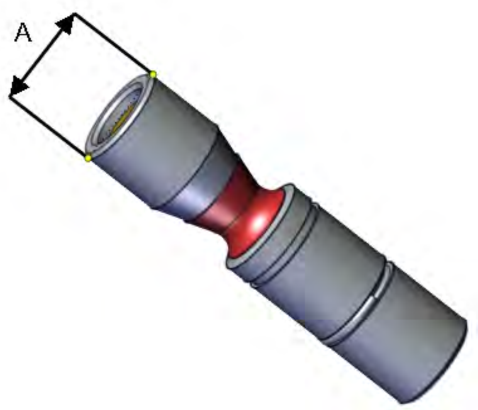
- Straightness within 0.005 mm.



xx1500000951

A	Outer diameter

Identifying the calibrating tools

It is possible to make the pins identifiable with, for example, an RFID chip. The procedure of how to install an RFID chip is described below.

Note

The pin identifier is NOT delivered from ABB, it is a customized solution.

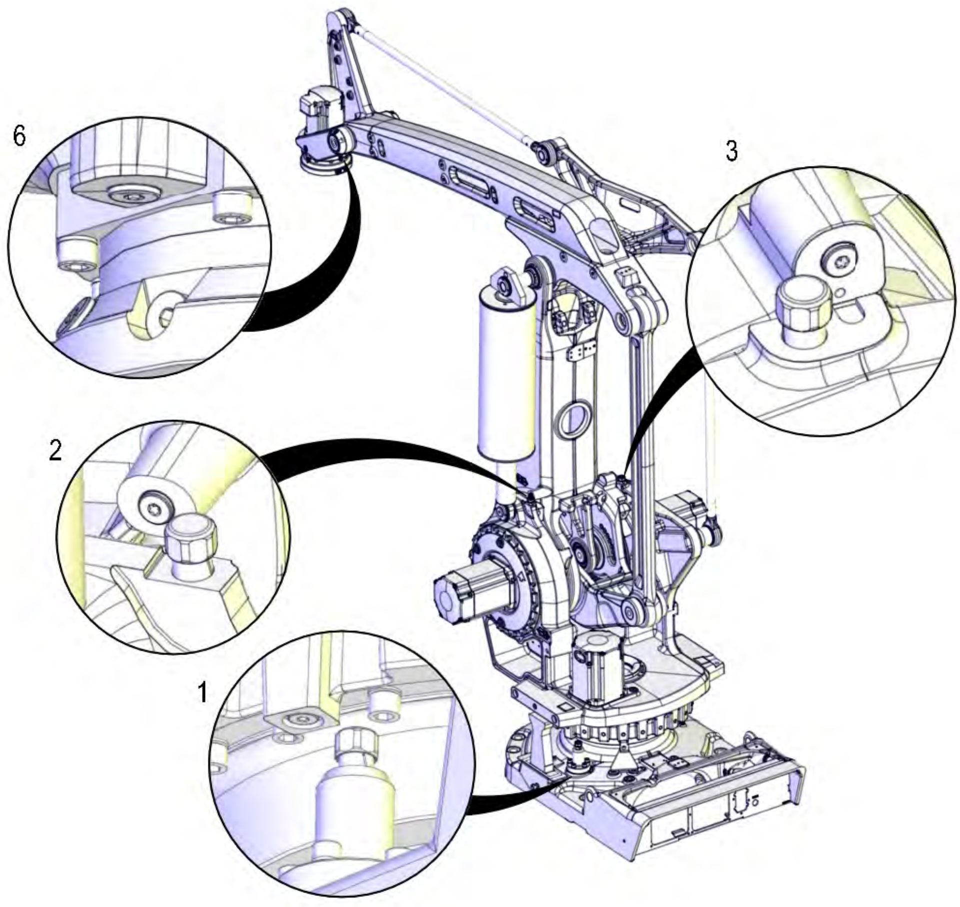
	Action	Note
1	It is possible to use any RFID solution, with the correct dimensions. ABB has verifed function on some suppliers fulfilling the requirements of NFC compatible devices (13.56 Mhz) according to ISO 14443 or ISO 15693. **Note** The maximum dimensions on the RFID chip must not exceed Ø7.9 mm x 8.0 mm, Ø5.9 mm x 8.0 mm or Ø3.9 mm x 8.0 mm (depending on calibration tool size).	
2	There is a cavity on one end of the calibration tool in which the RFID chip can be installed. Install the RFID chip according to supplier instructions. Install the chip in flush with the tool end.	

5.4.3 Location of calibration items

Location of calibration items

A fixed calibration pin and a bushing for the movable calibration tool are located on each axis as follows.

If there is not enough space on an axis to install a fixed calibration pin, the axis is equipped with two bushings instead, for installation of two calibration tools when calibration is carried out. This is shown in the figure.



xx1600000699

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.

Continues on next page

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 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 331*.
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

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.

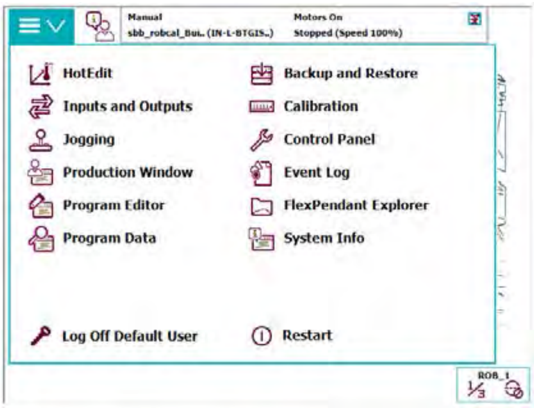
Preparation prior to calibration

The calibration procedure is described in the FlexPendant while conducting it.

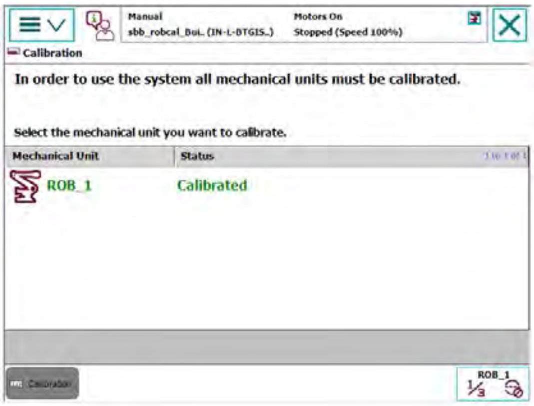
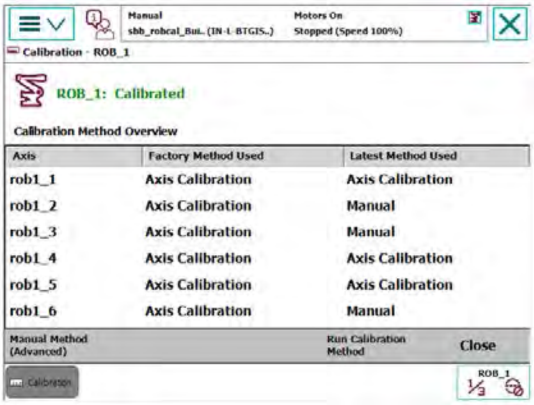
	Action	Note
1	**DANGER** While conducting the calibration, the robot needs to be connected to power. Make sure that the robots working area is empty, as the robot can make unpredicted movements.	
2	Wipe the calibration tool clean. **Note** The calibration method is exact. Dust, dirt or color flakes will 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**.  xx1500000942	

Continues on next page

	Action	Note
2	All mechanical units connected to the system are shown with their calibration status. Tap the mechanical unit in question.  xx1500000943	
3	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.  xx1500000944	The FlexPendant will give all information needed to proceed with Axis Calibration.
4	Follow the instructions given on the FlexPendant.	A brief overview of the sequence that will be run on the FlexPendant is given in *Overview of the calibration procedure on the FlexPendant on page 336*.

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

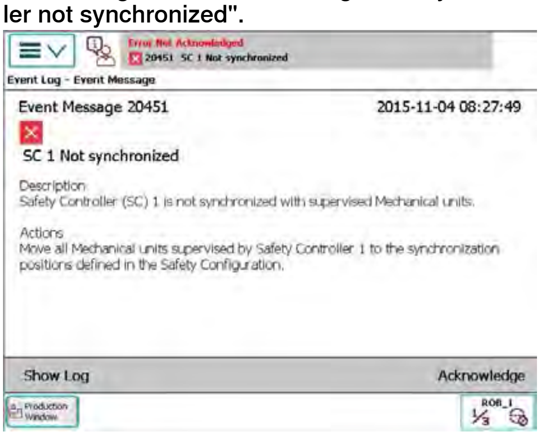
Situation	Action
The RobotWare program is terminated with **PP to Main**.	Remove the calibration tool, if it is installed, and restart the calibration procedure from the beginning. See *Starting the calibration procedure on page 337*. If the calibration tool is in contact the robot axis needs to be jogged 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 *Calibration movement directions for all axes on page 325*

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.

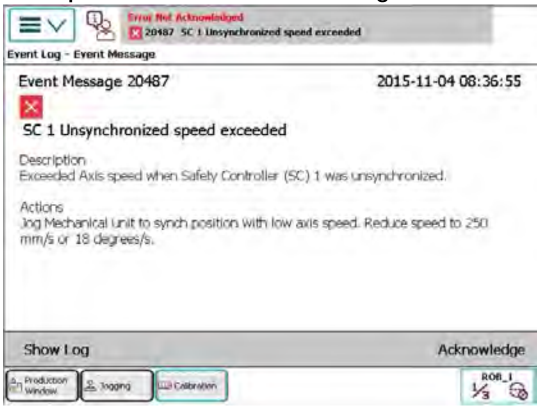
However, SafeMove may generate other warning messages anytime during the Axis Calibration routine.

Safety controller not synchronized - SafeMove message

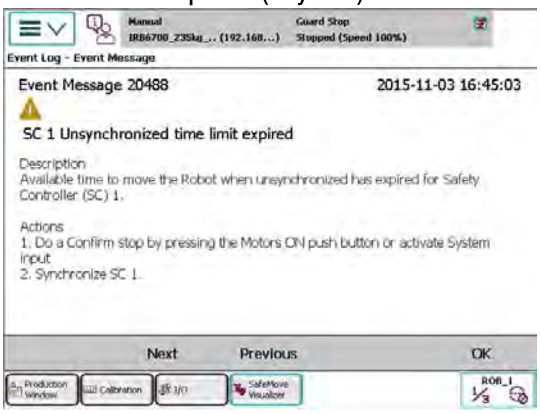
	Action	Note
1	SafeMove generates the message "Safety controller not synchronized".  xx1500002480	
2	Confirm unsynchronized state by pressing **Acknowledge** to continue Axis Calibration procedure.	
3	Restart Axis Calibration procedure by pressing **Play**.	

Continues on next page

Unsynchronized speed exceeded - SafeMove message while saving robot data

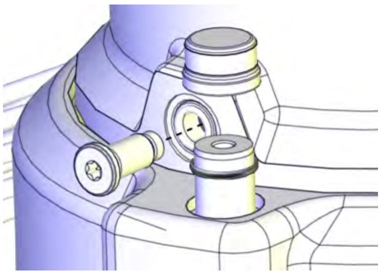
	Action	Note
1	SafeMove generates the message "Unsynchronized speed exceeded" while saving robot data.  xx1500002481	
2	Press **Acknowledge** to continue Axis Calibration procedure.	
3	Restart Axis Calibration procedure by pressing **Play**.	

Unsynchronized time limit expired - SafeMove message anytime during Axis Calibration routine

	Action	Note
1	SafeMove generates the message "Unsynchronized time limit expired" (anytime).  xx1500002482	
2	Press **OK** to continue Axis Calibration procedure.	
3	Restart Axis Calibration procedure by pressing **Play**.	

Continues on next page

After calibration

	Action	Note
1	Check the o-ring on the fixed calibration pin. Replace if damaged or missing.	 xx1500000952 Protection cover and plug set: 3HAC056806-001.
2	Reinstall the protective cover on the fixed calibration pin and the protective plug on the bushing on each axis, directly after the axis is calibrated. Replace the cover/plug 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.

5.6 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 *Checking the synchronization position on page 344*.
2	Adjust the *synchronization marks* when the calibration is done, if necessary.	This is detailed in section *Synchronization marks and synchronization position for axes on page 323*.
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

Use this procedure to create a program that runs all the robot axes to their synchronization position.

	Action	Note
1	On ABB menu tap **Program editor**.	
2	Create a new program.	
3	Use **MoveAbsJ** in the **Motion&Proc** menu.	

4	Create the following program:
	`MoveAbsJ [[0,0,0,0,0,0],`
	`[9E9,9E9,9E9,9E9,9E9,9E9]]`
	`\NoEOffs, v1000, fine, tool0`	

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 *Synchronization marks and synchronization position for axes on page 323* and *Updating revolution counters on page 326*.

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 *Synchronization marks and synchronization position for axes on page 323* and *Updating revolution counters on page 326*.

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.

6.2 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 *Standard tools on page 359*.
Protective clothing that also covers face and hands	-	Must protect against spatter of sparks and flames.
Cutting torch with a long shaft	-	For opening housing and cutting coils. The long shaft is a safety requirement.
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

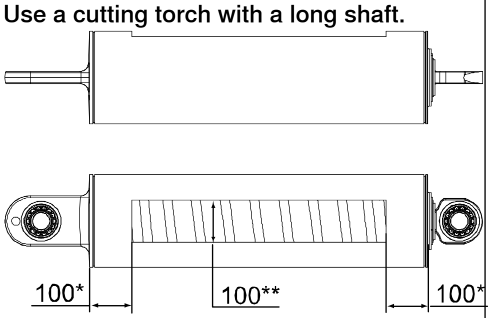
The procedure below details the actions to perform on field, when the balancing device is to be decommissioned.

	Action	Note
1	Remove the balancing device from the robot.	Detailed in section *Replacing the balancing device on page 249*.
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 and plastic. The following procedure contains useful information about decommissioning.

Continues on next page

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	**DANGER** There is stored energy built up by high tensioned compression springs inside the balancing device! When a coil is cut the released tension creates a spatter of sparks and flames. The working area must be free of flammable materials. Position the balancing device so that the spatter will be directed away from personnel.	
2	Clamp the device at the working location. Place the device at ground level so that the hole and spring coils are cut from a more safe distance.	
3	**WARNING** There is some grease and a plastic layer inside the balancing device. When opening a hole in the device, the cutting torch will cause the plastic and the grease to start to burn. Wear protective clothing! Make sure that the working area is well ventilated!	
4	**DANGER** The hole must be cut as specified in the figure. Pieces can be ejected from the cylinder at high speed if the hole is cut larger than specified!	
5	Cut a hole in the housing as shown in the figure.	Use a cutting torch with a long shaft.  xx1100000096 * Minimum measure, in millimeters. ** Maximum measure, in millimeters.

Continues on next page

	Action	Note
6	**DANGER** There is stored energy built up by high tensioned compression springs inside the balancing device! When a coil is cut the released tension creates a spatter of sparks and flames. The working area must be free of flammable materials. Position the balancing device so that the spatter will be directed away from personnel.	
7	Cut at least eight coils of the spring inside the housing.	Use a cutting torch with a long shaft.
8	Double-check the number of coils cut and make sure all the tension in the spring is removed. Cut more coils if there is still tension in the spring.	

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7 Reference information

7.1 Introduction

General

This chapter includes general information, complementing the more specific information in the different procedures in the manual.

7.2 Applicable safety standards

Standards, EN ISO

The robot system 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 [i]	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 [ii]	Arc welding equipment - Part 1: Welding power sources
EN IEC 60974-10 [ii]	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)

i Only robots with protection Clean Room.
ii 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
EN 953	Safety of machinery - General requirements for the design and construction of fixed and movable guards

Other standards

Standard	Description
ANSI/RIA R15.06	Safety requirements for industrial robots and robot systems
ANSI/UL 1740 (option 429-1)	Safety standard for robots and robotic equipment

Continues on next page

Standard	Description
CAN/CSA Z 434-03 (option 429-1)	Industrial robots and robot Systems - General safety requirements

7.3 Unit conversion

Converter table

Use the following table to convert units used in this manual.

Quantity	Units		
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	

7.4 Screw joints

General

This section describes how to tighten the various types of screw joints on the IRB 660.

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

- 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 (Molycote, Gleitmo or equivalent) with allen head screws

The following table specifies the recommended standard tightening torque for *screws lubricated with Molycote 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 [i]	Tightening torque (Nm) Class 12.9, lubricated [i]
M8	28	35
M10	55	70
M12	96	120
M16	235	280
M20	460	550
M24	790	950

[i] Lubricated with Molycote 1000, Gleitmo 603 or equivalent

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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

7.5 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:

	Action	Note
	CAUTION The robot weighs 1750 kg. All lifting accessories used must be sized accordingly!	

7.6 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	

7.7 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 359*, and of special tools, listed directly in the instructions and also gathered in this section.

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.

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Oil exchange equipment

The following table specifies the recommended equipment for oil exchange.

Description	Art. no.	Note
Oil exchange equipment	3HAC021745-001	Includes: • Vacuum pump with regulator, hose and coupling • Couplings and adapters • Pump (manual) with hose and coupling • Graduated measuring glass • Oil gun • User instructions.

Basic tools

The following table specifies the tools in the basic toolkit that are used for the current robot model. This toolkit is necessary primarily when removing and refitting the motors.

The tools are also listed directly in the instructions.

Description	Qty	Art. no.
Guide pins M10 x 100	2	3HAC15521-1
Guide pins M10 x 150	2	3HAC15521-2
Lifting tool, motor ax 1	1	3HAC14459-1
Lifting tool, motor ax 2, 3	1	3HAC15534-1
Removal tool, motor M12x		Fits motors axes 1, 2 and 3.
Rotation tool	1	3HAC17105-1
Standard toolkit (content described in section *Standard tools on page 359*)	1	-

Lifting tools

The following table specifies the lifting 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, procedures*.

Description	Qty	Article no.
Lifting tool, tilt house		3HAC023154-001
		3HAC8446-1
		3HAC8445-1
Lifting tool, motor		3HAC14586-1
Lifting tool, gear ax.2		3HAC023240-001
Lifting tool, frame		3HAC023308-001
Lifting tool, complete robot		3HAC15607-1
Lifting tool, parallel arm		3HAC023098-001
Lifting tool, turning device gearbox ax.1		3HAC14406-1
Lifting tool, base		3HAC14868-1

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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.

Description	Qty	Article no.
Lower arm fixture		3HAC7035-1
Pressing, link		3HAC023081-001
Pressing, outer ring on link		3HAC023079-001
KM8 socket		Standard
KM10 socket		Standard
KM12 socket (special)		3HAC5347-1
Pinion crank		3HAC023132-001
Pressing, lower arm/balancing weight		3HAC023092-001
Pressing, upper arm		3HAC023084-001
Pressing, tie rod		3HAC5021-1
Pressing, tilt house		3HAC023080-001
Pressing, outer ring, tilt house		3HAC023075-001
Auxiliary shaft, long		3HAC5275-1
Auxiliary shaft, short		3HAC5276-1
Support shaft/bearing race		3HAC5281-1
Axis 1 pinion		3HAC022436-001
Tool for lubrication		3HAC5222-1
Adapter for shaft axis 3		3HAC023916-001
Guide sleeves		3HAC14446-1

7.8 Lifting accessories and lifting instructions

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.

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8 Spare part lists

8.1 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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9 Circuit diagrams

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
Circuit diagram - IRC5	*3HAC024480-011*
Circuit diagram - IRC5 Compact	*3HAC049406-003*
Circuit diagram - IRC5 Panel Mounted Controller	*3HAC026871-020*
Circuit diagram - Euromap	*3HAC024120-004*
Circuit diagram - Spot welding cabinet	*3HAC057185-001*

Robots

Product	Article numbers for circuit diagrams
Circuit diagram - IRB 120	*3HAC031408-003*
Circuit diagram - IRB 140 type C	*3HAC6816-3*
Circuit diagram - IRB 260	*3HAC025611-001*
Circuit diagram - IRB 360	*3HAC028647-009*
Circuit diagram - IRB 460	*3HAC036446-005*
Circuit diagram - IRB 660	*3HAC025691-001*
Circuit diagram - IRB 760	*3HAC025691-001*
Circuit diagram - IRB 1200	*3HAC046307-003*
Circuit diagram - IRB 1410	*3HAC2800-3*
Circuit diagram - IRB 1600/1660	*3HAC021351-003*
Circuit diagram - IRB 1520	*3HAC039498-007*
Circuit diagram - IRB 2400	*3HAC6670-3*
Circuit diagram - IRB 2600	*3HAC029570-007*
Circuit diagram - IRB 4400/4450S	*3HAC9821-1*
Circuit diagram - IRB 4600	*3HAC029038-003*
Circuit diagram - IRB 6400RF	*3HAC8935-1*
Circuit diagram - IRB 6600 type A	*3HAC13347-1* *3HAC025744-001*
Circuit diagram - IRB 6600 type B	*3HAC13347-1* *3HAC025744-001*
Circuit diagram - IRB 6620	*3HAC025090-001*

Continues on next page

Product	**Article numbers for circuit diagrams**
Circuit diagram - IRB 6620 / IRB 6620LX	*3HAC025090-001*
Circuit diagram - IRB 6640	*3HAC025744-001*
Circuit diagram - IRB 6650S	*3HAC13347-1* *3HAC025744-001*
Circuit diagram - IRB 6660	*3HAC025744-001* *3HAC029940-001*
Circuit diagram - IRB 6700	*3HAC043446-005*
Circuit diagram - IRB 7600	*3HAC13347-1* *3HAC025744-001*
Circuit diagram - IRB 14000	*3HAC050778-003*
Circuit diagram - IRB 910SC	*3HAC056159-002*

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Contact us

ABB AB
Discrete Automation and Motion
Robotics
S-721 68 VÄSTERÅS, Sweden
Telephone +46 (0) 21 344 400

ABB AS, Robotics
Discrete Automation and Motion
Nordlysvegen 7, N-4340 BRYNE, Norway
Box 265, N-4349 BRYNE, Norway
Telephone: +47 51489000

ABB Engineering (Shanghai) Ltd.
No. 4528 Kangxin Highway
PuDong District
SHANGHAI 201319, China
Telephone: +86 21 6105 6666

www.abb.com/robotics

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